FIRM, INNOVATION, COMPETITIVENESS AND SCIENCE PARK DEVELOPMENT IN THAILAND

by

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A thesis submitted to the University of Birmingham for the degree of DOCTOR OF PHILOSOPHY

Birmingham Business School
College of Social Sciences
University of Birmingham
September 2021

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ABSTRACT

Science parks (SPs) have been a feature of innovation policies across developed market economies for over 70 years. The future of emerging economies lies in innovation. The development of policies that enhance pathways to innovation in emerging economies is therefore critical, but as yet this issue is under-developed in the literature. SP policy has often been guided by the application of a triple helix approach which, however, presupposes the existence of a framework of well-established institutions that may still be forming in an emerging economy. To understand the contribution SPs make to emerging economies, it is necessary to supplement the triple helix approach by exploring the conditions for successful innovation in specific collaborative projects within the context of an emerging economy setting.

This study aims to understand regional innovation processes in an emerging economy, with special reference to SPs. The objectives are to 1) explore the adoption and implementation of a SP policy in an emerging economy, 2) identify the roles played by triple helix actors and define the relationships that support commercialisation of innovation projects and firm innovativeness, 3) develop an inter- and intra-firm project-level understanding of the impacts of the implementation of a SP policy in an emerging economy setting including exploring critical inputs from SPs, academics, and entrepreneurs, and 4) evaluate existing theory that has been applied to understanding SPs at the firm/project level.

The study is based on 57 in-depth interviews with SP directors, entrepreneurs, academics, university representatives those engaged with innovation projects in one of Thailand's regional SPs. The results show that SP analysis, informed by the triple helix approach, has less validity within an emerging economy setting where the triple helix's components are not yet fully established. The triple helix approach highlights limitations within

the existing institutional environment in emerging countries which obstructs regional innovation processes, including limited availability of resources for entrepreneur development, the inconsistency of supporting policies, and underdeveloped HEI structures. These challenges are too complex to overcome without having long-term strategies. Alternatively, a small steps approach to enhancing innovation can be adopted by focusing on firm-level innovation projects including identifying opportunities for policy enhancement. The innovation value chain (IVC) approach provides one way to conceptualise firm-level innovation highlighting the critical inputs required for innovation to occur and the relationships created between project team members and the ways these influence project outcomes. The triple helix and IVC approaches then supplement one another to enhance understanding of emerging economy innovation.

Nevertheless, a more granular approach that examines and conceptualises the conditions for successful innovation project development is required, and this is developed for the first time in this thesis with a focus on the project level. The approach proposed and developed here is one that, draws inspiration from string theory. This string-based approach explores the ways in which different types of expertise are braided together within a SP innovation project. Within this braiding process, there are challenges in balancing competing institutional logics which provides a critical additional challenge requiring the development of new policy pathways within emerging economy settings. The key issue is to appreciate how conflicting logics enable or constrain firm-level innovation processes within the context of the wider framework conditions that emerge with SP policy implementation within emerging economy settings. Investigating innovation projects, where the institutional framework is still consolidating, can shed light on innovation projects where these frameworks are well established in developed market economies.

DEDICATION

I would like to dedicate this thesis to my parents, Nantachai and Hemmaluck Wongwanich. For your hard work, your push, and your wish for me to earn a PhD, I have it now.

ACKNOWLEDGEMENTS

Behind my achievements, there are supports from the people who believe in me. This thesis is a great accomplishment that will not be made possible without them, and I want to take this opportunity to inform them how much I appreciate it.

First, I am grateful for the support of the government of Thailand for granting me the full PhD scholarship. Without this fund that included all necessary expenses, I would not even be thinking about starting my PhD journey.

I cannot say thank you enough to my supervisors, Professor John R. Bryson, Mr Christopher J. Collinge, and Dr Catherine H. Harris, who were very patient and saw my potential while I was so doubtful with myself. You are my candle in a dark tunnel.

Thank you to the CoSS support staff, especially Marleen Vanstockem and Anne Brooke, for helping me with all enquiries and administrative issues.

Thanks to the SPA officers for helping me with government paperwork, and thanks to RSPs officers for coordinating and arranged the meeting with the participants. Without them, acquiring the data would be a lot more complicated.

Thanks to all PhD 'office friends' who are my source of relaxation, including Julian Barnes, Juliana Carneiro, Reani and especially to Helen Hu, who labelled me as her best friend after meeting me a few times. Life was fun with you.

Special thanks to my family, who always believe in me and encourage me through the hard times. My parents - Nantachai and Hemmaluck Wongwanich, my brother and his family – Krissada, Jidapha, and Nichary Wongwanich. Watching your video brought a lot of joins. Thank from my heart to Eduard Bulf, who keeps me sane and be a great supporter at all times.

Lastly, I want to thank all participants for providing valuable and sincere information that contributed to the research. Without your engagement, this thesis would not have been possible.

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LIST OF ABBREVIATIONS

AIT	Asian Institute of Technology
BIOTEC	National Center for Genetic Engineering and Biotechnology
BISPA	Business Incubators and Science Parks Association
BOI	Board of Investment
CMU	Chiang Mai University
COE	Center of Excellence
DIP	Department of Industry Promotion
DUI	Doing, Using and interaction
EEC	Eastern Economic Corridor
FDA	Food and Drug Association
GNI	Gross National Income
HEI	Higher Education Institute
IMD	International Institute for Management Development
INE	Spanish Statistical Office
IRTC	Industrial Research and Technology Capacity Development
IVC	Innovation Value Chain
MFI	Microfinance Institution
MFLU	Mae Fah Luang University
MJU	Mae Joe University
MTEC	National Metal and Materials Technology Center
NANOTEC	National Nanotechnology Center
NCC	Office of National Committee on Competitive Advantage

NECTEC	National Electronics and Computer Technology Center
NESDB	National Economic and Social Development Board
NESP	Northeastern Science Park
NSP	Northern Science Park
NSTDA	National Science and Technology Development Agency
NU	Naresuan University
OEM	Original Equipment Manufacturer
OHEC	Office of the Higher Education Commission
PPP	Public-private Partnership
PSRU	Pibulsongkram Rajaphat University
RSP	Regional Science Park
SDGs	United Nation Sustainable Development Goals
SIIT	Sirindhorn International Institute of Technology
SP	Science Park
SPA	Science Park Promotion Agency
S&T	Scientific and Technological
STeP	Science and Technology Park, Chiang Mai University
STI, ST&I	Science, Technology, and Innovation
STSP	Southern Science Park
TFP	Total Factor Productivity
TISTR	Thailand's Institute of Scientific and Technological Research
TMC	Technology Management Center
TSP	Thailand Science Park
UBI	University Business Incubation

UNCTAD	United Nations Conference on Trade and Development
UP	University of Phayao
URU	Uttaradit Rajaphat University
WEF	World Economic Forum
WG	Working Group

CHAPTER 1

FIRM, INNOVATION, COMPETITIVENESS AND SCIENCE PARK DEVELOPMENT IN THAILAND

1.1 Introduction

Innovation sits behind processes that create jobs and ultimately underpins taxation that supports the provision of public services, including those linked to national security. Understanding innovation processes is critical for both regional and national prosperity. There is a very large literature on innovation (Etzkowitz and Leydesdorff, 2000; Carlsson, 2007; Jensen *et al.*, 2007; Lundvall, 2007; Isaksen and Nilsson, 2013; Tomlinson and Fai, 2013; Anttonen *et al.*, 2018; Etzkowitz and Zhou, 2018; Leydesdorff, 2018) and a much more focused literature on regional innovation systems (Saxenian, 1989; Cooke, Gomez Uranga and Etxebarria, 1997; Keeble, 1999a; Breschi and Lissoni, 2001; Doloreux, 2002; Asheim and Coenen, 2005; Asheim, 2007; Chang *et al.*, 2010; Isaksen and Karlsen, 2010; Goddard, Robertson and Vallance, 2012; Isaksen and Karlsen, 2012; McAdam and Debackere, 2018; Bramwell, Hepburn and Wolfe, 2019). Nevertheless, one policy and research challenge is that much of the literature on regional innovation systems focuses on developed market economies rather than emerging economies. This is unfortunate given the on-going realignment of centers of population from the Global North to the Global South. Much more research is required to support regional innovation policy formulation in emerging economy settings.

Innovation is a complex process that is multi scalar. It links set of global potential drivers with a series of national drivers, regional drivers, and people drivers. Emerging economies are one of the scales placed in the wider context of the global as well as developed economies. To understanding innovation, a more granular nuanced understanding of innovation must be developed and applied in the context of original innovation by placing the firms in the

context of regional innovation systems within which they are embedded. One difficulty is that there is too much literature which focuses at the regional or triple helix scale and there is a relative neglect of exploring firm-level innovation projects within a regional context.

It is vital that a more balanced approach to innovation emerges that includes a focus on all types of the national economy including emerging economies. The focus of innovation research will need to alter toward emerging economies for three reasons:

1. Population growth in emerging economies is shifting the distribution of the global population away from developed market economies towards emerging economies.
2. There is an essential opportunity to contribute to understanding innovation processes in different contexts other than developed economy.
3. Innovation in emerging economies may have different characteristics.

An excellent starting point for a study of innovation is to start with an example. Miss T was a pharmaceutical student who always wanted to establish her own business. Together with her classmates, she began to develop, manufacture and sell cosmetic products in 2013. Some products were developed based on university research. Manufacturing commenced in a small office space rented from the university using shared production tools and equipment from university laboratories. This company proliferated. Customers were located all over the country. During the first three years of operations, the firm's revenue increased by over 100% annually. Business growth slowed during 2016 and 2017, but revenue still increased by about 50% from the year before. The firm invested in expansion, buying machines and renting larger space to accommodate more employees. At the end of 2018, the firm built its first factory not far from the university. They were ready to move as soon as the building was completed. This is perhaps an unusual example. This is a firm established by students with support from a

university and a science park (SP) and the company's location was in an emerging market economy – Thailand.

I was born and raised in Thailand and spent two-years working at the Ministry of Commerce and observed that successful new firm formation was unusual, for example the rapid growth in the case of Miss T. Additionally, as a policy analyst at the Science Park Promotion Agency (SPA) which was responsible for the establishment of Thailand Regional Science Parks (RSPs), my job required travelling to the sites (**Figure 1.1**) and evaluating ongoing RSPs' operation. The buildings of the RSPs were not completed at that time (**Figure 1.2**). SP innovation projects were carried out at the universities. This experience raised the questions regarding possible differences between firms participating in with the RSPs compared to other firms. Thus, what advantages did the firms gain from RSPs? In cases like Miss T's, what processes or characteristics were important for their survival and growth?

Figure 1.1 Visiting Northeastern Science Park



Figure 1.2 Southern Science Park construction site



Miss T and her co-founders had no experience of running a business and had access to limited capital to invest. This company vignette raises some important questions. How did a group of students without business knowledge and experience and with limited capital establish this business? How and where could they obtain the funding, knowledge and support required? What roles did the university and government play in this firm creation process? What role did

the SP play in this process? There is a much broader argument regarding the role public policy can play in facilitating innovation. This includes the policies and related practices that the government can develop and apply to encourage innovation. There are sector-based innovation policies, or vertical policy interventions, and more generic or horizontal policy interventions. There are place-based interventions, and national interventions. Nevertheless, the example of Miss T highlights the role that a university linked to a SP can play in catalyzing place-based innovation outcomes. A key issue here reflects the definition of innovation – this can be defined as that which is new to the world or new to a company or individual (OECD/Eurostat, 2019). SPs can facilitate both types of innovation.

To investigate these questions, this thesis explores the implementation of SP policy in an emerging economy setting with a focus on developing an inter- and intra-firm project-level analysis and this includes exploring critical inputs from SPs, academics, and entrepreneurs that underpin an innovation project's outcome by interviewing the key actors involved with innovation projects linked to Thailand's RSPs. The thesis engages with the substantial literature on innovation systems and regional development in the context of developed market economies (Keeble, 1989; Saxenian, 1989; Cooke, Gomez Uranga and Etxebarria, 1997; Doloreux, 2002; Hassink, 2005; Martin, 2010; Uyarra *et al.*, 2017), the development of SPs (Segal Quince Wicksteed, 1985; Massey, 1992; Saxenian, 1994; Guadix *et al.*, 2016), SPs and entrepreneur development (Garnsey and Cannon-Brookes, 1993; Westhead and Storey, 1994; Albahari *et al.*, 2018; Albahari, Klofsten and Rubio-Romero, 2019), and the triple helix model (Leydesdorff and Meyer, 2003; Etzkowitz, 2008; Scalia *et al.*, 2018; Galvao *et al.*, 2019). Nevertheless, this literature is applied to an emerging economy context– Thailand.

This chapter is divided into six sections. Section Two reviews the current understanding of place-based innovation policy development in the context of SP initiatives. Section Three

explores the triple helix model that has been developed to understand SP innovation systems and explores the innovation value chain (IVC) approach as it complements the triple helix model. Section Four introduces string-based approaches as an additional conceptual approach for exploring SPs that is layered on to the triple helix and the IVC approaches. The objectives of the study and research question are presented in Section Five. Section Six explores the decision to focus on Thailand, including a brief overview of the Thailand context and the northern region where the Northern Science Park (NSP), the focus of this research, is located. The thesis explores firms and innovation projects in the context of a SP that is located within a regional setting, however, it is important to note that the focus is not on regional economic development, but on firm level processes as they relate to innovation projects. The structure of the thesis is presented in Section Seven.

1.2 The development of place-based innovation policy with SP initiative

Regional development policy evolves based on economic conditions and existing policy in place; new policy emerges that is layered over existing policy (Uyarra *et al.*, 2017). There is no one-size-fits-all policy that can be easily copied and applied from one region to another (Tödtling and Trippl, 2005). Place-targeted policy needs to be underpinned by an area's core competencies and specialisms by building on an existing asset base. Current policy development focuses on technological innovations (McCann and Ortega-Argilés, 2013) with a place-specific emphasis on developing entrepreneurial ecosystems and linkages (Grillitsch and Asheim, 2018; Bramwell, Hepburn and Wolfe, 2019) with the accommodation of diversity and local differentiation. To Grillitsch and Asheim (2018), place-based policy aims to increase entrepreneurial diversity to avoid lock-in, create new path development for industries, and increase regional competitiveness and attractiveness.

Innovation policy reinforces regional development by supporting product and process development. Differences in geography and regional structure impact an area's ability to innovate; context shapes or influences place-based innovation outcomes. Place-based innovation policy stimulates learning, creating linkages between industries and new technology sources, such as research universities (McCann and Ortega-Argilés, 2013; Grillitsch and Asheim, 2018). Cooperation between private firms and higher education institutes (HEIs) is critical since academic knowledge may contribute to developing solutions to business problems, including product and process research and development (R&D) (Uyarra *et al.*, 2017).

Many countries have initiated place-based innovation policies by establishing intermediaries, including SPs, to promote exchanges between academic research and business (McCann and Ortega-Argilés, 2013). The reason for establishing a SP depends on each country's policies. SPs in the USA, the UK, and northern Europe were established to encourage industry innovation, and the university tends to lead the process**.** Spain, France, and Italy established SPs to facilitate regional economic development, but universities did not lead these initiatives (Vásquez-Urriago, Barge-Gil and Modrego Rico, 2016). In Thailand, RSPs have the primary purposes of connecting businesses with universities to promote innovation-led growth through R&D activities, supporting the universities in research commercialisation and academic spin-offs, and matching the needs of firms to the resources from universities at no or low cost (The Securities and Exchange Commission, 2013). The case of Miss T is an excellent example.

SP initiatives in developed market economy contexts have been widely studied, and attempts have been made to replicate best practice in other regional and national contexts (Saxenian, 1994; Kenney and von Burg, 1999; Science Park Promotion Agency, 2014),

including in emerging economies. However, emerging economies have different characteristics from developed market economies and are less well developed in terms of R&D, capital markets, and processes of transferring knowledge and resources to commercial outputs. There is a danger that copying a policy initiative results in applying a policy to a place without sufficient consideration of the local context (Radosevic and Myrzakhmet, 2009). Although each national and geographical context have distinct characteristics, SP innovation polices worldwide have been applied a triple helix model in the management approach, and this is explored in the next section.

1.3 The triple helix and regional innovation systems

Innovation is an exceptionally complex process. It occurs everywhere and takes different forms. This thesis's focus is on innovation within firms that are supported by some form of regional innovation ecosystem. For this thesis, the focus is on innovation as a firm-level process linked to product or process modification, development or even invention. These firm-level processes are then positioned within the context of a SP regional innovation system. The academic literature would suggest that the starting point for this analysis would be the triple helix model.

The term ‘triple helix’ was first used in biochemistry representing the three-strand structure of the nucleic acid discovered in 1957 by Felsenfeld and Rich (1957). It was later adapted and developed in social and economic fields and introduced as *a spiral model of innovation* by Etzkowitz and Leydesdorff (1995, 1998, 2000). In the economic field, the triple helix was defined as institutional knowledge-based connections between universities, industry, and government that form a network (Leydesdorff, 2018), highlighting the university's critical role in economic development (Sá, Casais and Silva, 2019). The triple helix approach is based

on a rather narrow definition of an innovation system that requires collaborations between the R&D function of universities, public and private sectors (Asheim and Coenen, 2005), which requires the combination of top-down and bottom-up initiatives (Cai and Lattu, 2021). In the Thailand context, a SP policy was developed and implemented by the national government, and this then represents the imposition of a top-down approach. Nevertheless, an iterative process then occurred with the regional implementation of this national policy. The outcome, in the Thailand context, of the development of a triple helix informed policy must be conceptualised as being simultaneously a top-down and bottom-up process. Government is an essential mechanism in driving regional innovation under the triple helix model by supporting business growth and enhancing the relationship between universities and firms. Once the region can sustain innovation development, the university and government may step back and play the businesses' supporter role (Etzkowitz, 2012). The triple helix model was originated in developed economies, but other countries have also tried to implement it into their national contexts (Williams and Woodson, 2012; Hladchenko and Pinheiro, 2019). In the developing country, the triple helix's implementation still needs to be driven by the government (Etzkowitz and Leydesdorff, 1995; Nakwa and Zawdie, 2016).

The triple helix model assumes that a coordinator is required to facilitate interactions between the three elements of the helix (Champenois and Etzkowitz, 2018). This knowledge transfer process that is central to the triple helix approach can be accommodated by a SP located either within or outside the university (Goddard, Vallance and Puukka, 2011). A SP itself cannot fully develop the knowledge-based community and needs to have cooperation from the university, industry, and government (Etzkowitz and Zhou, 2018). The level of collaboration is different depends on the context of the SP establishment area. Since 1950s, the triple helix has

played an important role in place-based innovation policy based around SP initiatives. However, the triple helix role is still limited to the macro-level (Sá, Casais and Silva, 2019).

The triple helix is the starting point for this analysis, but it is worth emphasising that this is an approach focused on institutions as key actors. There is a firm-level literature on innovation that adopts a very different perspective (Collinson and Gregson, 2003; Tomlinson and Fai, 2013). These includes the IVC approach which highlights learning, creation/formation and commercialisation processes inside firms that may also stretch to include inter-firm relationships with both firms and non-firm actors (Ganotakis and Love, 2012). The IVC approach can be applied at the firm, product, or process level. All firms may be engaged in many different types of innovation. These include innovation related to immediate problems and innovation that is more long-term. Innovation occurs over different durations, and innovation processes have very different geographies.

The IVC approach highlights the complexity of innovation at a firm-level, but there are still problems with this account. A key issue involves linking firm-level with non-firm level processes. This also includes understanding how different actors come together but have different degrees of success or failure. The challenge is to develop a theory that links different scales over which innovation occurs. Thus, what is required is a multi-scalar approach to innovation. Innovation is a multi-scalar process impacting on individuals, firms, regions and national economies. This thesis engages with the national and regional/local scales. This requires the application of a multi-scalar perspective. Innovation and SPs engage with the national level as well as regional or local levels. Nevertheless, the local hides a finer granularity of scale as the local is a complex system. Another set of subscales are required including the micro or project-level, meso or firm-level, and macro or institution-level and these will be explored in this thesis.

The triple helix and IVC approaches provide one way to explore the relationships between place, scale, and innovation. Nevertheless, the triple helix approach is based on exploring institutions while the IVC approach explores a specific innovation process. Innovation is a highly complex process involving formal and informal interactions between stakeholders and institutions with different geographies. Understanding this process requires a conceptual framework that blends the macro, meso and micro settings within and across which innovation processes are enacted. The string-based approach was developed in this thesis as an approach to explore SPs at a project level within firms in the context of developments in the wider regional framework conditions intended to support regional innovation. The research challenge is to explore and explain the linkages between the micro (project-level), meso (firm-level), and macro levels (institution-level) as they relate to regional innovation. It is this challenge that I will now explore.

1.4 String-based approach

This section introduces the development of a novel string-based approach as a framework for understanding interactions between key actors involved in the IVC approach, how actors from different organisations blend in and create relationships, what should the focus be in terms of project delivery including commercialisation, and how actors/individuals/firms work together to deliver outcomes. This string-based approach is developed in this thesis and represents a new conceptual approach for exploring project-based innovation within the context of a SP setting. The triple helix model originated in the natural sciences and was adapted as a framework for exploring economic development and for formulating SP regional policy. There are other theories and conceptual approaches that have developed in other disciplines that can be applied to explore innovation. One of these is string theory that has been developed within

physics. String theory is a problematic physics theory, but the approach can inform conceptual development in other settings including regional economic development.

In physics, string theory is based on the premise that a mass is a combination of smaller particles that are shaped like strings, and they vibrate differently and combine with other strings, and the combination of different types and vibrations of strings creates different types of mass (Hawking, 2016). In this research, we applied the string-based approach to analyse SP innovation projects with a string representing an individual key actor. Strings combine to form project teams that are temporarily connected to perform an R&D project. Each string vibrates according to the string's logic, and this creates different project outcomes. The string's ability to bend in any direction means the actors can shift their attention backward and forward during the IVC process before finally delivering the project outcome or product commercialisation. A SP policy can include bottom-up initiatives that complement the more top-down approach of the triple helix. The strings' qualification in connecting with other actors, inside and outside of a SP, includes the necessity that the innovation project relates to suppliers, the market, and other economic actors. The string-based approach helps to understand what is going on at the micro – project level, in the context of meso - firm level, and macro – institutional level. The critical issue is to link the micro level to the complexity of the macro level in the regional innovation system since different agents are related and the flow of knowledge or interactions between the agents influence changes in the system in some perspectives (Cooke, Gomez Uranga and Etxebarria, 1997).

This is a very brief account of the application of string theory to regional innovation systems that is developed and elaborated in Chapter Seven. Combining the triple helix approach with the IVC literature led to the search for an additional conceptual framework to supplement

existing approaches to understanding place, innovation, and firms. This then informed the aims and objectives of this thesis.

1.5 Aims, objectives and research question

The study of SP policy implementation has focused on developed market economies and there is a much more limited literature on place-based innovation policies and SPs in emerging economies (Radosevic and Myrzakhmet, 2009). The over emphasis on developed market economies may hide innovation processes that may be revealed in other geographical contexts. This may be related to the intensity of innovation in developed market economies that may make it much harder to identify some of the complexities of innovation processes compared to emerging economies. It may be that innovation is different in emerging economy settings. Moreover, the triple helix model has dominated SP policy development. It is a macro level framework that does not focus on practitioner performance at the project level, and it is the performance of projects that is critical for enhancing firm innovativeness. In this account, further research is required to understand the adoption of SP policies in a broader context of emerging economies, and the existing theory used to analyse SP should be examined. A new conceptual framework should be developed to supplement the triple helix approach. This thesis engages with these gaps by exploring the implementation of SPs policy in Thailand aiming to understand the relationships between SP innovation projects and the triple helix institutional framework in emerging economies and to develop a project-based approach of innovation processes in the context of the triple helix. Much of the research on SPs has been framed with reference to the triple helix approach. It is important to appreciate that firms located on a SP, or linked in some way to a SP, are involved in defined projects intended to enhance their innovation in some manner.

Given this, the primary research question explored in this thesis is as follows: *How are innovation projects within firms linked to a SP organised, and how are differential outcomes explained in terms of more successful projects compared to those projects that fail to meet the objectives set by the firm and/or the SP?* This research question then leads to four objectives:

1. *Explore the adoption and implementation of a SP policy in an emerging economy.*
2. *Identify and explore the roles key institutional actors play in the triple helix and define the relationships that support commercialisation processes within innovation projects and the impacts on firm innovativeness in an emerging economy context.*
3. *Develop an inter- and intra-firm project-level understanding of the impacts of the implementation of a SP policy in an emerging economy setting including exploring critical inputs from SPs, academics, and entrepreneurs that underpin an innovation project's outcome.*
4. *Develop a critical evaluation and appraisal of exiting theory applied to understanding SPs at the firm/project level. This includes applying existing theory but also developing new approaches to theorising SPs*

The thesis will contribute to understanding the implementation of SP policy in emerging economy settings and develops a new theoretical framework that can be applied and tested in other contexts. For this thesis, the context was Thailand, and this is explored in the next section.

1.6 Why Thailand?

Much of the research on SPs has focused on developed market economies and SPs in emerging economies have been under-researched. The primary object of study of this thesis is on exploring the dynamics of innovation projects undertaken by firms located on or linked to a SP. The SP is located in Thailand and this location adds an additional place-based or regional

dimension to this research. This regional dimension includes Thailand's economic structure and the regional economy within which the SP is embedded. Nevertheless, it is important to remember that the focus is not on understanding regional innovation systems but on the characteristics and dynamics of intra-firm innovation projects and the ways these relate to inter-firm relationships in the context of a SP setting. Given this it is important to outline some aspects of the national and regional setting.

An emerging economy is a developing country that is in the process transitioning from a low income, agricultural-based economy towards an industrial economy with a higher standard of living (Silver *et al.*, 2020). This requires rapid changes that produce uncertainty and this is complicated by natural disasters, external price shocks, or domestic policy instability (Mody, 2004; Amadeo, 2020). The major weaknesses of emerging economies are not centered on skill shortages, basic research, information infrastructure and risk capital, but problems with related and supporting industries (Radosevic and Myrzakhmet, 2009). The high degree of business informality in emerging economies is often the result of strict regulations and a tax system which creates administrative and financial burdens on entrepreneurs and foreign investors. The businesses have no access to formal credit and legal protection. Policies to reduce the burdens and stimulate learning by businesses are required, but many emerging countries need to obtain the necessary knowledge and experience to inform the development of local policy (Thurik, 2008).

Since the early 2000s, emerging economies became the destination for foreign multinational enterprises' R&D investment due to market attractiveness and lower costs (D'Agostino and Santangelo, 2012). The development of technology and innovation can upgrade the future regional economy (Schiller, 2006). Many emerging economy governments have altered their development policies and R&D systems to support innovation and promote

a knowledge-based economy in which economic growth is based on the creation, distribution and use of technology (Kim, 2008). Emerging economies have increased their engagement in innovative activities involving global innovation network with a lower degree of complexity and geographical concentration. Some emerging economies have become new sources of knowledge rather than being targeted for market expansion and production (D'Agostino and Santangelo, 2012; Jha, Dhanaraj and Krishnan, 2018; Zhao *et al.*, 2020). Based on the classification of UNCTAD (2020) and UNESCO (2019), there are 38 economic territories that are defined as emerging economies (**Table 1.1**) and 55% of these (21 territories) have introduced SP policies (**Table 1.2 and 1.3**).

Table 1.1 Emerging markets classified by income status

Economic status	**Africa**	**America**	**Asia**	**Europe and Kazakhstan**
High-income countries (GNI per capita of USD 12,536 or more)	-	Chile Uruguay	Bahrain China, Hong Kong SAR China, Taiwan Province of Korea, Republic of Kuwait Oman Qatar Saudi Arabia Singapore United Arab Emirates	Croatia Czechia Hungary Poland
Upper middle-income countries (GNI per capita between USD 4,046 and USD 12,535)	South Africa	Argentina Brazil Colombia Ecuador Mexico Peru Venezuela	China Malaysia **Thailand** Turkey	Kazakhstan Romania Russian Federation Serbia
Lower middle-income countries (GNI per capita between USD 1,036 and USD 4,045)	Egypt Nigeria	-	Philippines Indonesia India	Ukraine

Source: UNCTAD (2020); OECD (2021)

Table 1.2 Emerging economies which implemented SP policy (2019)

Economic status	Africa	America	Asia	Europe
High-income countries (GNI per capita of USD 12,536 or more)	-	-	Bahrain China, Hong Kong SAR China, Taiwan Province of Korea, Republic of Kuwait Oman Qatar Saudi Arabia Singapore United Arab Emirates	Czechia Poland
Upper middle-income countries (GNI per capita between USD 4,046 and USD 12,535)	South Africa	Brazil Ecuador	China Malaysia **Thailand**	Russian Federation
Lower middle-income countries (GNI per capita between USD 1,036 and USD 4,045)	-	-	Philippines India	-

Source: UNESCO (2019); UNCTAD (2020); OECD (2021)

Table 1.3 Economic structure of emerging economies which have implemented a SP policy (2018)

Country	GDP (USD)	GNI per capita (USD)	Employment rate (%)	Employment by sector (%)			Export (% of GDP)
				Service	Agriculture	Industry	
South Africa	404.84 billion	6,340	73.09	71.71	5.16	23.13	27.49
Brazil	1.92 trillion	9,170	87.67	70.61	9.26	20.13	14.64
Ecuador	107.56 billion	6,090	96.47	52.65	28.83	18.53	22.61
China	13.90 trillion	9,540	95.70	45.61	26.07	28.32	19.11
Malaysia	358.80 billion	10,650	96.70	62.26	10.63	27.11	68.56
Thailand	506.61 billion	6,610	99.23	45.06	32.14	22.81	64.86
Russia Federation	1.66 trillion	10,250	95.15	67.31	5.88	26.81	30.79

Source: World Bank (2022)

It is important to place Thailand in the context of other emerging economies. **Table 1.3** identifies seven emerging economies in the Upper Middle-Income category in which the GNI per capita was between USD 4,046 and USD 12,535. There are some differences between these countries in their economic structure. The GDP of China was at the highest position while Malaysia was at the top on GNI per capita compared to other middle-income countries. The

employment rate for all was close to 100% except for Brazil and South Africa and the majority of the workforce in all seven countries were employed in service industries. Most of the countries were not than reliant on earnings from the export of goods and services, but the expectations here are Thailand and Malaysia. This analysis highlights that Thailand has many similarities to other middle-income countries but is more reliant on exports and this is one of the justifications for focusing on project performance within firms located in SPs in Thailand.

1.6.1 Thailand's context

Thailand is a country location in the Southeast Asia peninsular with an area of 513,120 square kilometres and a population of approximately 69 million (2019). Thailand has borders with Myanmar, Laos, Vietnam, Cambodia, and Malaysia. There are 77 provinces in Thailand divided in to five regions; Bangkok is the administrative centre of state and the country's largest city. Being the central city and political capital, Bangkok is the most populated city with approximately 14 million people living in the Bangkok metropolitan area. Thailand's political has been unstable. Despite the establishment of a constitutional monarchy and parliamentary democracy in 1932, the military still plays a significant role in Thai politics. The last coup d'état was in 2014.

Thailand has the second-largest economy in Southeast Asia after Indonesia. The country's economy is heavily relied on international trade which the export of goods and services accounting for over two-thirds of GDP. In 2019, Thailand's exports accounted for 64.86% of its GDP (World Bank, 2022) and these exports include automobiles and parts, electronics, agricultural commodities, and processed foods. The industrial sector accounted for the largest share, and with the most important sectors being automotive and electronics.

Thailand's main trading partners are the USA, China, and Japan (Ministry of Commerce, 2019).

Table 1.4 Thailand - Core characteristics

Capital city	Bangkok
Governance system	A constitutional monarchy based on parliamentary democracy
Population	69,625,581
GNI per capita (USD)	7,260
GDP (billion USD)	544.264
GDP by sector	Agricultural sector: 8% Industrial sector: 33.4% Services sector: 58.6%
Employment structure	Thailand has 39 million people in active labour force in which - 32.14% are in agricultural sector - 22.81% are in industrial sector - 45.06% are in services sector
Main Industries	Automobiles and automotive parts (11%), financial services (9%), electric appliances and components (8%), tourism (6%), cement, auto manufacturing, heavy and light industries, appliances, computers and parts, furniture, plastics, textiles and garments, agricultural processing, beverages, tobacco

Source: Keyes, Keyes and Hafner (2021); Santander (2021); World Bank (2022)

Table 1.4 shows that, in 2018, Thailand had a labour force of approximately 39 million mainly employed in the service sector (45.06%). The industrial and service sectors accounted for over 90% of GDP. Whilst the agricultural sector produced less than 10% of GDP, it employed about one-third of the workforce mostly in smaller farms (CIA, 2022). Since January 2013, the official minimum wage in Thailand was 300 THB per day, or roughly 10 USD. The unemployment rate was 0.77% in 2019, but more than half of the workers tend to be in unstable or informal occupations. Moreover, about 40% of the workforce were underemployed. From 1999 to 2007, Thailand's GDP growth rate was between 2.1% and 7.1% per year. The instability caused by major protests in 2010 resulted in Thailand's GDP growth dropping to 4–5% per

year. Political uncertainty is the primary cause of the deterioration in investor and consumer confidence.

In 2020, with COVID-19, Thailand's economy contracted by 6.1% compared to the previous year and a similar level of contraction occurred during the Tom Yam Kung Crisis (Bank of Thailand, 2021). Government measures to control the pandemic resulted in a reduction in economic activities in many sectors, especially the tourism sector which was severely affected by a dramatic reduction in the number of foreign tourists.

1.6.2 Thailand's northern region

This thesis analysed the implementation of SP policy in Thailand. The study focussed on exploring one regional SP, the Northern Science Park or NSP. In this regard, it is necessary to understand the regional context in which this SP was located.

Thailand's northern region contains 96,077 square kilometres or one-third of the country. This area connects to the Mekong sub-region economies and South Asian countries. Northern Thailand shares borders with Lao PDR and Myanmar. There are 17 provinces in which Chiang Mai is the largest and the most populated city, accounting for about 20% of the region's GPP (Gross Provincial Product). In 2019, the GRP (Gross Regional Product) per capita of the northern region was about 3,000 USD. This is only half of the country's GDP per capita. The top three provinces with the highest income per capita were Lampoon, Kampangpeth, and Chiang Mai; these provinces are the region's main industrial areas. Northern Thailand has a labour force of 6.9 million people and this accounts for 18% of the country's workforce. Employment in the agricultural, industrial, and service sectors accounted for 45%, 31%, and 24% of the northern workforce respectively.

The northern region provides the smallest economic contribution nationally accounting for only 7.7% of the country's GDP (Office of the National Economic and Social Development Council, 2019). The regional economic structure is dominated by the service and agricultural sectors. In 2019, the service sector accounted for 60.1% of GRP, mostly from wholesale, retail, education, and government services. The agricultural sector plays an important role in the northern economy as this represents the most important income base accounting for 25.6% of GRP and is also the largest employment sector. The main products included rice, livestock, cattle maize, longan, and sugarcane. In 2019, the industrial sector contributed the least to this region's GRP (14.4%). The main manufactured products were food, electronics, beverage, non-metallic minerals, and textile and garment. Most of the manufacturing firms still rely on local natural resources including agricultural raw materials, kaolin ore, and processed timber, as well as relying mainly on skilled labour. There are industrial estates in Pichit and Lampoon that were predominantly occupied by Japanese electronics manufacturers. There are small and medium-sized factories for processed food and light industries located at Chiang Mai, Lampoon, and Lampang.

In the northern region, more recently, creative industries involved in producing software and digital content emerged with the introduction of the 10th National Development Plan. Between 2012-2015, the software industry and the number of digital content entrepreneurs grew by 29.8% per year, especially in Chiang Mai (Office of the National Economic and Social Development Council, 2019). This part of the region is involved with developing start-up businesses supported by the Digital Economy Promotion Agency working with Chiang Mai University.

Thailand is an emerging country (UNCTAD, 2020) that includes the United Nations Sustainable Development Goals (SDGs) in its development policy. It is currently being held in the country with economic growth of efficient production (efficiency-driven). This may not be enough to push the economy to grow steadily in the long term. The possible solution is to accelerate economic growth through innovation (innovation-driven), focusing on science and technology R&D as a main driving force to restructure the economy towards sustainable growth and quality of life (The Securities and Exchange Commission, 2013). Being an emerging market, the obstruction of the firms' R&D is a lack of resources (fund and personnel) and awareness of the necessity in doing R&D (Nakwa and Zawdie, 2016). It is unlikely that entrepreneurs will enhance their competitive capabilities on a timely basis. The government needs to seriously and continuously support them in policy, creating a research environment, develop and innovate high-quality human resources, research infrastructure, law and regulations, measures and incentives for financial and fiscal matters for a favourable condition to invest and conduct R&D activities.

The government realised the importance of economic development and the need to support entrepreneurs. Various innovation policies have been launched, such as the Ministry of Industry's clusters policy, the university business incubator program (UBI) by the Ministry of Education, and SP policy by the Ministry of Science and Technology. The industries, which the Thai government prioritised on the development, including activities that use advanced technology and industry of the future development, aim to develop clusters for other potential sectors such as processed agricultural products and textile clusters (Thailand Board of Investment, 2015). Thailand has implemented the place-based innovation policy with SP initiative in line with industrial development plans focusing on enhancing the existing industries' capacity, supporting innovation businesses, and encouraging industrial

agglomeration. The first SP in Thailand was established in 2002 without the cooperation of a HEI. In 2013, three RSPs were developed to increase the SMEs innovativeness, create jobs, and increase regional economic growth. The implementation of the SP policy in Thailand is still at the initial stage. The RSPs were established in the less developed area of the country with low complexity of the innovation system. It is appropriate to consider Thailand as an object to study how the SP policy has been implemented in emerging economies. Additionally, considering the researcher's understanding of Thai culture and language as a native, the problem of data misinterpretation will be eliminated.

1.7 Structure of the thesis

This thesis explores the implementation of place-based innovation policy in the context of the introduction of a SP initiative in Thailand. The focus is on one regional SP, the Northern Science Park (NSP) and its innovation projects and the approach adopted is to explore characteristics and configuration of innovation projects within firms connected to the NSP. The analysis unfolds over eight chapters in the study, and these are as follows.

Chapter Two reviews previous literature on the establishment of SPs and regional economic development. The literature on SP development in developed and emerging economies will be reviewed, as well as the literature on innovation policy, the triple helix model, firm innovativeness, the roles played by universities in developing knowledge-based communities, and regional economic development. The analysis of Chapter Two lays the formations to develop the conceptual framework which underpins this research.

Chapter Three is the methodological chapter that outlines the research design and related methods. The tools and method used in data collection are explored in this chapter. The problems encountered during the data collection and the strategies to overcome those

difficulties are highlighted. A mix of qualitative and quantitative tools were used to analyse the data gathered from the interviews with participants engaged with Thailand SP policy implementation. The discussion of data analysis also includes an account of the translation process as the interviews were undertaken in Thai rather than English. The chapter also considered the author's influence as a Thai female researcher who has worked for SPA, Ministry of Science and Technology responsible for the RSP policy implementation in Thailand.

Chapter Four examines and reviews Thailand's economy and related development policies. This chapter focuses on exploring the development of policies related to the regional and national economy, including industrial cluster and the ST&I policies. This chapter reviews how Thailand implemented its place-based innovation policy with SP initiatives in all four regions: central, northern, northeastern, and southern Thailand. The objectives of establishing each SP are explored, including the target industries as flagship projects of each RSP. The outcome of each RSP's operation in developing the entrepreneur ecosystem and Thailand's regional economy is presented.

Chapter Five identifies the key actors' roles and functions in Thailand's SP policy implementation based on the triple helix model, including the government's role in managing SPs, HEIs and their personnel, and private businesses. The triple helix allows SP components to be explored as institutions, but not at an individual level. This chapter explores each key actor's fundamental roles and expectations, including SP directors and academics, who contributed to the establishment of SPs in Thailand. The relationships created between the entrepreneurs and the academics are explored and identified, as well as the expectations of private businesses and the actual improvement gained from participating in RSP projects. The influence of Thailand SPs on regional economic development is explored in this chapter.

Chapter Six explores the relationships which form between the institutions involved within the Northern Science Park (NSP), the subject of study, further down to the project level by applying the IVC approach as a complementary framework to support the application of the triple helix approach. Innovation projects are divided into three stages: acquiring knowledge, building innovation, and commercialisation stage. The performance of each helix will be identified at all three stages. Although the firm is the main actor driving the R&D project toward commercialisation, the inputs from academics and SPs contribute to the project and are deemed critical in delivering project success. This chapter evaluates the combination of inputs from the SP, academics, and the entrepreneur alongside the IVC process that led to product commercialisation and firm-level innovativeness. Furthermore, this chapter also points out that innovation occurs in a non-linear pattern, leading us to Chapter Seven.

Chapter Seven introduces the line metaphor based on the principle of string theory in physics, defining SP's key actors as a string that are involved in a braiding process as a firm or an organisation couples or interacts with other strings to engage in innovation-related activities. Moreover, a string can bend in any direction, going back and forth between the three innovation stages identified by the IVC approach, supporting the proposed theory that innovation is a non-linear process. This chapter also considers that the actors/strings perform differently in a specific situation based on their institutional logics and different inputs from other actors. The strings' vibrations can create constructive or destructive interferences that act as a supportive or non-supportive relationship between actors that can enhance or compromise project success. One consequence of this approach is that SP regional innovation policy in an emerging economy setting requires the application of a bottom-up (project/firm level) approach that is combined with the triple helix approach and the implementation of a top-down policy to establish regional SPs.

Chapter Eight summarizes the key concepts from all chapters and the contributions to our understanding of SP establishment and the attempt to implement the place-based innovation policy with SP initiative in an emerging economy and its impact on firm's innovativeness with a focus on projects within firms located or linked to a SP. This identifies critical contributions that this thesis makes to the field of knowledge and the policy setting. The limitation of this research and suggestion for further study is also presented.

CHAPTER 2

SCIENCE PARK AND REGIONAL INNOVATION: FROM TRIPLE HELIX TO INNOVATION VALUE CHAIN

2.1 Introduction

There is a concern with encouraging innovation but combined with a focus on national and regional economic growth. In many countries, Science Park (SP) has been considered to be an important component of localised innovation ecosystems (Ratinho and Henriques, 2010). SPs were established to support small and medium-sized enterprises (SMEs) and startup firms with a focus on enhancing and encouraging innovation. Well known SPs such as Silicon Valley, also known as Stanford Research Park, in the USA, the Cambridge Science Park in the UK, and the Research Triangle Park of North Carolina State in the USA have been widely studied and attempts have been made to replicate their best practice in other regional and national contexts (Saxenian, 1994; Kenney and von Burg, 1999). For example, the success of the Silicon Valley has been replicated internationally not only by establishing SPs, but also replicating management programs to support new entrepreneurs, and to enhance the links between firms and the universities (Saxenian, 1994). SPs have played an important role in the knowledge ecosystems of developed economies. Moreover, as a role to support the businesses, SPs ensure that companies can access the pool of high-technology equipment and researchers who have expertise in related fields and also provide knowledge that is transferred to entrepreneurs and promotes local economic activities.

Thailand has been trying to establish SPs using the model of developed economies. However, as an emerging country that the economy is relied on agricultural-based industries and has different context than developed countries, the understanding of the country context at a regional and national level as well as taking global supply chains into consideration is crucial.

In establishing a successful SP policy, it is important to explore the operation of established SPs. This required an evaluation of the academic and policy literatures to identify what works and what is less effective in terms of establishing a SP innovation ecosystem.

The aims of this study are to understand the relationships between SP innovation projects at a firm level in the context of triple helix model in emerging economies and to develop a project-based approach to analyse the triple helix innovation process. This literature review reflects critical previous understanding of the topics related to the aims by exploring the emergence of SP policy focusing on the identification and analysis of the key components including the development of SP policy and its implementation in developed countries (Massey, 1992; Löfsten and Lindelöf, 2002; Etzkowitz and Zhou, 2018) and emerging economies (Jie, Ning and Fengdan, 2008; Kim, 2008; Radosevic and Myrzakhmet, 2009), the roles of higher education institutions (HEIs) in regional development (Anselin, Varga and Acs, 1997; Perry, Wiewel and Menendez, 2009; Goddard *et al.*, 2014), and the development of firms innovativeness (Milgrom and Roberts, 1988; Westhead and Storey, 1994). The literature review includes the debate on regional economic development (Hassink, 2005; Frenken and Boschma, 2007; Boschma and Martin, 2010; Martin, 2012), regional innovation system (Asheim and Coenen, 2005; Lundvall, 2007; Bramwell, Hepburn and Wolfe, 2019) and the approaches for innovation analysis including the triple helix model (Leydesdorff, 2000; Etzkowitz, 2008; Cai and Etzkowitz, 2020) and innovation value chain (IVC) (Pietrobelli and Rabellotti, 2011; Ganotakis and Love, 2012; Tomlinson and Fai, 2013).

The chapter is divided in to six sections. Section Two explores the development of literature on regional development and innovation. The approaches using in analyse the innovation system, namely the triple helix and IVC, are explored. Section Three explores the development of SP including its roles in regional development and SPs in emerging economies

to identify weaknesses in policy development and implementation that might explain some of the difficulties experienced. Section Four focuses on HEIs in relation to the industries and its contribution in SP establishment. Then, Section Five explores the behaviour of firms involved with SPs focusing on a discussion of their relationships and contribution to regional economic development. This chapter ends with Section Six concluding the development of SP literature and informing the gaps of previous literature and how this research will be conducted to fulfil them.

2.2 Regional development and innovation

The regional development debate

The literature on regional development has always expresses attention toward the development of firms and their innovativeness. According to Frenken and Boschma (2007), evolutionary economic geography informs the process of changes of firms, industries, cities, and network in entering, growing, and exiting or relocation. In this account, the region provides essential source of competitive advantage to the firm (Isaksen and Karlsen, 2012) and the strength and weaknesses of the region should be considered by the involvement of local authority in setting up the development policy (Saxenian, 1994). The policy is an important guide for creating regional innovation, but the businesses still need to keep improving their strengths and capability (Cooke, Gomez Uranga and Etxebarria, 1997). Florida and Kenney (1990) pointed that small firms are capable for innovation better than the big firms because of its flexibility to the change. However, Doloreux (2002) suggested that, no matter the firms' sizes, their success that lead to economic growth, was influenced by local behaviour, demand, strategies of supporting businesses, and the firms' strategies. Furthermore, the development of the firm resulting in driving the whole value chain to upgrade (Pietrobelli and Rabellotti, 2011).

As such, the firm's innovativeness and development of the region are co-supportive and seem to be inseparable.

From the late 1990s, the regional innovation development literature focused on network creation and the development of regional cluster. Cluster is "a concentration of 'inter-dependent' firms within the same or adjacent industrial sectors in a small geographic area" (Asheim and Coenen, 2005, p. 1174). Their cooperation is based on reciprocal relationships creating a highly integrated vertical and horizontal set of complementarily linkages[1]. To Keeble (1999a), a cluster provides the entrepreneurs opportunities to improve their specialization as close distance of each firm allows the interaction and knowledge transfer within the industry and that specializations increase competitiveness of the region. Different forms of relationship within a cluster create different levels of development (Hess, 2004). Knowledge exchange among the members of a cluster (Bathelt, Malmberg and Maskell, 2004), and with other clusters (Cooke, Gomez Uranga and Etxebarria, 1997) are vital in regional development (Doloreux, 2002; Hess, 2004). For example, the region can keep its innovativeness by benefit from the movement of skilled labour who carry tacit knowledge and distribute it to the others from place to place (Keeble, 1999b). Additionally, the blending of local and external knowledge stimulates the regional innovativeness, however, only if these is knowledge sharing within the cluster/region (Hess, 2004; Asheim and Coenen, 2005; Pietrobelli and Rabellotti, 2011; Etzkowitz, 2012).

One example of the success industrial cluster is Silicon Valley. According to Saxenian (1996), during 1975-1990, Silicon Valley generated approximately 150,000 jobs. In 1990, Silicon Valley firms exported over USD 11 billion worth of electronic products. It almost for 35% of total US exports. Nonetheless, 39 on-site firms in Silicon Valley were on the nation's

[1] The vertical linkage is an association of entrepreneurs from upstream to downstream. The horizontal linkage is linked to the support of various industries, including business services, trade associations, educational and training institutions, R&D as well as government agencies concerned.

list of the 100 fastest growing electronic corporations (Saxenian, 1994, 1996). The success of Silicon Valley came from the development of a flexible and decentralized management structure that allows fast decision-making, capabilities to adapt to technology change, specialization in core competences, and outsourcing for other things. However, not all clusters were successful. To Saxenian (1996), Route 128 has been in decline since 1980. The region relied too much on military expenditure. Once the military budget was cut, new markets should have been explored. The firms in Route 128 had a less flexible structure. The knowledge and technique were mostly shared within the companies. Most of the firms competed rather than exchanging knowledge and there was an inability to adapt to change and new technology. Route 128 firms could not grow back and flourish as the Silicon Valley firms did.

From 2000s, the literature in this field started to explore the learning modes of firms and the transferring of knowledge from external sources, such as HEIs, to the firms in the cluster. To Hansen and Birkinshaw (2007), creating external relationship can help generate idea to develop products. Knowledge is available worldwide, but some firms still prefer keeping a close distance with the knowledge sources (Isaksen and Karlsen, 2010, 2012) since a close proximity between firm and university supports a two-ways communication that deems critical in creating supportive relationship between the entrepreneurs and the researchers (Albahari, Klofsten and Rubio-Romero, 2019). For example, the functional food cluster settled near the university of Lund. Knowledge spillover from HEIs became critical in firm's development (Breschi and Lissoni, 2001; Asheim and Coenen, 2005). The university became the key mechanism in regional development with the roles include providing services according to business's needs such as incubation and SP and adapt the regional needs to its research and teaching activities (Schiller, 2006; Isaksen and Karlsen, 2010).

On the one hand, the government may obstruct the regional innovation. To Hassink (2005), some restructuring of the old industrial areas using a 'learning region' policy had failed. The local authority may discourage the firms to be innovative by trying to preserve their performance as it's already 'good enough' for the region. The development failed due to political lock-in and unwillingness to unlearn and other forms of path dependency. These clusters will later experience the declining of demand from market saturation (Asheim and Coenen, 2005; Frenken and Boschma, 2007). In contrast, the government can be an important mechanism in driving regional innovation by supporting the growth of business and enhancing connection between university and firm (Etzkowitz, 2012; Smith, Bagchi-Sen and Edmunds, 2016).

The regional development literature from 2010s still concentrated on clustering, specifically on the agglomeration activities in relation to the local area development. The economic geography tends to be shaped to serve the activities of industries located in the area at its best (Dovey, Rao and Pafka, 2018). The agglomeration occurs because the individual seeking support from the others locally (Scott and Storper, 2015), or by the emergence of the spin-off firms that offer similar or related products to their parents firms (Mayer, 2013). The agglomeration forms can be varied depends on the relationship of each element such as alliance between businesses or the new comers entering a cluster (Anderson and McFarlane, 2011). Beside binding the businesses together, the agglomeration benefits all members in term of sharing of infrastructure and knowledge, matching between businesses, job seekers, facilitating businesses, and benefit to social aspects such as cultural and political dimension (Storper and Scott, 2016; Dovey, Rao and Pafka, 2018). It also attracts similar or supporting businesses into the area. The agglomeration is a combination of different thought or activities which performed by variety of agents in the group. The idea of development is how to create relationships those

will benefit all stakeholders at best. Moreover, to keep stimulating regional economic growth, it is necessary to have an interaction between at least two regions for trading and sharing of knowledge that will further encourage an innovation (Scott and Storper, 2015).

The academics also paid attention toward the linkage creation between industry and HEIs. The creation of university-industry linkage is not a new thing as it has been internationally promoted since 1980 (Schiller, 2006). According to Etzkowitz (2012), the university, over than teaching and research duties, has to help transferring the knowledge to create the regional innovation or creating new innovation base on its expertise and network. However, there was no fixed formula on how the university can enhance regional innovativeness, but the university-industry linkage tends to depend on an individual case (Isaksen and Karlsen, 2010).

What is innovation in regional development?

Ganotakis and Love (2012, p. 839) said that "innovation is central to the survival and growth of firms, and ultimately to the health of the economies of which they are part". Innovation was acknowledged by governments, universities, and businesses over the past 20-30 years as a key tool to improve local economic activity (Westhead and Storey, 1994). To develop the regional innovation system, it needs to develop the firms' innovativeness and competence (Lundvall, 2007). Innovation usually occur inside the firm or in a cluster (Frenken and Boschma, 2007). To Asheim (2007); Mele and Russo-Spena (2017), innovation is not a linear process but the ongoing chain of interactions between actors that add value to the process underpinned by an institutional framework.

In regional innovation system, HEIs are the key mechanism for upgrading technology and connecting with each stakeholder (Schiller, 2006; Theeranattapong, Pickernell and Simms,

2021). Even a firm has its R&D department, it still needs support on academic knowledge to advance the product development. Thus, the relationship between university and firms is critical in improving innovation process (Asheim and Coenen, 2005). Furthermore, new scientific discoveries from the HEIs may create variation of industrial paths allowing the region to avoid lock-in and these new paths can be related to the existing industries or completely new to the region (Grillitsch and Asheim, 2018). The successful innovation policy setting should encourage the cooperation between government, university, and businesses (Etzkowitz, 2012), increase capacities of actors to enhance research commercialisation (Grillitsch and Asheim, 2018), and create suitable environment for technology-based companies by concerning the use of local resources and to attract the new firms to the area (Etzkowitz and Zhou, 2018).

Place-based innovation policy with SP initiative was developed to use SP as an intermediary connecting HEIs to industries in developing regional clusters (Asheim and Coenen, 2005; Goddard, Vallance and Puukka, 2011). To Goddard, Vallance and Puukka (2011); Etzkowitz (2012), HEIs and government, under the SP program, support knowledge transferring to the existing clusters and creating new clusters from a knowledge base, and this transformed the cluster structure from the single helix model of industry to a triple helix model of university-industry-government cooperation.

Triple helix –the spiral model of innovation

To Leydesdorff (2018, p. 5), "the TH [triple helix] was first defined in terms of links among universities, industries, and government(s) as institutional relations. However, an essential element of the triple helix thesis is that the relations among institutions have become knowledge-based and have therefore grown into a network". A concept of the ‘triple helix’ was developed as a metaphor for scientific discovery of the three-strand DNA structure to analyse

innovation system in the knowledge-based economy (Etzkowitz and Leydesdorff, 1995, 1998; Leydesdorff and Etzkowitz, 1998; Etzkowitz and Leydesdorff, 2000) by realizing the important of government support on innovation development in addition to the double helix of university-industry relationship (Etzkowitz and Zhou, 2006).

At the initial stage of concept development and it application to regional innovation, the discussion was focusing on the expected roles of HEIs and government, how to have effective communication between them, and the necessity of patent system (Leydesdorff and Etzkowitz, 1996; Etzkowitz and Leydesdorff, 1997). Three models of triple helix emerged during the second triple helix international conference in 1998 (Leydesdorff and Etzkowitz, 1998). According to Dzisah and Etzkowitz (2008); Etzkowitz (2008); Ranga and Etzkowitz (2013), the different models of the triple helix reflexed the country's management policy. The *Statist model* represents an innovation system ruled by the government as the main actor in creating the linkage between the university and industry and setting up policy. In the *Laisez-faire model*, the industry is the primary force in economic system. Government intervenes only as a supporter. Three institutes work separately, and the communication occurs mainly through the appointed third party. The third, *Balanced model*, arose from developing in the roles and interaction of the three helixes. Three institutional spheres overlapping each other informing each institute may also perform the role of the others (Leydesdorff and Etzkowitz, 1998; Etzkowitz and Zhou, 2006). For example, the university taking tasks in creating entrepreneur, or firms to develop training for high-skilled labour. The reorganizing also extended to other agencies engaging in university research, such as fund givers, to pursue future research toward industrial development (Benner and Sandström, 2000). Moreover, triple helix was considered as a catalyze in transitioning the knowledge production from Mode 1 (disciplinary knowledge)

to Mode 2 (knowledge for application) (Leydesdorff and Etzkowitz, 1998; Shinn, 2002; Park, Hong and Leydesdorff, 2005).

The discussion of adding the fourth helix started in 2006. However, due to the complex nature of the relationship which needed to be considered, Etzkowitz and Zhou (2006) instead proposed applying the triple helix concept to sustainability innovation development considering public attention accompanying the development under the university-industry-government model. However, there has been no further development on the proposed idea. Recently, academics reconsidered the implications of applying the triple helix approach toward sustainable development (Anttonen *et al.*, 2018; Scalia *et al.*, 2018) and the possibility of adding the fourth and the fifth helix (Cai and Etzkowitz, 2020) including funding organisation (Galvao *et al.*, 2019) and cultural-based context and natural environment (Sá, Casais and Silva, 2019; Bodolica and Spraggon, 2021), and to develop the future site of a mediator organisation, such as a SP, to better answer the addition of the fourth helix (Almaamory and Slik, 2021).

The triple helix literature also explored in broader context of innovation system including at national level (Leydesdorff and Zawdie, 2010; Ranga and Etzkowitz, 2013) and global level (Lawton Smith and Leydesdorff, 2014) in which the challenging of politic, global trend, and economy were taken into account. Some academics equate the triple helix with the concept of an innovation system (Cai and Etzkowitz, 2020) emphasising innovation as a top-down approach. Thus, "a narrow definition of the innovation system primarily incorporates the R&D functions of universities, public and private research institutes and corporations, reflecting a top-down model of innovation as exemplified by the triple helix approach" (Asheim and Coenen, 2005, p. 1179). This type of statement reflects the first triple helix model, *the Statis model*, in which government has control over research institutes and private businesses with a focus on developing innovations (Etzkowitz, 2003). However, the triple helix approach evolved

and developed into what is termed *the Balanced model* in which the three spheres overlap with other societal processes and contribute towards creating a knowledge-based society, and this "requires the loosening of top-down control and the creation of a civil society, thus opening the way to bottom-up innovations" (Hladchenko and Pinheiro, 2019, p. 5). In this revised account then it is assumed that:

> Triple Helix systems acknowledge the importance of individual innovators (scientists, business people, policy makers, students, entrepreneurs, venture capitalists, business angels, and so on) and their role in initiating and consolidating institutional processes... They coordinate a mix of top-down and bottom-up processes and innovation stakeholders from different organizational backgrounds and perspectives, who come together to build a platform for new ideas, promote economic and social development and ensure agreement and support for their realization (Ranga and Etzkowitz, 2013, p. 242).

This also includes "the coordination for developing the Triple Helix interactions, the core is to enable functional mechanisms mediating between top-down and bottom-up initiatives" (Cai and Etzkowitz, 2020, p. 16). The implication is that the formulation and implementation of a triple helix framework, in a regional context, requires a pre-structured approach that needs to bring together top-down and bottom-up initiatives (Etzkowitz, 2003; Ranga and Etzkowitz, 2013; Cai and Etzkowitz, 2020; Cai and Lattu, 2021) and this includes encounters with society and individuals beyond the three elements of the helix to initiate the formulation of a bottom-up approach (Hladchenko and Pinheiro, 2019).

However, some accounts of innovation systems assume that the role of the triple helix is limited to the macro level and tends to neglect the input of actors at the micro level and yet micro-level processes are critical for value creation (Bunders, Broerse and Zweekhorst, 1999; McAdam and Debackere, 2018; Sá, Casais and Silva, 2019). In a study of Portugal's less-favoured regions, Sá, Casais and Silva (2019) identified that the application of the triple helix approach to creating a knowledge-based region was based on a top-down policy that ignored multiple local actors. In this case, the development of a triple helix policy-informed approach

did not move beyond top-down control and this was also the case according to research on Bangladesh (Bunders, Broerse and Zweekhorst, 1999). It appears that the implementation of the triple helix model in some national contexts, specifically in less developed countries, appears to be orientated towards a more top-down approach constructed around the activities of policymakers from government, or the executive level, without sufficient consideration of the micro/individual level.

Research on the triple helix must be positioned within an appreciation of time and context. Different contexts and times will reflect different approaches to configuring a triple helix informed regional innovation policy. In Thailand, SPs were set up in response to the formulation of a national government policy and this was very much a top-down initiative. However, during the implementation process, this top-down approach was adjusted to match the regional context. This means that in Thailand the implementation of a triple helix policy must be conceptualized as being simultaneously a top-down and bottom-up process.

Nonetheless, the research on triple helix rarely explored the operation of the helixes at the overlapping spheres (Champenois and Etzkowitz, 2018). To Champenois and Etzkowitz (2018), the collaboration within the triple helix can be accommodated by an intermediate organisation such as an NGO (Williams and Woodson, 2012), or SP (Johnson, 2008; Goddard, Vallance and Puukka, 2011; Etzkowitz and Zhou, 2018) that created the linkages with HEIs and firms in the cluster's area. Relationship between the three institutes has been the primary concern of triple helix literature as the links created between the government, universities, and business affect the performance of a SP and regional innovativeness (Cadorin, Johansson and Klofsten, 2017; Etzkowitz and Zhou, 2018). Beside the critical supports from government in term of policy and funding (Leydesdorff, 2018; Albahari, Klofsten and Rubio-Romero, 2019; Sá, Casais and Silva, 2019), university was viewed as a key mechanism in transferring

knowledge and skilled labour to the private sectors in this SP initiative under the triple helix approach (Goddard, Vallance and Puukka, 2011; Pique, Berbegal-Mirabent and Etzkowitz, 2018; Theeranattapong, Pickernell and Simms, 2021). Although the principle of SP is similar in every country as it based on the triple helix model, the outcome is varied depend on the country's context (Doloreux, 2002). To Asheim and Coenen (2005); Asheim (2007), SP usually comprises of high-tech firms working cooperate with universities but creates weak network with the local industries and failed to create innovative linkages of inter-firm within a SP, and this led to the question about the ability to enhance local competence and cooperation of the SP to stimulate cluster's economic activities.

The triple helix model reached world-wide attention within a few years of emerging. It has been implicated to analyse innovation system in many countries including Bangladesh (Bunders, Broerse and Zweekhorst, 1999), Portugal (Natário, Pedro Almeida Couto and Fernandes Roque de Almeida, 2012; Farinha, Ferreira and Gouveia, 2016; Sá, Casais and Silva, 2019), Thailand (Nakwa and Zawdie, 2016), Spain (Hernández-Trasobares and Murillo-Luna, 2020), or to compare between countries such as Japan and Singapore (Baber, 2001), and South Korea and the Netherlands (Park, Hong and Leydesdorff, 2005). It appears that, in less developed countries, the linkage between the three institutes seemed to be weak and needed infrastructure to support the collaboration as well as funding for R&D is required by the firms (Dzisah and Etzkowitz, 2008).

The triple helix is one of the most popular approaches used for analysing innovation ecosystems (Pique, Berbegal-Mirabent and Etzkowitz, 2018) based on collaborations between three institutes. However, innovation systems extend to smaller scales that require further attention within the triple helix framework. An innovation process at the project level is essential in delivering the innovations created within or between firms or by collaboration

between a researcher and an entrepreneur, and this affects the innovativeness of the region. The implementation of regional innovation policy requires understanding of innovation processes at the project level. Innovation within firms is investigated by the IVC approach and this is explored in the next section.

Innovation Value Chain (IVC)

The concept of an IVC was developed during 2006-2007 (Roper, Du and Love, 2006; Hansen and Birkinshaw, 2007). To Roper, Du and Love (2006), an IVC represents a recursive process of gathering knowledge and transformation that results in new products or improvement in the business performance. The IVC comprises three stages: acquiring knowledge, building innovation, and commercialisation (Hansen and Birkinshaw, 2007) and these three stages are interlinked (Doran and O'Leary, 2011).

Firms that are adaptable to changes are better at generating new idea (Smit, 2015). Furthermore, to Roper, Du and Love (2008), the firms that create innovation, either to products or processes, grow at a faster rate. Although, engaging in innovation process comes with risks, uncertainty, and requires investment, the firms were motivated by the pressures from competitors or market opportunities. Feedback from customer influences firm's decision in creating product and process innovations (Roper and Arvanitis, 2012) while inputs from suppliers and competitors influences process innovation. To Doran and O'Leary (2011), firms that lack resources, for example qualified personal, and experience uncertain of demand, tend to engage more in creating innovation trying to overcome challenges.

The process of IVC starts with acquiring knowledge. Knowledge can come from internal (cross department) or external sources (customers, suppliers, competitors, and HEIs) (Roper, Du and Love, 2008; Doran and O'Leary, 2011; Ganotakis and Love, 2012; Mele and

Russo-Spena, 2017) and from domestic or foreign collaborations (Hsieh *et al.*, 2018). To Doran and O'Leary (2011, p. 201), "knowledge acquired from the market influences the on-going development and exploitation of innovation output". Although in-house knowledge can be enhanced by the use of information technology (Hensen and Dong, 2020) and is the primary source, the firms tend to find external knowledge when they have highest absorptive capacity or with public sector support (Roper, Du and Love, 2006). In developing ideas across units, it is important to create informal relationship between teams (Hansen and Birkinshaw, 2007). For SMEs that are too small to create innovation from within, it is vital to overcome innovation shortage by creating networks with external sources (Tomlinson and Fai, 2013). In general, small firms tend to acquire external knowledge from competitors and suppliers (Roper, Du and Love, 2008). To Roper and Arvanitis (2012), the firms which have high intensity of in-house knowledge require less knowledge from external sources. However, the firms that acquire knowledge from diverse sources are the most innovative (Isaksen and Nilsson, 2013).

The second stage of the IVC is building innovation or developing the product. The efficiency of the developed product depends on firm's resources and knowledge inputs (Roper, Du and Love, 2006). However, there are other factors that affect the firms' ability in creating innovation including the absorptive capacity of the workers, size, industry, and management (Dervitsiotis, 2011; Doran and O'Leary, 2011). The challenge of managing the IVC differs between each firm. An innovative idea can be obstructed by limited funding, strict funding criteria, and a narrow-minded management style (Hansen and Birkinshaw, 2007). Firms with limited funding might face difficulties in product development and, in this account, support from the government comes into play. The success of innovation, both product and process, directly affects the turnover rate and employment growth (Doran and O'Leary, 2011) that is important in knowledge accumulation and will transform the in-house knowledge of firms.

There is the point to consider that if the knowledge was externally sourced, especially from competitors or partners, then IP protection should be applied to prevent imitation that may occur at any phase of the IVC process (Veer, Lorenz and Blind, 2013).

Product commercialisation is the last stage of an IVC. This stage focusses on the exploitation of the innovation created, either to increase revenue or performance. Firm-level innovation requires the acquisition of new knowledge without disrupting existing stakeholders including suppliers and customers (Hall and Martin, 2005). Productivity may reduce during the introduction of new innovations (Roper, Du and Love, 2008). However, the success of commercialisation may depend on business size and the market network since large firms have more productivity on the innovation outcomes even creating less innovation than the smaller firms (Doran and O'Leary, 2011). Moreover, the firms that acquire knowledge from the market may have better access to networks to facilitate the commercialisation process.

The advantage of the IVC approach is that it highlights the structure and complexity of the innovation process (Doran and O'Leary, 2011), emphasizing the roles at different stages and shows that project outcomes and the firms' performance are influenced by different knowledge inputs (Ganotakis and Love, 2012; Mele and Russo-Spena, 2017) including other factors affecting firms' behaviour in sourcing and exploiting knowledge, including absorptive capacity, financial status, size of firm, and government policy (Roper, Du and Love, 2008). To Roper, Du and Love (2006), an IVC is a linear process in which the output of an innovation process must be pre-determined, however, it does not provide methods to facilitate innovation processes (Sheu and Lee, 2011; Hsieh *et al.*, 2018). Doran and O'Leary (2011) also suggested that to effectively create innovation that will result in higher productivity, it is essential to consider feedback loops along the IVC process, specifically during the building innovation and commercialisation stages.

The IVC has been applied in various aspects including analysing firms' productivity and performance (Dervitsiotis, 2011; Doran and O'Leary, 2011; Smit, 2015), innovation performance of the industry (Roper and Arvanitis, 2012; Chen, Liu and Zhu, 2020; Lin, Xiao and Wang, 2021), inter-firm collaboration (Beelaerts van Blokland and Santema, 2006; Bornkessel, Bröring and Omta, 2014; Hsieh *et al.*, 2018), open innovation system (Mohalajeng and Kroon, 2016) and the risk of being imitated (Veer, Lorenz and Blind, 2013). The IVC also applied to develop other analysing tools such as *a systematic innovation process* in solving businesses' problems (Sheu and Lee, 2011) and *GIVC (Green Innovation Value Chain)* to analyse financial viability of green products (Olson, 2013).

The innovation value chain literature is a very precisely defined and crafted literature. There are many other literatures about project management and organizational management in multiple disciplines including economic sociology, economic geography and business management operations. This thesis applies the triple helix and IVC approaches and then these inform the development of a new conceptual approach that emerges in this thesis and which is informed by string-theory. The triple helix approach is the dominant framework applied to explore SPs whilst the IVC approach has been developed to provide a much more granular approach to firm-level innovation processes and this includes a focus on individual projects. However, there are many different academic debates that focus on innovation, organisational learning and project management. Thus, it is important to acknowledge on-going debates on organizational learning, network collaboration and boundary spanning (Westerlund and Rajala, 2010; Champenois and Etzkowitz, 2018). Learning can occur within and between firms which includes three steps; processes of creating, retaining, and transferring knowledge outcome to increase competitiveness and company performance in which employees have a prominent place (Argote and Miron-Spektor, 2011; Cross *et al.*, 2015; Argote and Hora, 2017). The

knowledge is created either by exploiting or exploring opportunities and this might be facilitated by boundary spanning activities reflecting forms of inter- and intra-organisational learning (Brady and Davies, 2004; Westerlund and Rajala, 2010; Zhang, Gregory and Neely, 2016). Individual absorptive capacity is vital with knowledge acquisition and learning embedded in learning networks (Brady and Davies, 2004). Collaboration networks play a major formal and informal part in inter-firm learning processes (Westerlund and Rajala, 2010), and this type of network development is critical in facilitating future learning and innovation (Miettinen, Lehenkari and Tuunainen, 2008). Thus, effective knowledge management is required to support network operations (Zhang, Gregory and Neely, 2016). This learning process, once it occurs in a SP setting, is catalysed by mediators, or boundary spanners, who are critical for learning and knowledge transfer and in linking the three elements of the triple helix together to contribute to new collaborations in which the three spheres overlap (Lundberg, 2013; Champenois and Etzkowitz, 2018). This process of boundary spanning contributes to value co-creation processes related to information/knowledge exchange and resource integration (Aldrich and Herker, 1977; Breidbach and Maglio, 2016). Approaches to understanding network learning enhance the ways in which learning processes facilitate the effective functioning of an IVC. The IVC approach is based on exploring knowledge exchange with a focus on understanding firm and project level innovation processes.

In this thesis, the IVC approach will be used as a tool to help analyse the implementation of SP policy focusing on the roles of the triple helix actors in contributing to the development of a SP, firm's innovativeness, and regional development in the latter chapters. The duality of the triple helix and IVC approaches will enhance understanding of actors' contributions at a project level that occur within the institutional level of the triple helix framework. The advantages of applying an IVC approach to this study is related to the emphasis placed in this

research on exploring innovation projects. In addition, the focus is on learning processes that facilitate product and process innovation and this includes understanding initial learning that facilitates innovation to occur that is then commercialised. Network collaboration and boundary spanning processes are essential in facilitating intra- and inter-firm learning. To date, research on SPs that applies a triple helix and IVC approach has not been identified. This thesis is the first to combine these two approaches to explore SPs. To that matter, it is useful to define each approach's qualification here (**Table 2.1**).

Table 2.1 Comparison of triple helix and IVC approaches for SP analysis

	Triple helix	**IVC**
Characteristic	Highlighting the need for cooperation from three main institutions (the government, HEIs, and private businesses) and informing their expected roles and responsibilities in developing knowledge-based innovation system.	Defining the innovation process into three sequential stages including acquiring knowledge, building innovation, and commercialisation.
Strength	The ideal model blends a top-down approach with bottom-up initiatives configured around existing regional assets.	Extracting the innovation process into stages allows the policy maker to define and fulfil different input needed.
Weaknesses	It does not consider other issues that may affect the firms and SPs development such as environment. One implication is that this may ignore the contributions individuals/firms make at the micro level that may have a positive influence on innovation outcomes. The collaboration between the helixes often requires intermediate organisation to accommodate.	This approach does not consider the possibility that innovation is a non-sequential process. In the real situation, the researcher may need to go back to acquiring knowledge during the building innovation or commercialisation stage before completing the final product that ready for the market.

2.3 SPs and regional economic development

> A science park is considered as a hybrid organisation, which is the result of a systemized form of cooperation between the university, the government, and the private sector organizations. It constitutes an important regional development tool, capable of transforming the socio-economic profile of a region. It promotes the culture of innovation and the competitive advantage of companies and institutions, by stimulating the creation and the development of technology-based companies (Bencke *et al.*, 2020, p. 22).

SPs are usually established based on the principle of triple helix collaboration as a tool for regional economic development strategy (Ratinho and Henriques, 2010). For example, during the 1980s, the Birmingham City Council expected that the Aston Science Park would contribute to the restructuring of existing basic infrastructures those that generate wealth to the community as well as developing new industries that would contribute to exporting. The job creation was considered as a long-term achievement (Massey, 1992). Many previous literatures studied the success of a SP in influencing regional economy (Garnsey and Cannon-Brookes, 1993; Anselin, Varga and Acs, 1997; Löfsten and Lindelöf, 2002; Garnsey and Heffernan, 2005; Guadix *et al.*, 2016). Most of them measured the success of operations from the long established SPs since the early stage one are still unable to collect the data, either to measure their impacts on the regional economy or the success of the development policy (Ratinho and Henriques, 2010). According to Quintas, Wield and Massey (1992) the success of a SP can only be fully measured after at least 15 years of establishment.

SP plays a critical role in regional development (Tan, 2006) as it attracts talented personnel to the region and develop local entrepreneur for higher performance (Cadorin, Johansson and Klofsten, 2017). Beside directly drive up the local economy through job creation and the support of firms' growth, SP can indirectly encourage economic growth of other activities that support its operations and workers' lifestyle (Massey, 1992). For instance, since 1980s the rental rate of property nearby the Cambridge Science Park has increased as influenced

by the relocation of firms and their employees to the area. These firms moved to settle on-site and brought skilled workers with them. Some countries, such as Thailand and Portugal, tried to build SPs in each region to drive local economic activities (Ratinho and Henriques, 2010; Science Park Promotion Agency, 2013, 2017a). However, the number of SPs is not related to a country's degree of innovativeness nor the level of impacts on a regional economy. In particular, Portugal has a higher ratio of SPs per population than the UK, but the economic development of Portugal is only at the EU average (Ratinho and Henriques, 2010). However, higher numbers of SP establishment in the nearby area may allow each of them to create specialization rather than carry the R&D in all fields (Theeranattapong, Pickernell and Simms, 2021). For the region to fully benefit from the establishment of SP, the policymakers need to consider the existing or potential industries and the capability of the locality.

Massey (1992) interviewed 128 on-site firms. More than 25% responded that the important factor to consider in locating their businesses in the SP area was that the key founders were from the local HEI or had been living in the nearby area. To Keeble (1999b), spin-offs and startup firms of the founders who have expertise in research and management activity will circulate knowledge and learning capability to the region. Namely, the Cambridge region is a community of spin-off technology-based firms that refused to settle elsewhere. Skill and tacit knowledge are transferred amongst them through the movement of employees. Most of them still retain contact with the parent firm or incubator. This is how a technology-based SP cluster emerges and it directly influences local competitiveness. While the parents and large firms tend to be in a stage of mature and can be less innovative, the spin-off and small firms are still in the development stage and require higher level of coordination from the university in R&D activities. Within the cluster with various sizes of related technology businesses, these firms can benefit from knowledge transfer either from the university or from co-located firms (Florida

and Kenney, 1990; Anselin, Varga and Acs, 1997; Tan, 2006; Pietrobelli and Rabellotti, 2011; Chen, Sun and Batchuluun, 2016). However, a region will benefit from a SP cluster if businesses work collaboratively, and mutually exchange knowledge and the development of products and services. According to Florida and Kenney (1990), Silicon Valley's firms needed to order their parts from off shore suppliers as no local suppliers could produce the required components. Furthermore, another problem for new firms in Silicon Valley was they were unable to identify business partners given the small size of companies. For example, Gazelle Microelectronic had a difficult time finding a local supplier for its 11-employee business. It ended up trading with Kyocera, a Japanese company. As such, the local business and the region did not gain fully from this firm's growth. Thus, to develop a regional economy effectively, SP may have to expand its network and consider national innovation system including local to global network and value chain into account.

2.3.1 The roles and benefits of SP establishment

Creating the R&D linkage between HEIs and the firms

A SP is a property-based institute that concentrates on creating the links between universities and industry, knowledge and technology transfer, and encourages the commercialisation of university research (Massey, 1992; Tan, 2006; Etzkowitz, 2008; Theeranattapong, Pickernell and Simms, 2021). In doing so, SP policy encourages academic spin-offs or matching businesses innovation needs to the expertise available from universities, as well as providing private sector firms with access to high-technology equipment to undertake R&D (Massey, 1992). The main purposes of establishing a SP is to bridge the two worlds of private sector business and HEIs and to encourage the growth of innovation through R&D activities, promote research institutes to commercialise their research outputs, and to provide

high-technology tools and equipment and space for businesses (Quintas, Wield and Massey, 1992; Vedovello, 1997; Bakouros, Mardas and Varsakelis, 2002; Löfsten and Lindelöf, 2002; Garnsey and Heffernan, 2005; Phan, Siegel and Wright, 2005; Ratinho and Henriques, 2010; Díez-Vial, 2016; Vásquez-Urriago, Barge-Gil and Modrego Rico, 2016).

However, Quintas, Wield and Massey (1992) and Vedovello (1997) identified that formal linkage[2] between universities and the firms were not successfully established. The physical distance does not seem to be an important factor in weakening or strengthening the relationship between firms and universities in term of R&D activity. Quintas, Wield and Massey (1992) studied 183 on-site firms located across 38 SPs in the UK and compared these firms to 101 off-site firms in term of the distance between the firm and the university and the nature of the linkage created between the SP firms and the HEIs. This analysis found no difference in the formal research links between firms and universities. Nevertheless, on-site firms received privileges from forming informal links and by using university facilities. To Massey (1992), the survey of UNSPA-OU-CURDS also identified that there was no difference between the formal link created between SP located firms and HEIs compared to firms located away from a SP. However, the on-site firms create more informal linkages[3] than the off-site firms. This finding is supported by the latter literature. Vásquez-Urriago, Barge-Gil and Modrego Rico (2016) undertook a study based on the 2007 Spanish Survey of Technological Innovation in Companies by the Spanish Institute of Statistics (INE)[4] of 39,722 Spanish businesses across all sectors, sizes, and locations. From these, 653 were in 22 SPs in Spain. The

[2] Research related relationship between the business and university
[3] Connections between the business and university those not directly relate to R&D activity i.e., strategies, human resources, information management, relationship management
[4] See more on INE webpage: http://www.ine.es/dynt3/metadatos/es/RespuestaDatos htm?oe=30061

result also supports the argument that firms located on the SP had developed better informal relationship with research institutes in the HEI compared to off-site firms.

Vedovello (1997) expressed the idea that proximity can strengthen the linkages between a company and a university through an analysis of British SPs. SPs were established to improve the innovation of the British industrial sector. They were created close to universities and industries on the understanding that they would provide HEIs with an additional income source and, at the same time, increase innovation across the private sector. Kenney and von Burg (1999); Doloreux (2002) supported that a close distance helps reduce time spent on traveling and aid the establishment and development of the relationship between the two parties since it is more convenient to meet face-to-face or to arrange meetings. However, more recent research suggests that proximity between a firm and a university is not a direct factor influencing firm innovation and knowledge transfer with the university, and the primary factor is the connection between businesses and HEIs and the matching of expertise required to support product R&D (Massey, 1992; Etzkowitz, 2008; Díez-Vial, 2016).

Increasing the firms' credibility

Massey (1992); Albahari *et al.* (2018) states that the reputation of SPs is the main factor that magnetizes firms to located within a SP and the image of a SP is an important factor to be considered in building up the academic partnership. This finding was supported by Bakouros, Mardas and Varsakelis (2002). They conducted research based on a survey of 17 on-site firms located in three Greek SPs. Most of these firms chose to occupy space in a SP because they expected to benefit from developing a good reputation that came from an association with an area known for high-tech combined with fully utilizing a SP's facilities. Only a few firms expected to develop connections with other co-located firms or with the university. Also, very

few of them expected to benefit from receiving low-cost knowledge transfers from the university. The Greek SPs have failed to create an interaction in term of R&D between the on-site firms and the university. The only relationships they created were for commercial and social purposes. The Greek SPs' role is more likely to be related to property management. Chan and Lau (2005) also confirmed this argument by noting that some firms located in SP benefit from a SP's reputation, and this enhances the firm's credibility.

Providing business-related services to firms

Stoneman and Diederen (1994) proposed that SP should provide IP service for tenants. Patent protection will encourage firms to be more innovative since it will protect their rights to benefit from innovation. Nonetheless, incubation is another issue raised in an argument regarding what additional services SPs should provide on-site (Aportela-Rodríguez and Pacios, 2019), particularly for new or startup firms. Phan, Siegel and Wright (2005) noted that SPs and incubators were created by HEIs in order to encourage the growth of entrepreneurship by using the university's research and technology. As a result, an incubation process encourages firms to spin off to the region and can lead to an increase in regional economic activity. But most of the on-site firms are in the early stages of developing as a technology-based firms and this means that many of them have limited or no experience of market penetration. SPs realized the need to get rid of this weakness, therefore, providing incubator services to support tenants according to the development stage reached by each firm (Chan and Lau, 2005). Ratinho and Henriques (2010) confirmed this by revealing that besides R&D activities and knowledge sharing, the on-site firms also require assistance in business development processes and management to help growing the businesses. It is important that startup firms understand the market. To Love, Roper and Bryson (2011), the firms those understand their customer shows significantly high rate of

service innovativeness compares to those companies that have no such links. Also, one competitor can reduce innovation sales by 1.2% (Love, Roper and Bryson, 2011). Without understanding the market and its customer, the company's growth can be compromised.

2.3.2 The implementation of SP policy

SPs are developed to provide floor space and to promote the growth of business through innovativeness. It provides shared facilities, equipment and tools for R&D of its' tenant firms. It should also provide the support required to connect a firm with a research institute or university according to their needs and to develop HEI-firm relationships to support the product and service development. Some SPs also offer business incubation and consultation as part of their services. The result of its operation should encourage regional economic activities and create local jobs. This relationship between a SP and the regional economy is complex as it involves relationships between different actors (**Figure 2.1**). Thus, managing a SP does not only involve property management, but also requires knowledge of business development and networking. Understanding of public policy and dealing with various stakeholders such as government authorities and financial institutes is important. SPs that fail to develop relationships with relevant stakeholders, especially from universities, will become just providers of office space and will not create the types of wider regional economic impacts that are associated with a SP.

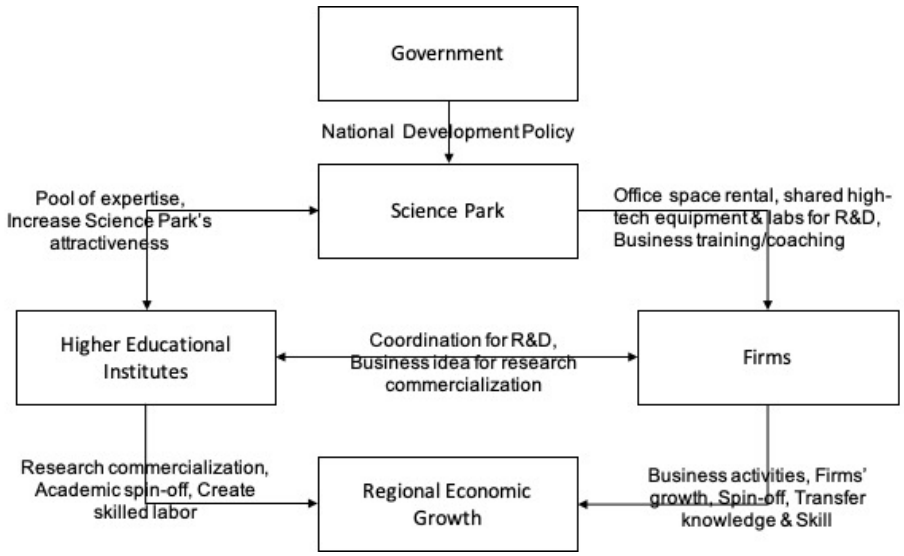


Figure 2.1 Relationship of science park, HEI, and firms

SP should not only be a place for firms to share high-tech R&D facilities, but also to play an active role in creating networks for knowledge sharing since the relationships between firms, universities, and the wider locality can encourage innovation within a regional economy. In formulating the development policy for a SP, policymakers should not only focus on the linkage between firms and universities, but also on the interactions between co-located firms and a key element is to ensure that there is an increase in the transfer of technical knowledge and innovativeness (Díez-Vial, 2016). From Saxenian (1994), comparative study of the recovery from the economic crisis in 1980s of technology-based companies in Silicon Valley, California, and on Route 128, Boston, Massachusetts, found that the relationship amongst firms is the main concern in running a SP located company. Furthermore, the entrepreneur tends to share more about their businesses if they have something in common (Chan and Lau, 2005; Etzkowitz, 2008). In addition, SPs should be established and operate by mirroring the needs of sustainable economic development at 1) community level 2) regional level 3) national level and 4) trends at the international level (Garnsey and Heffernan, 2005). To Saxenian (1994), regional policy should stimulate and coordinate and be tailored to meet the local context with the

engagement of local authorities rather than directly managed by the central government. The establishment of SPs must relate to the development of existing industries or local competences to support the tradition of the region and to create job bases on existing know-how (Massey, 1992) on a region's current resource base.

To Saxenian (1994); Garnsey and Heffernan (2005), SPs in a developed country do not need government support to establish and grow. The universities are mostly capable of working with the business sector to commercialise the research and development of products. In contrast, Love, Roper and Bryson (2011) noted that government support helps enhance a firm's innovativeness. From this study, it was identified that firms that received public support had 12-16% higher rate of sales linked to innovation.

Phan, Siegel and Wright (2005) and Ratinho and Henriques (2010) explains that the development SP strategies is a complex issue. The establishment of SP requires to create relationship and collaboration from the triple helix: university, firm, and government. However, a SP is the result of collaboration also from extended stakeholders in public and private sectors. It is influenced by the logic of various stakeholder and may experience institutional complexity as same as other organisations (Hladchenko and Pinheiro, 2019). The needs and expectations of each partner, thus, must be considered. Local authorities and financial institutions should also participate in setting up the policy and be part of its operation as this can encourage local economic activities and increase job creation (Löfsten and Lindelöf, 2002).

Guadix *et al.* (2016) stated that in order to successfully establish a SP, policymakers should have a deep understanding of the operation plans of existing SPs. This is to create a model that might be able to be applied to the development of a new SP. The success of a SP is related to 1) the ability of a SP to survive through the initial stages and have high revenue, 2) occupy a large site with space to expand, and 3) the park should have a high employment rate.

A different point of view was developed by Garnsey and Heffernan (2005) who measured the success of SPs using the rate of employment, number of surviving firms and number of spin-off from SP located firms. Thus, to enhance the success of a SP and its on-site firms, the management should have specific knowledge and expertise of SP development and operations. This should include, for example, business development, cooperation and knowledge transfer from the university (Ratinho and Henriques, 2010), and make sure that the SP program will benefit high-tech SMEs rather than the branches of international or mature firms that might locate on a SP to benefit from tax or other benefits (Chan and Lau, 2005).

Furthermore, the policymakers must include financial support for startup firms. Small startups are unable to generate sufficient income at the establishment stage. SPs should support them by offering low rates or discount rental fees according to a firm's development stage (Chan and Lau, 2005). Nevertheless, a SP's strategy should encourage academic spin-offs and attract technology-based firms to encourage further growth of the SP, businesses, and the regional economy (Ratinho and Henriques, 2010).

2.3.3 SPs in emerging economies

SP and a triple helix model originating in developed economies but there have been attempts to implement the concept in other national contexts (Goddard, Robertson and Vallance, 2012; Hladchenko and Pinheiro, 2019). The role of each helix in regional innovation development as the firms conduct R&D in their premises, universities commercialises its research, and the government promotes and support projects with high risks for initial rewards (Schiller, 2006). However, the concept of innovation in less developed countries is different compared to developed countries due to differences in capital and infrastructure (Williams and

Woodson, 2012). From the available literature, the implementation of SP policy in emerging economies shows some development and obstacles that I will classify them by institutions.

The government

The implementation of triple helix framework in developing country faced limited participation from the private sector and the government still need to be the main driver (Etzkowitz and Leydesdorff, 1995; Nakwa and Zawdie, 2016; Torres de Oliveira, Gentile-Lüdecke and Figueira, 2021), including setting up the policies along with the national development strategies to support the emergence of knowledge-based society, funding for research and tax incentives (Zakiyeva, 2020), and investing in R&D infrastructure (Koh, Koh and Tschang, 2005; Schiller, 2006) as represented by the *statis model*. In South Korea, the policy has to make sure that the SMEs receive enough benefit to compete with larger firms (Kim, 2008). In Kazakhstan, the establishment of SP aimed to develop the digital platform that serve the industries and citizens (Zakiyeva, 2020). While in China, SPs work as a hub for foreign investment that will create spillover benefit to the domestic firms, and the national SP enjoys more preferential policy than regional or local SPs (Zou and Zhao, 2014; Torres de Oliveira, Gentile-Lüdecke and Figueira, 2021). To Hasan, Klaiber and Sheldon (2020), national policy on incentive helps improve productivity of the SMEs in the SP cluster. However, in general, the SP policy implementation in emerging economies still lagging full understanding of the critical elements of SP in adding value to the businesses and the slow process of IP registration, thus, most of the SPs became unattractive to potential firms and turned to be just an office space rental.

The HEIs

One advantage of establishing a SP is the pooling of experts from the HEIs (Chen, Sun and Batchuluun, 2016) for transferring knowledge to the industries. The universities in emerging economies extend its roles from teaching and doing research for academic purpose to better answer the formation of knowledge-based community by offering the business training and incubation program for its staffs and students (Chan and Lau, 2005; Bodolica and Spraggon, 2021). The aim of doing research has been shifted toward commercialisation through business partner. Although, the successful knowledge transfer requires close interaction to stimulate the learning process that benefit both sides and the firms show higher performance when receiving academic knowledge transfer (Nakwa and Zawdie, 2016), university-industry link in emerging economies is still weak or not exist (Pietrobelli and Rabellotti, 2011). There was limited commercialisation of academic research and inefficient evaluation measures for research staff (Comins and Rowe, 2008). In the case of Russia, the weak knowledge transfer was because the low demand for high-tech product (Kihlgren, 2003). Additionally, despite the reducing of government funding has been driven the university to find extra sources of income, its rules and regulation were still controlled by the central policy (Schiller, 2006; Tan, 2006; Zou and Zhao, 2014) which had limited options for the university to acquire extra funding and for its staffs to work with the private sector firms. Also, the SP's cluster itself cannot support the university in doing research that benefit the cluster and this left the government to still be the initial source of R&D funding (Nakwa and Zawdie, 2016).

The firms

Obstacles in implementing a SP policy in emerging economies related to the firms include the low entrepreneurship in the knowledge-workers, new entrepreneurs lack of business

knowledge (Comins and Rowe, 2008), the entrepreneurs do not realize the need for product development and the lack of support policies for business, including access to funding (Nakwa and Zawdie, 2016) and inefficient IP protection law (Tan, 2006; Comins and Rowe, 2008; Zou and Zhao, 2014). In some countries, such as Poland, the services of SP still need to be promoted (Świadek and Gorączkowska, 2020). Furthermore, the university knowledge outputs can be too general or too academic that the firms cannot utilized easily (Radosevic and Myrzakhmet, 2009) and this can be the result of lack of communication or weak linkage between the firms and the HEIs. However, within the supportive environment for knowledge sharing of SP network, the entrepreneurs can benefit from exchanging with similar businesses (Świadek and Gorączkowska, 2020). To Torres de Oliveira, Gentile-Lüdecke and Figueira (2021), the research on 137 Chinese firms informs that SPs are vital in emerging economies due to its weak institutional framework allows the firms' external knowledge exploitation that are not limited to the HEIs and that can improve innovative performance of the firms. However, the competition between the firms in the SP cluster can be intense due to the similarity of products also require similar resources such as personnel, technology, supplier, and customer (Tan, 2006). Furthermore, Koh, Koh and Tschang (2005) found that the network between the actors inside and outside the SP still need to be developed.

According to UNESCO (2019), there were 536 SPs around the world in which 27.8% or 149 SPs were in emerging economies[5] and this number is growing. Although there are patterns of innovation occurring, the previous literature did not pay much attention on systematic overview of the SPs development and their effectiveness in emerging economies (Theeranattapong, Pickernell and Simms, 2021) and the SP analysation tacitly applied a linear

[5] As of UNCTAD (2020)

approach focusing on knowledge transfer from HEIs to the firms (Bodolica and Spraggon, 2021; Torres de Oliveira, Gentile-Lüdecke and Figueira, 2021) with limited formulation of the actual interaction that may or may not occur (Radosevic and Myrzakhmet, 2009; Williams and Woodson, 2012). This leaves so many areas to study, such as the role and contributions of each helix in the SP innovation project that influence research commercialisation in which we will explore it in the latter chapters.

2.4 HEIs and regional economic development

Research has explored the relationships between HEIs and regional economic development, and one focus has been on SP operations and the role HEIs can play in assisting and cooperating with on-site firms for product R&D. HEIs, as an anchor institution, have critical roles to play in supporting the development of economic activities within the communities in which they are embedded (Perry, Wiewel and Menendez, 2009; Goddard *et al.*, 2014). This includes transferring knowledge, providing skilled workers, and helping to solve problems (Etzkowitz, 2008; Goddard, Robertson and Vallance, 2012; Goddard, Kempton and Vallance, 2013). University research may influence the development of local industrial clusters (Goddard, Vallance and Puukka, 2011). In this account, the development of university policies and processes to enhance local knowledge transfer is essential (Birch, Perry and Taylor, 2013). Furthermore, in areas which lack sources of knowledge, the HEIs may be able to enhance the regional innovation systems via their absorptive capacity and by supporting technological development (Schiller, 2006; Theeranattapong, Pickernell and Simms, 2021). In addition, a university can play an essential role in supporting innovation processes within regional industries (Isaksen and Karlsen, 2010; Theeranattapong, Pickernell and Simms, 2021). The development can be done effectively only with the cooperation of local authorities and relevant stakeholders in the community (Perry, Wiewel and Menendez, 2009). SP and the region will

benefit more from having a strong connection with the HEIs (Aportela-Rodríguez and Pacios, 2019). Thus, to exploit fully benefit from the HEIs, the strong connection between HEIs and the industries must be created, and it should be based on technology rather than just being in a proximity since the embeddedness of the university rather occurs when the expertise matches with the local needs (Goddard *et al.*, 2014; Díez-Vial, 2016).

Relationship between HEIs and industry

To Massey (1992), the nature of the research link depends on each SP. Even in the same country, there are some variations. For instance, the Aston Science Park had a higher rate of research links creation compared to the Cambridge Science Park. There was a limitation on laboratory equipment, and less available compared to the Cambridge Science Park. However, the researchers at the Aston Science Park seemed to put greater effort in utilizing all resources they had to benefit their network and partners.

Saxenian (1994) notes that during 1950 Stanford University had a program targeted at local companies to persuade them to attend engineering classes and graduate courses. This increased the formal link between the Stanford University and the firms and transferred knowledge of new engineering techniques to the companies and created skilled labor in the market. HEIs provide support to the SP encouraging business innovativeness (**Figure 2.2**).

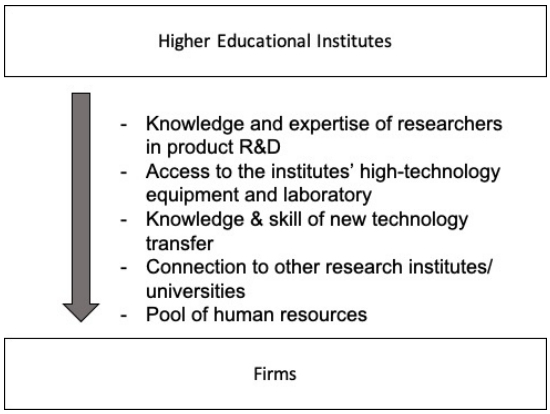


Figure 3.2 Roles of HEIs in supporting businesses' innovation

Moreover, Vedovello (1997) identified that firms located on a SP tend to engage more with other universities rather than with the SP's host university. The research link between a firm and a university is less about co-location or proximity and more about a match between a HEI's research interests and a firm's R&D requirements (Vedovello, 1997; Etzkowitz, 2008). Thus, creating the link between firm and the university is not only about the equipment and expects supporting a firm's interests, but it is also important to match the need of the firm with the expertise available at the HEI (Etzkowitz, 2008).

Additionally, Etzkowitz (2008) revealed that the knowledge transfer between the university-industry can occur in form of individual circulation between these two institutes. The business may spin off from the university and the entrepreneur might also become a lecturer. Both of them might be active in both roles as a business person and in the academic area or completely transform and change the career path. Ratinho and Henriques (2010) further inform us that the link between firms and HEI does not have a direct influence on the spin-off process. This can be the result of the absence of a university policy that encourages academic spin-off and, thus obstruct the knowledge transfer to the region (Etzkowitz, 2012).

However, the HEIs were an important part of SP for the firms' innovation and impacted on regional economic development. Without cooperation from HEIs, SP can only provide rental space equipped with high-tech tools and equipment. Anselin, Varga and Acs (1997) explained that HEIs have an important role to play in spreading knowledge and technology at the regional level by undertaking research, developing skilled labour and influencing private sector R&D activities in metropolitan areas. In contrast, private R&D activities had no influence on the research agenda of HEIs. The university can also help on-site firms innovate by providing them access to knowledge and resources, including linking firms to local institutions and businesses (Díez-Vial, 2016). The collaborative work between the university and the industry not only

support the business's R&D, but also lead to new theory developing for further research development (Etzkowitz, 2008). Furthermore, according to Love, Roper and Bryson (2011), from a study of 1,151 business companies in the UK, it is essential in having relationships with research institutes to deliver the final product/service. Likewise, the relationship with customers is also important in creating innovation, especially for service businesses.

HEIs policy supporting SP strategy

HEIs policy can encourage the relationship between the firms and a university. The research undertaken by Massey (1992); Quintas, Wield and Massey (1992); and Vedovello (1997), noted that during 1970-1980s the UK government had cut funding to HEIs. These reductions encouraged the universities to identify other sources of income, through research commercialisation and working with the private sector. HEIs also supported a SP in developing regional economic activities by encouraging academic spin-off through research commercialisation. However, some spin-off might occur under an unexpected situation. Massey (1992) found that Aston Science Park had high rate of academic spin-off. This was not only because researchers could obtain funding support from the venture capital, but also because of reductions in academic budget that forced researchers to commercialise their products. The academic spin-off firms tend to keep close connection with their origin and this creates the cluster of innovation around the university area (Etzkowitz, 2008).

In addition, the university also has a role in creating entrepreneur to the region. Vedovello (1997) identified that 73% of the firms located on the Surrey Research Park recruited students as part of their R&D activities. This is due to a policy of the host university, the University of Surrey, which required undergraduate students to attend a training period before graduation. The university researcher can benefit from working with the business by earning

extra income and may use the experience of working with the firm to teach the students (Etzkowitz, 2012) that will later become skilled workers to the industries. Additionally, in 1999, over 200 US universities contributed over USD 40 billions to the economy from patenting and commercialising their academic research outputs with the establishment of more than 300 new firms (Etzkowitz, 2008).

However, the university researcher usually occupied by academic duty and not all of them suitable to work with the private sector. The university and the government must understand the logic of the academic to convince them to do research for the private sector and community (Goddard, Kempton and Vallance, 2013). The university may needs to encourage staffs' professional development to acknowledge this additional duty in doing the research base on the need of private sector and the result must be able to marketise (Evans, 2008).

2.5 The firms

The business sector or firm is one of the three main components[6] of the SP operation. The word ‘firm’ has been conceptualised using various definitions. Firms are the main employers with legal control over labour. It is the place that gather workers together to perform production in one place (Walker, 1989). According to Taylor and Oinas (2006), a firm is a set of production functions that support the exchange of products with other firms through the process of marketing, at the lowest costs and at the highest return as much as possible. Production also involves decision-making from the administrator/manager. The organisational structure of each firm can be different. Managers will have different goals and objectives according to their positions. However, these goals must rely with one another and aim for the same target - the main aim of the firm.

[6] The three main components of SP consist of the SP (infrastructure and management), university, and business.

Efficiency and effectiveness are the central to the operations of a firm. The production process, or the movement of resources, reflects market conditions and the internal factors of the firm itself. In trying to reach economic efficiency, increase competitive advantages, and to expand, the firm resorts to substituting resources that offer the lowest cost, such as raw materials and human resources. Also, to expand, one firm needs to achieve competitive advantages over other potential and actual competitors. Firms need to compete as the resources are not available to all. Dicken and Thrift (1992) explains that firms develop networks and relationships with their partners, not only to acquire access to lower cost resources, but also to create network of alliances to support market competition. However, at the same time, they also learn from each other. Taylor and Oinas (2006) noted that new techniques are developed in term of both technical and administrative skills while maintaining a firm's core competency. Thus, a firm operates and is a result of learning and continual improvement.

The firms' relationship with SPs

Vedovello (1997) studied 60 firms on the Surrey Research Park. He identified that the firms considered the main advantages of being on-site are the encouraging working environment, and the infrastructure and services provided by a SP rather than an opportunity to create a connection with the HEIs for R&D activity. The pooling of resources from SP facilities reduces the cost of firms' production increasing efficiency. These were considered as critical issues for startup firms. The establishment of SPs can only provide firms with an opportunity to develop informal links with a HEI and it appears to have less influence on HEI and private sector research activity. However, Keeble (1999b) showed that spin-off firms prefer to stay in the Cambridge area rather than relocate to other areas because of the accessibility to expertise as well as good living environment for employees and the reputation of the region. This was

supported by Garnsey and Heffernan (2005) who noted that many spin-off firms perform businesses related to their former company and through co-location contribute to the establishment of an localised industrial cluster in the area nearby their source of knowledge, university. The university and R&D consultancy enhance the nature and reliability of collaboration between HEIs and firms. They benefit small firms in terms of encouragement in the field of technological innovation and enhances firm growth. Löfsten and Lindelöf (2002) identified that firms operating on SP perform better than firms located off-site. This assessment was based on the analysis of firm growth rate based on employment, sales, and profit. Firms operating on-site were able to work with HEIs in a more effective way compares to those located off-site.

It was expected by SP managers and policymakers that on-site firms will benefit from receiving a higher chance of sharing knowledge and creating potential networks with other firms. They compete with each other but, at the same time, share and learn about the market and technology from one another (Saxenian, 1994). The partnership between HP and Weitek, the leading designer of ultra-high-speed chips, is a good example. In 1987, HP agreed to let Weitek produce the chips using HP's high-technology facility to enhance chip performance. This followed by a win-win three-year contract to produce high performance chips for Weitek at HP's facilities. This partnership guaranteed that HP would have sufficient supply while Weitek could produce higher quality products compared to those that it could produce using its own facilities (Saxenian, 1996).

Although the firms have higher chance to innovate by interact with other firms (Doloreux, 2002), knowledge exchange or the links created amongst on-site firms merely occur given the non-similarity of businesses or products (Chan and Lau, 2005). Some on-site firms even compete with each other in the same market. Etzkowitz (2008) supports this argument by

informing that the firms tend to group together with the other firms those are similar to themselves first, before partnering with the less similar firms. This principle was later confirmed by Díez-Vial (2016) that knowledge sharing is the key for firm innovation. Not only having relationship with the university will help on-site firms increase their innovativeness, but also exchanging and sharing technical knowledge between co-located firms.

A firm can increase its innovativeness by intra-firm cross-functional and knowledge exchange (Love, Roper and Bryson, 2011). However, as most of the firms under the support of SP are startups or SMEs, this process is difficult to occur as they have only small number of employees in one firm. Innovation, thus, rather comes from knowledge sharing with other firms or with HEIs. Furthermore, successful firms tend to utilize more local knowledge and relationships to expand new markets and products by adding value to the products and services to any stages of innovation such as production and commercialisation (Florida and Kenney, 1990; Love, Roper and Bryson, 2011). Thus, it is worth considering setting up a SP as an initiative to gather the same type of business and to be a center of expertise encouraging the sharing of knowledge amongst on-site firms by taking the existing industries and know-how of the region into consideration. This is also to increase the opportunity for cluster formation in the region that will further influence and strengthen regional economic development.

The starting point for SP analysis is the application of the triple helix approach as this has become a common framework that is applied during the process of establishing a SP. However, although providing a good understanding of the roles of the government, HEIs, and the private sector firms at an institutional level, the contributions of the actors as an individual or project level is still unclear. The IVC will be added to the triple helix informed analysis as this defines an innovation project as consisting of three linked stages. The inputs provided by

each actor and their relationships will be explored in this thesis, including how they enhance opportunities for research commercialisation. Learning what drives the performance of actors and how cooperation is created will complete the understanding of SP analysis. In this account, there is a need to develop a conceptualisation of innovation but at the level of individual innovation projects. With this in mind, this thesis draws upon ideas that have been developed in physics, the *string-based approach* is developed in Chapter Seven to theorising SP to complement the triple helix and IVC approaches. The contribution of these three approaches in understanding SP is outlined in **Table 2.2.**

Table 2.2 Comparison of triple helix, IVC, and string-based approaches for SP analysis

	Triple helix	**IVC**	**String-based**
Characteristics	Highlighting the need for cooperation from three primary institutions (government, HEIs, and private businesses) and informing their expected roles and responsibilities in developing a knowledge-based innovation system.	Defining the innovation process into three sequential stages including acquiring knowledge, building innovation, and commercialisation.	Defining an individual person as a string which contains qualifications and logics. A SP innovation project represents a braiding of strings of actors that are also positioned in the context of the triple helix and IVC.
Area to analyse a SP	Exploring the roles of institutions.	Exploring a specific innovation process.	Exploring interactions between individuals.
Contribution	Create the ideal approach based on integrating top-down and bottom-up initiatives during the policy implementation process.	Extracting the innovation process into stages allows policy makers to define, identify and fulfil different input needed.	Highlighting the importance of understanding linkages between micro (project), meso (firm), and macro (institution) levels.

2.6 Conclusion

The first SP, Stanford Research Park, was established in 1951. However, SPs began to receive academic interest since the late 1970s in response to the success of Silicon Valley and Route 128 in the USA, followed by the Cambridge Science Park and other UK SPs and, in particular, those set up to increase the UK's innovativeness and to recover from the 1980s economic recession (U.K. Science Park Association, 1986). The flourishing of the UK SPs was also encouraged by cutback university budgets from 1981 (Quintas, Wield and Massey, 1992). The universities needed to find other sources of income, through research commercialisation and by working with the private sector (U.K. Science Park Association, 1986; Massey, 1992; Quintas, Wield and Massey, 1992; Vedovello, 1997). Up to 2016, 87 publications[7] about SP can be identified and these publications are about SPs in the UK and China (Hobbs, Link and Scott, 2017). However, none of these papers have studied SP policy or management plans in detail.

From the late 1970s to mid 1980s, most of the studies concentrated on the Cambridge Science Park. It was set up in response to government policy during the 1970s to encourage collaboration in R&D between HEIs and firms. As SPs were still new to the public, the academic literature predominately focused on exploring the definition of SP and their objectives. Several academic papers focused on exploring the on-going development of the Cambridge Science Park including its impacts on increasing land prices and the employment rate in the Cambridge region. Together with the discussion of the future development of SP, these studies also paid attention to the development of firms (Delayed, 1973; Bradfield, 1981; Mawson, 1982; Tweddle, 1984; Segal, 1986). During the late 1980s to the beginning of 1990s, the topic of interest was on the development of firms, their location, and ability to survive the economic crisis. The success of the firms in Silicon Valley was compared to those on Route 128 to explore

[7] Exclude books and book chapters

why one area could escape the economic downturn whist the other could not (Florida and Kenney, 1990; Saxenian, 1994). The literature focused on large firms and firms located at the SP without comparing them with off-site firms.

In 1990s, the main interest was shifted toward the role of SP in creating linkage between HEIs and firms (Massey, 1992; Quintas, Wield and Massey, 1992; Guy, 1996; Vedovello, 1997) as well as the benefits those SPs provided to their tenants. The proximity between firms and the universities was considered as a critical factor in creating university-industry linkage (Vedovello, 1997; Kenney and von Burg, 1999). Comparing between on and off-park firms, the research showed that formal linkages between HEIs and the firms was not successfully established. SPs can only provide firms with an opportunity to develop informal links and to access the human resources required from HEIs and there is less influence on shaping HEI research activity (Quintas, Wield and Massey, 1992; Vedovello, 1997). The physical distance seems not to be an essential factor in weakening or strengthening the R&D relationship between firms and HEIs (Massey, 1992; Westhead and Storey, 1994; Vedovello, 1997).

From the late 1990s, researchers also paid attention to regional development caused by knowledge transfer and cluster formation (Anselin, Varga and Acs, 1997; Keeble, 1999b, a; Kenney and von Burg, 1999; Garnsey and Heffernan, 2005; Hassink, 2005; Etzkowitz, 2008; Díez-Vial, 2016). Later, in 2000s, the research began to explore the development of SP in other national contexts (Saxenian and Hsu, 2001; Bakouros, Mardas and Varsakelis, 2002; Löfsten and Lindelöf, 2002; Jie, Ning and Fengdan, 2008; Chang *et al.*, 2010; Ratinho and Henriques, 2010; Guadix *et al.*, 2016; Vásquez-Urriago, Barge-Gil and Modrego Rico, 2016; Albahari *et al.*, 2017; Lamperti, Mavilia and Castellini, 2017), and studied the development policy of successful SPs to identify best practice for new SP establishment (Guadix *et al.*, 2016). However, the main interest is still on how to maximize firm competitiveness. Policies mentioned

in studies include incubators and the provision of other business related services (Chan and Lau, 2005; Ratinho and Henriques, 2010; Love, Roper and Bryson, 2011), government support (Saxenian, 1994; Garnsey and Heffernan, 2005; Love, Roper and Bryson, 2011), funding (Löfsten and Lindelöf, 2002; Chan and Lau, 2005), and IP management (Stoneman and Diederen, 1994; Albahari *et al.*, 2017). Some recent papers show interest in extending the features of SPs to support the addition of the fourth actor to the triple helix (Almaamory and Slik, 2021). However, the development of additional helixes is still in the academic discussion.

Overall, the research on SPs has been dominated by studies of SPs in developed countries, firm performance, and how SPs can maximize their tenants R&D activities, abided by the objectives to increase firm innovativeness, create jobs, and increase economic activity by promoting collaboration between HEIs and high technology-based firms. Many less developed countries adopted the best practice from studying successful SPs. However, considering that the global innovation source is currently shifting toward emerging economies, there is only limited number of literatures of SP policy initiative in emerging economies and mainly dominated by SPs in China. There is a need to understand the implementation of SP policy in wider contexts of emerging economies. The low complexity of an innovation system in emerging economies can give clearer view in SP analysis than in developed economies. Moreover, the existing literature has made a vital contribution by exploring the triple helix model but has tended to avoid exploring the influence of micro level project processes that play key roles in shaping SP outcomes. Furthermore, each triple helix actor in a SP has a different institutional set up and this then is reflected in different motivations for their involvement in a SP. This highlights that these differences need to be considered and played within the context of a project-informed analysis of SPs that is informed by the development of a dialogue between the triple helix and IVC approaches. This research tries to fulfil these gaps by exploring the implementation of SP

policy in Thailand focusing on the relationships between projects within firms and between projects and inputs from HEIs and SPs. The analysis is based on the application of triple helix and the IVC approaches. However, a new *string-based* approach will be developed to enhance understanding of the roles and contributions different innovation stakeholders play at the project level and placed within the context of the triple helix and IVC approaches, linking the micro with the meso and macro levels.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This thesis explores the following research questions: *How are innovation projects within firms linked to a SP organized, and how are differential outcomes explained in terms of more successful projects compared to those projects that failed to meet the objectives set by the firm and/or the SP?* The research objectives include a focus on exploring the implementation of place-based innovation policies focusing on science park (SP) initiatives in emerging economies and their influence on firms' innovativeness and the regional economy through an analysis of innovation projects within firms within the context of the on-going implementation of SP policy. This includes defining the role played by SPs including critical inputs provided from SPs, academics, and entrepreneurs, and the relationships created that drive the success or failure of innovation projects within firms. Moreover, the study developed and applied a critical evaluation and appraisal of exiting theory to understand SPs and to consider this in the context of an emerging economy setting, including developing new approaches to theorising SPs.

To explore these research questions and objectives, it is important to understand the development of SPs in general, including SP policy implementation in advanced and emerging economies. There are many studies of well-known SPs such as the Cambridge Science Park, UK, and SPs in Silicon Valley, USA, and these have tended to dominate the conceptual and policy framing of SPs. Likewise, there are less well known SPs including those in Greece (Bakouros, Mardas and Varsakelis, 2002), Portugal (Ratinho and Henriques, 2010), Spain (Vásquez-Urriago, Barge-Gil and Modrego Rico, 2016; Albahari *et al.*, 2017; Hobbs, Link and Scott, 2017).

SP policies have been widely adopted by developed and emerging economies and usually these policies have been informed by the triple helix model that highlights the need for cooperation between government, higher education institutes (HEIs), and private businesses; the roles played by these key actors must be identified as well as the expectations of each actor and the benefits they might receive from participating in SP programs.

This chapter explores the tools and techniques required in gathering and analysing the data to answer the research objectives. The tools and techniques were selected and customized to meet the local context. The development and implementation of the study's data collection plan, difficulties encountered in the field, and the strategies to overcome these obstacles are reviewed. There is a positionality issue that needs to be highlighted. I used to work for Thailand's Science Park Promotion Agency (SPA) and it was this agency that was responsible for the establishment of the country's RSPs. The former role enabled access to officials, but there was not direct evidence of this influencing the interview process.

The next section of this chapter explores the research design which is based on a comparative case study method with firm-based innovation projects of firms involved with Thailand's Northern Science Park (NSP) initiative as the object of study. The third section reviews the methodology and the stages involved in the research design and linked methodology and this includes the literature review, policy analyses, developing and testing the face-to-face interview tools, data collection and analysis. Problems encountered during the data collection process are presented in the fourth section, following ethical concerns, and this chapter ends with a summary.

3.2 Research design

Understanding phenomena or exploring research questions can be undertaken using appropriate research designs and related methodologies (Hakim, 2000; Gorard, 2013). Hence each design provides different benefits and limitations; it is crucial that the researcher has to carefully select the most appropriate approach for the question(s). Moreover, De Vaus (2001) mentioned that most social research students often lack appropriate design, which has led to difficulty in choosing data collection methods. Acknowledging those, a research design was carefully selected to match the research objectives and could be operationalised.

The comparative case study approach was considered the most appropriate design for this research. SPs in advanced and emerging economies will be studied to identify the factors that positively and negatively affect the success or failure of the SPs' establishment. The SP's innovation projects will be analysed to find the key inputs that influence or compromise the research commercialisation and firm's innovativeness, and the impact of each RSPs on the regional economy will be explored.

Comparative case study approach

A case study method is the preferred approach to answering 'how' and 'why' questions (Yin, 2009). The case study is an analysis or exploration that allows a more profound understanding of the 'case' or a study unit on the wide-context issue. In this case, it may contain a large variety of success factors. There is a wide variation of the study (Bryman, 2016), including an individual's life, such as marriage, work, or household. Studying about places can be varied from a house, a region, to a country or continent. Events that happen in one area can also be served as a case. The organisation, such as a company, hospital, and school, can be a study unit. The decision can be a case as well as time, such as changing the workplace or

relocation or what happened in 1970. Data to develop a case study may be available from documents, artifacts, interviews, observations, surveys, and archival data (Eisenhardt and Graebner, 2007; Yin, 2009). As summarised by Potisook (2011), a case study design is commonly used in social sciences research such as social anthropology, psychology, history, and education. It is a widely used method in both quantitative and qualitative research for studying one subject intensely (Yin, 2009, 2012; Bryman, 2016).

Case study research can help the researcher explores further than the limitation of quantitative research as it entails the researcher applying a holism approach to the study (Zainal, 2007). The research usually concentrates and complete throughout the specified period. It grants the researcher to observe the object in a natural environment or how things happen in the actual situation. It can give a broad range of knowledge depends on the researcher's perspective. Thus, the researcher needs to speculate the selected cases from different perspectives or scans for other possibilities to prevent bias, conflict, or any faulty in the study (Hakim, 2000). The researcher should have basic knowledge about the case to understand its overall perspective. Besides, some cases may require technical or specific knowledge for a better understanding.

As the case study design allows the researcher to investigate the single subject in-depth in its natural environment (Eisenhardt, 1989) by combining external and internal influences, this research design can give a more accurate explanation than other designs. The disadvantage of a single case study is that it shows the fact of only one subject. The researcher cannot go beyond that case because each case has its character and was affected by different influences. To extend the study's accuracy, the researcher may investigate several cases that share some common issues. The multiple cases study may require more investment in time and cost in exploration. However, the analysis is more accurate than a single case study given the ability to compare between two or more cases (Bryman, 2016). Therefore, to understand the common

factors that enhance or compromise the success of the innovation project and SP's operation, the comparative case study is the most suitable approach for conducting this research.

The exploration focussed on studying SP operational functionalities at the institutional and project level. To De Vaus (2001), the case study research design allows the research to use the theory-centered approach. There is theory testing and theory building approaches. Applying the theory testing approach, the researcher research by having a specific proposition about the research's answer and investigate the case(s) to either prove or disprove the proposition. In contrast, a theory-building approach is the study method in which the researcher sets up the research question and explores the case(s) and then presents the specific proposition that gives a clear understanding of the case in the actual situation (Eisenhardt, 1989; Bryman, 2016). This process of theory building emerges by identifying repetitive patterns within the case data informed by theory and engagement with the literature (Eisenhardt and Graebner, 2007). Therefore, a case study approach allows theory-building to be applied to explore multiple examples of firm level innovation projects to identify similarities and differences linked to the success or failure to commercialize the outputs from a SP facilitated research and development project.

Data collection was undertaken using a mixed method approach due to the sample size, data availability, and participant culture. Quantitative data included statistical information for example the increasing rate of firms' R&D investment and revenue, numbers of tenants on a SP's premises, and evidence for any increase in economic activities around each RSP. Qualitative data included the management of SPs, relationships between academics and entrepreneurs, entrepreneur's expectations and the benefit received from participating in a SP program. The data collection process was informed by the literature review, SP annual reports, government publications and interviews with relevant stakeholders.

3.3 Phases within the research design, including methodology

This thesis explores the implementation of innovation policy within the context of a SP initiative in an emerging economy setting and this includes defining the roles, activities, and relationships between each actor involved in the triple helix with a focus on participation within Thailand RSPs establishment. This analysis was framed within an analysis of the influence this RSPs had on the development of local industrial clusters and the regional economy. To Bowen (2009), details regarding how the research was designed and conducted should be presented in detail. This section explores the development and application of a phased or staged approach to the data collection process and this reflects the sequence of activities developed as part of the research design (see Bryman, 2016, p. 378). This data collection process was developed and amended in the field in response to local conditions including problems with accessing participants. Each stage will be explored in turn including any alterations to the research design and related methodology and the consequences of these alterations.

The research design consisted of eight stages reflecting approaches that are commonly accepted within existing published papers on SPs (see Massey, 1992; Vedovello, 1997; Radosevic and Myrzakhmet, 2009; Ratinho and Henriques, 2010; Cadorin, Johansson and Klofsten, 2017; Etzkowitz and Zhou, 2018; Albahari, Klofsten and Rubio-Romero, 2019; Cadorin *et al.*, 2020; Ng *et al.*, 2021). These papers, begin with a literature review, and then identify and justify the selection of the SP(s) as an object of study and place the selected SP(s) within a wider context of policy analysis. The data collection process often includes series of focused interviews with participants involved in specific SP(s) including private businesses (Ng *et al.*, 2021), SP management (Ratinho and Henriques, 2010; Cadorin, Johansson and Klofsten, 2017; Albahari, Klofsten and Rubio-Romero, 2019; Cadorin *et al.*, 2020), academic researchers, or more than one participant groups (Massey, 1992; Vedovello, 1997; Radosevic

and Myrzakhmet, 2009; Etzkowitz and Zhou, 2018). This thesis applied a similar research design and methodology to that which has been developed and tests in existing papers. Each stage will now be explored in turn.

Stage 1: The analysis of previous literature on innovation policy and SP development

A detailed literature review was undertaken to frame this study within the existing academic and policy literature (Bryman, 2016). In this research, the previous literature about the development of SPs or cluster technology overseas in the advanced and industrialised economies, such as the Cambridge Science Park and the Aston Science Park in the UK, the Silicon Valley and the Route 128 in the USA, and SPs in Spain and Portugal was reviewed as well as the literature on SPs in emerging economies such as China and Greece to identify factors that might influence the success and failure of SP policy implementation. The available literature on the triple helix, the role of HEIs in developing firms' innovativeness and regional economy, economic geography, and the innovation process of the firm and institutional logic is also considered.

This literature review highlighted that SP policy implementation has tended to be based on the triple helix model and the roles played by government, HEIs, and private business at the macro-institutional level. Nevertheless, it is important to understand policy implementation at a micro level defined as innovation projects within firms that are involved with a SP. Here it is important to appreciate that the three institutions that are highlighted in the triple helix approach may be perhaps less well-developed in an emerging economy context. This is an important point. Then suggests that within emerging economies that the research focus of studies into SPs must focus on firm-level processes that are explored in the context of a triple helix framework. There is another point to consider. Within an emerging economy setting the regional innovation

setting may perhaps be less complex compared to developed market economies and one implication being that innovation processes may be much more transparent or easier to identify and research. In this context, it is important to note that research on SPs has focussed more on developed market economies and that much less is known about regional and firm-level innovation processes in emerging economies. The data for further study will be collected by interviewing the participants who were involved with innovation projects supported by one of Thailand's RSPs. The next stage describes SP's identification in Thailand, which we will use as an object of this study.

Stage 2: Identify the SP in Thailand

SP that will be identified as the subject of study should provide rich in accurate and sufficient information to be explored effectively (Potisook, 2011). There are four SPs in Thailand (**Table 3.1**). Thailand Science Park (TSP), located in central Thailand, operated by the National Science and Technology Development Center (NSTDA). There was no cooperation with the university, but it has five research units of its own. TSP was established to commercialise the research of those five research institutions. The other three SPs locate in northern, northeastern, and southern Thailand. These RSPs were operated under the monitoring of the SPA. The RSPs were established to support the small and medium-sized enterprises (SMEs) and start-up firms in the local area to advance their businesses by using local HEIs. There are 13 universities in the RSPs networks. The budget is allocated to the host universities that will allocate to the network universities according to their expected performance each year.

Table 3.1 Summary of Thailand's Science Parks (as of March 2019)

Name	Thailand Science Park	Northern Science Park	Southern Science Park	Northeastern Science Park
Start Year	2002	2013	2013	2013
Host University	No	Chiang Mai University	Prince of Songkla University	Khon Kaen University
Network University (include host)	Four research units of NSTDA	7	2+1 software development centre	4
Number of active Researchers	2,780	406*	220*	462*
Budget (2013-2017) (Million Bath)	N/A	2,680	3,198	2,746
Area (sq. m.)	266,000	TBA	320,000	56,000
Building Status	Completed phase 2 in 2017	Completed in 2018	to be complete in 2019	Completed in 2018
Tenants	90	selecting process	selecting process	selecting process

Note: *(Wongpridi and Sudhipongpracha, 2017)

From all the SPs in Thailand, excluding the TSP that has different management and policy, NSP is the most appropriate subject to this study due to its readiness of infrastructure, size of researchers and businesses participated in its programs, all universities in the network operate full SP's functions, and the understanding of the management toward the RSP policy implementation.

Stage 3: The analysis of Thailand's policy

This stage was exploring Thailand's background, including the country's economy and the development of policies. The analysis of data collected from organizations and institutions was important to inform the qualitative research phase combined with other research methods (Bowen, 2009). In this thesis, the documents related to the topic of interest including government policies and plans, economic reports, annual reports, policy reviews, articles,

journals and other publications mainly were available online in Thai language. The documents about RSP development policy, such as RSPs annual reports and the strategic plans, were collected from SPA in hardcopy and digital formats. The documents were grouped according to the topic (**Table 3.2)**.

Table 3.2 List of documents for Thailand policy development background

National policy documents
The 11th national economic and social development plan (2012-2016)
The 12th national economic and social development plan (2017-2020)
The 20-year Thailand National Development Strategy (2017-2036)
An industrial development policy document
National Industrial Development Master Plan 2012-2031
Cluster policy documents
Cluster project by Industry Promotion Office, 2007
Cluster mapping project by Kenan Institute Asia, 2008
The diamond model analysis of the ICT cluster in Thailand, 2012
Concept paper: Innovation, R&D driven cluster development, 2013
Cluster: Business Integration for Increasing Competitiveness, 2015
Thailand moving ahead with cluster development by Thailand Board of Investment, 2015
Ten Target Industries: Driving the Economy for the Future, 2015
Special economic zone in cluster form, 2016
Ministry of Industry announced a cluster development plan for future industries, 2016
Ten target industries, a mechanism for economic development (New engine of growth) by the Office of Industrial Economics, 2017
Executive summary: White paper on SME 2019 by the Office of Small and Medium Enterprises Promotion
Science, technology and innovation policy documents
The 1st national science, technology and innovation policy and planning (2012-2021)
The 20-year Strategic Plan, Ministry of Science and Technology (2017-2036)
The 5-year Strategic Plan, Ministry of Science and Technology (2018-2022)
Action plan of the Ministry of Science and Technology 2017
Action plan of the National Science Technology and Innovation Policy Office 2017
Thailand's Competitiveness in Science, Technology, and Innovation 2017 by the National Science Technology and Innovation Policy Office
Budget for Research and Development 2018, Ministry of Science and Technology

Ministry of Higher Education Science Research and Innovation Annual budget summary 2020
University business incubation program
Teacher Civil Service and Educational Personnel Act, BE 2547
University Business Incubation and Thailand Development Gateway by Office of the Higher Education Commission
Background of University Business Incubator by University Business Incubator Rajamangala University of Technology Lanna
Business Incubation Center in Higher Education Institutes by University of Phayao Incubator
University Business Incubation program (UBI), 2015
Critical Factors of Thailand University Business Incubator, 2018
Science Park policy
History of Thailand Science Park by TSP
The regulations of the office of Prime Minister on science park promotion, 2011
Strategic development of Thailand's science parks (2013-2017) by SPA
Science Park for increasing country's competitiveness by The Securities and Exchange Commission, 2013
Study of Strategic Factors in Developing Science Park for Success: International Good Practice by SPA, 2014
Development strategies of science, technology and innovation infrastructure by NESP
Northern Science Park Annual Report 2014
Northeastern Science Park Annual Report 2014
Southern Science Park Annual Report 2014
Northern Science Park Annual Report 2015
Northeastern Science Park Annual Report 2015
Southern Science Park Annual Report 2015
Northern Science Park Annual Report 2016
Northeastern Science Park Annual Report 2016
Southern Science Park Annual Report 2016
Summary of Thailand Regional Science Parks Operation 2013-2016
Innovation Roadmap: Regional Science Parks and Flagship Industries Drive by SPA, 2017
Northern Science Park Annual Report 2017
Northeastern Science Park Annual Report 2017
Southern Science Park Annual Report 2017
Northern Science Park Annual Report 2018
Northeastern Science Park Annual Report 2018
Southern Science Park Annual Report 2018
Science Park Network Project by SPA, 2019

Lower-Northeastern Science Park Project by SPA, 2019

Thailand 4.0 policy
Thailand Industrial Development Strategy 4.0 20 years plan (2017-2036)
Summary of Thailand 4.0 policy by the Royal Thai Embassy at Washington DC
Summary of Thailand 4.0 policy by The Secretariat of the House of Representatives, 2016
Follow up with the policy - Thai Research for Thailand 4.0, 2018
Thailand 4.0 policy: Opportunity, threat, and benefit of Thailand in ASEAN, 2018
Policy review
Trends and directions in science and technology research to enhance national competitiveness, 2013
Science, Technology & Innovation Policy Review by UNCTAD, 2015
Mega Dive Thailand Report 2016 by IMD World Competitiveness Center
The global competitiveness report 2017-2018 by World Economic Forum
Thailand Ease of Doing Business Index by World Bank

At this point, the understanding of the Thailand economy and the development of innovation policy in Thailand formed. The SP policy from the Ministry of Science and Technology and the cluster policy from the Ministry of Industry are related and cannot implement without coordination. The cluster policy aimed to enhance the businesses competitiveness, which had to be supported with the SP policy that will connect the entrepreneurs in the clusters to the universities' academic knowledge and R&D equipment. The policies implementation had to be explored further by interviewing the practitioners. The development of questionnaires is presented in the next stage.

Stage 4: Developing of the interview guides

Additional data about innovation policy implementation and the innovation projects of NSP were collected by semi-structured interviews informed by an interview guide developed through a detailed and critical reading of the literature. A series of questions were prepared as an interview guide but the sequence in which questions were asked varied between interviews

and additional follow-on questions were also added based on interviewee's feedback (Bryman, 2016). Interviews are often the primary source of data as it is an effective approach for collecting rich empirical data (Eisenhardt and Graebner, 2007). Moreover, an interview can give more detailed information than using surveys or secondary data (Yin, 2012). This method was selected also, considering that most participants preferred to talk rather than fill up the form or write the open-question survey. Moreover, semi-structured interviews highlight interviewee's opinions rather than reflecting interviewer's concerns (Bryman, 2016). An in-depth interview provides an opportunity for participants to express their opinions and understanding of a topic (Yin, 2009). A face-to-face interview provides opportunities for a discussion to develop that ideally should result in the development of a rich dialogues that has the potential to enhance understanding of processes and related events, and it can support theory building as aimed for this research.

The interview guides were developed in five different sets for each group including Thailand's SPs directors, NSP director, universities in the NSP network, business entrepreneurs, and academic researchers. Although having minor differences, the interview guides contained the same objectives in gathering information on the development of firms in NSP, how SP influenced the local economy, cooperation between SP and HEIs, roles of an institute and the participants in SP policy implementation and regional economic development, the relationship in NSP innovation project, and perception of the participants toward RSP policy implementation including any limitation and recommendation.

Timing is vital in conducting the interview; the interview guides were kept brief with an estimated interview time not to exceed 1.5 hours. The first draft of the interview guides included over 30 questions but later grouped and amended to have less than ten questions and concluded the conversation within the expected time frame. The final version of the interview

guides (**Appendix A-E**) was then translated to Thai (**Appendix F- J**) and sent out to the potential participants with a recruitment letter, participant information sheet, and consent form during the recruiting process.

Stage 5: Recruiting participants

To reduce data collection bias, interviews were conducted with participants from different group (Eisenhardt and Graebner, 2007). Accessing key informants plays an important role in the success of a study (Yin, 2009). This research collected data by interviewing participants from Thailand's SP directors, universities in the NSP network, business entrepreneurs and academics who were engaged in NSP's innovation projects. In-depth interviews are required to identify each actor's inputs and relationship at the project level and explore how the RSP policy has been implemented. The data was collected from all four SPs' directors since they work cooperatively as a national network. The entrepreneurs who participated in NSP's innovation project, and the representative of universities in a network and their academics who join the NSP innovation project need to be interviewed to have the data that include all key actors from each helix. The selection criteria and the approach to recruit each group were different.

It should be noted that the recruitment letters and other documents sent to the potential participants are in Thai, translated from the original documents developed in English (**Appendix K-O**). Considering that I still hold a position as a government officer during this study and all four SPs in Thailand were state-owned, it was appropriated and more effective to have the letters signed by the Minister of Science and Technology. Moreover, the contact information of SPs directors, NSP network universities, and entrepreneurs in NSP projects were available in the SPA database which I had access to it.

1. Recruiting the SPs directors and managers of universities' SPs in the NSP network

Thailand RSPs are operated under the management of the host universities. NSP was hosted by Chiang Mai University (CMU). Six network universities were spread throughout northern Thailand. Each has its SP as one department of the university. Thus, the representatives from the host and other six universities[8] in the network of NSP will be included in the interview (**Appendix P**). The contact information of all SP directors and network universities were available at the SPA. Recruitment letters, a participant information sheet and consent form, and a list of questions were sent by post and email, asking them to allocate their available time for approximately an hour-long interview.

2. Recruiting private business entrepreneurs

The entrepreneurs are vital in this research as their development is the objective of RSPs establishment. The criteria for selecting the entrepreneurs for the interview are that they had to be matched with an academic and participated in at least one NSP innovation project. The business must still be active in the market by the time of recruitment. The businesses' industries should be mixed, including agricultural and food processing, leisure service, construction, healthcare, entertainment product, and IT service.

The list of the firms participated with NSP, and full contact detail was obtained from SPA in July 2018. Recruitment letters, participant information sheet and consent forms, and a list of questions were sent directly to 29 potential businesses by post and email. The list of potential firms to be recruited was also sent to the NSP to help persuade them to participate. Twenty-one respondents agreed to be interviewed either by phone or face-to-face. However, as

[8] Network university is the research institutes and public university that already has strong R&D capability. These selected universities are encouraged to establish their own SP relying on the existing resources as the base and investing in the infrastructures those still lacking (Science Park Promotion Agency, 2013). The network universities will cooperate with their RSP. For example, the six network universities in northern Thailand will operate under the budget and KPI allocated from the NSP.

businesses' location should be balanced between outside and inside the SP premises, additional 12 letters to recruit selected businesses were sent out in January 2019. This time, the letters were sent to NSP as the coordinator agreed to deliver and coordinate further with the entrepreneurs. All of them agreed on interviewing. The list of participants from the private business shows in **Table 3.3**.

Table 3.3 Summary of 33 firms interviewed

Company	Location	HEIs Engage	Core Product/Service
C01	Off-site	CMU	OEM herbal products
C02	On-site	NU, MJU	Food supplement
C03	Off-site	NU	Drink
C04	Off-site	CMU, UP	Chilli paste
C05	Off-site	CMU, UP, MJU	Coffee products
C06	Off-site	CMU	Food
C07	Off-site	CMU	Construction material
C08	Off-site	CMU	Food processing machines
C09	Off-site	NU, PSRU	Food
C10	Off-site	MJU	Hotel business
C11	Off-site	MJU	Food
C12	Off-site	CMU	Soap material
C13	Off-site	MJU	Food supplement
C14	Off-site	CMU	Music box
C15	Off-site	UP	Food
C16	Off-site	PSRU	Food supplement
C17	On-site	NU	OEM cosmetic
C18	Off-site	PSRU	Food
C19	On-site	MJU	Software and system development service (IT)
C20	On-site	MFLU	Coffee products
C21	On-site	MFLU	Web development service
C22	On-site	MFLU	Eco-tour operating service
C23	On-site	NSP/CMU	Architect, interior, and corporate design service
C24	On-site	NSP/CMU	Products from honey
C25	On-site	NSP/CMU	Food supplements, cosmetics, and snack

Company	Location	HEIs Engage	Core Product/Service
C26	On-site	NSP/CMU	Market research, customer feedback
C27	On-site	NSP/CMU	Research based company focuses on AI technology
C28	On-site	NSP/CMU	Web platform for apartment management
C29	On-site	NSP/CMU	Customer feedback analytic
C30	On-site	NSP/CMU	Material, bioscience (food, extraction)
C31	On-site	NSP/CMU	Medical device & pharmaceutical
C32	On-site	NSP/CMU	Cooking sauce (healthy products)
C33	On-site	NSP/CMU	Education

Despite the 33 private sector firms are long-established or not, they were listed as 'small' businesses in the government's database. There were only four firms that had more than 50 employees. Over half of them were existing firms with experience producing and marketing their products at the local scale before registering for a new company and received support from the NSP. Most of the R&D supported by the SP was adding value to the product and waste, developing a new recipe, improving production efficiency, and creating a new product line that was different from the existing products. Sixteen firms just established by the time they attended the SP's programs, with three of them were formed for research commercialisation. Sixteen firms located in the network universities or NSP, and the other 17 firms located off-site.

3. Selection of academic researchers

The researchers were selected from different universities in the NSP network. They can be of any sex and age. The professions were mixed, including medical, food processing, engineering, IT, pharmaceutical, agricultural technology, and biotechnology. The participants should lead at least one NSP innovation project based on the firm's R&D request and currently active in academic duties.

The potential academics were selected from the SPA database that includes their contact detail. Considering the possibility in changing address or relocating the office, email was the

most effective communication for the university academic. The recruitment letters and related documents were sent by email to 44 researchers. Fourteen researchers agreed to be interviewed either face-to-face or by phone. The list of academic researchers who responded to the interview requests is shown in **Table 3.4**.

Table 3.4 Summary of 14 researchers interviewed

Code	Professional	University	Start Contract with HEI
R01	Food Science and Engineering	PSRU	1998
R02	Computer Engineering (Optimization Theory and Applications)	CMU	2011
R03	Agricultural Science	NU	1995
R04	Agricultural Engineering	CMU	NA
R05	Computer Science and Software Engineering	CMU	1996
R06	Medical Science, Pharmaceutical	UP	2006
R07	Phytochemistry, Bioactive compounds, Plant biochemistry	CMU	2011
R08	Food Science and Technology	UP	2003
R09	Product Development, Quality Control, Statistic Analysis	CMU	1996
R10	Health behavioural Modification, Nutritional behavioural Modification, Nutritional status Promotion in individual and community, Dietary supplement development for Healthy purpose	CMU (just transferred from UP)	2012
R11	Information Technology and Communication	MJU	1996
R12	Pharmacology and Toxicology	CMU	2001
R13	Engineering (Bio-Industrial Mechatronics Engineering)	MJU	2003
R14	Software Engineering	MFLU	2006

The 14 researchers had a variety of backgrounds. However, their research was mainly related to food and agricultural products, such as improving machine efficiency and recipes for food or dietary supplements. A few had undertaken R&D software development. All had experience of working with private businesses under the cooperation of NSP and other government projects. Seven out of the 14 were from CMU. This is because CMU is a famous

university in the northern area and is the host university for the NSP. It has equipment and researchers in all fields to support private business R&D activities linked to NSP. It has been contacted by entrepreneurs located in the region more than smaller universities.

The total number of participants recruited for this research was 57 respondents, including directors from all four SPs in Thailand, six representatives from the universities participating in the NSP's network, 14 academic researchers who had been or were currently involved in NSP innovation projects, and 33 entrepreneurs who had been or were currently involved in developing products or services with support from the NSP. The businesses were located either on the NSP (in the NSP's premise or in space provided by one of universities linked to the NSP) or located elsewhere but with an innovation product supported by the SP.

Stage 6: Interviewing process

The research and data collection process was planned based around the time available and the research funding (Bryman, 2016). The interviews were scheduled and conducted from October to December 2018. My base location was in Bangkok, the capital city of Thailand, located in the central region. The face-to-face interview requires travelling around the country since each SP located in a different region across Thailand. The travelling plan had been developed, putting more time in the northern region to cover as many participants as possible. Accommodations booking, route, and weather checking were made before starting the field trip to avoid unexpected circumstances that may delay the interviewing process. Time spent at each location was based on the number of participants in the nearby area and the driving route. Although I preferred having a face-to-face interview to observe the participants' facial and body expression, some interviews were conducted by phone. This is because some businesses located in the further area that was difficult to reach or the participants' available time slot did not

correspond with the field trip schedule developed based on the appointment time agreed with other participants (**Table 3.5**).

Table 3.5 Field trip timetable for an interview

Date of the month (2018)	**1-7**	**8-14**	**15-21**	**22-28**	**29-30/31**
October (northeastern)			Khon Kaen (16-20)		
November (north)		Chiang Mai (11-17)	Phayao (18-20)	Uttaradij (21-24)	Phitsanulok (25-30)
December (south)	Hat Yai (5-9)				

A reminder email or phone call was made one day before the interview date to reconfirm the time and venue. The interviews with SP directors were done at the SPs' offices, and this allows me to inspect the SPs facilities and their tenants at the same time. Most of the network university SPs' manager and the academics preferred having the interview at their offices. The entrepreneurs' interview venues were varied from their factories, the office at the university SPs, and the coffee shop. One to four interviews were done per day, depending on the distance from one place to another.

Before starting the interview, the participants were again presented with the participant information sheet and brief information about the research. It is essential to inform the participants that the conversation would be recorded. The interviews were conducted using the list of open-ended questions prepared as a guideline. The time spent on each interview ranged between 16 minutes to three hours. The consent form was collected after finishing the interview. The recorded interviews were copied and stored in the researcher's notebook computer, USB data storage, and at the University of Birmingham data storage daily. The interview was expected to complete in one time. However, two participants (an academic and TSP manager)

called asking about the questions and gave some information during the phone call. In that case, the participants were able to give more precise information at the face-to-face interviews.

Despite having only 14 academic participants, the data reached saturation after interviewing nine participants. Reaching a saturation point suggests that further data collection might be unnecessary (Saunders *et al.*, 2018), but the interviews continued until all 14 participants were interviewed. At the end of December 2018, it appeared that the interviews of the entrepreneurs were not balanced. There were not enough on-site firms since some did not answer the phone at the appointment time and cannot be reached after that. Additional participants of on-site firms are needed. The process had to start anew using the same selection criteria. However, instead of selecting the firms from NSP's database, these other firms were from the recommendation of network universities coordinators who hold the list of firms that were not yet updated to the database. This second batch of interviews was done only by phone from January to February 2019. The data collected from the firms reached its saturation after interviewing ten to twelve of them for both on-site and off-site firms. The summary of all 57 interviews is in **Table 3.6**. To protect the identity of the interviewees, each interviewee was assigned an identifier code. These codes contain a letter and number. Thus, the letter 'C' indicates that a quotation comes from an interview with a business entrepreneur. Thirty-three entrepreneurs were interviewed resulting in codes from C01 to C33. The letter 'R' was applied to identify academic researchers and these codes range from R01 to R14. The letter 'U' denotes interviews with representatives from universities involved in the NSP network and these codes range from U1 to U6.

Table 3.6 Summary of interviews

Date	Participant	Interview method	Duration (minutes)
5 October 2018	C10	Phone	15:54
11 October 2018	R01 (first interview)	Phone	35:56
12 October 2018	TSP (first interview)	Phone	46:39
18 October 2018	NESP	Face-to-face	34:08
22 October 2018	TSP (second interview)	Face-to-face	113:45
25 October 2018	R11	Phone	26:38
5 November 2018	U6	Face-to-face	49:24
12 November 2018	R05	Face-to-face	47:49
	R09	Face-to-face	27:39
13 November 2018	R02	Face-to-face	48:00
	C07	Phone	33:21
14 November 2018	C08	Face-to-face	34:09
	R10	Face-to-face	38:37
	C05	Face-to-face	59:04
15 November 2018	U3	Face-to-face	68:58
	NSP	Face-to-face	61:01
	C11	Phone	23:26
	R12	Face-to-face	23:29
16 November 2018	R13	Face-to-face	35:46
	R04	Face-to-face	40:17
	C06	Face-to-face	26:16
	R07	Face-to-face	26:16
17 November 2018	C14	Face-to-face	106:05
19 November 2018	U5	Face-to-face	82:29
	C13	Phone	25:17
20 November 2018	R08	Face-to-face	54:44
	R06	Face-to-face	24:13
	C15	Face-to-face	26:47
22 November 2018	C04	Phone	55:35
23 November 2018	C01	Phone	43:33
	U7	Face-to-face	61:24
	C12	Phone	17:44
24 November 2018	C03	Face-to-face	23:25

Date	Participant	Interview method	Duration (minutes)
27 November 2018	C16	Face-to-face	19:36
28 November 2018	R01 (second interview)	Face-to-face	61:19
	C09	Face-to-face	51:26
	C18	Face-to-face	29:10
29 November 2018	U4	Face-to-face	22:19
	R03	Face-to-face	31:23
	C02	Face-to-face	39:30
	C17	Face-to-face	36:04
6 December 2018	STSP	Face-to-face	79:11
21 December 2018	U2	Face-to-face	50:08
24 December 2018	C19	Phone	32:44
28 December 2018	C20	Phone	21:22
7 January 2019	C22	Phone	28:13
9 January 2019	C21	Phone	23:29
	R14	Phone	23:30
8 February 2019	C24	Phone	29:46
	C28	Phone	23:00
	C30	Phone	27:58
11 February 2019	C27	Phone	23:27
	C26	Phone	28:16
	C29	Phone	29:06
12 February 2019	C25	Phone	68:39
13 February 2019	C33	Phone	22:44
	C23	Phone	30:46
17 February 2019	C31	phone	33:22
19 February 2019	C32	Phone	29:11

Note: C: private business entrepreneur, R: academic researcher, and U: university involved in the NSP network

Stage 7: Transcription of interviews

The word-by-word transcription started during the time of the interviewing trip. It is essential to transcribe the interview as soon as possible since the conversation's memory is still fresh. It will be hard to revisit after time has passed. The draft of transcriptions was sent to

participants by email, and they could request for alteration or elimination. However, the final decision on making any amendment belongs to the researcher consideration. There were some requests to eliminate a few sentences off. However, after being reminded and confirmed that the participants' information that can be used to identify the person will be kept confidential, most of them agreed to keep the transcription as they were drafted.

The SPs directors, the network universities SPs managers, and the academics promptly submitted the transcription feedback. There was a problem that most of the entrepreneurs ignored to confirm the accuracy of the transcription. I had to call asking them to reply to the email. Most of them thought they did not have to confirm or answer if they had no problem with it since they already gave consent to record and use the interview data. This problem was later solved by informing the participants that any alteration or elimination had to be requested back to my email within two weeks, or the transcription will be used as-is.

The transcriptions were summarised and translated from Thai to English and sent to my supervisors for acknowledgement and monitoring purposes. It should be noted that some words in Thai can have different meanings depending on the context, and that meaning needs to be interpreted before translating. For example, ‘มัน’ (pronounce as Man) can be translated directly to ‘it’, ‘oily’, ‘fat’, ‘fun’. This word can also be referred to the disliked third person or the discussion topic in both a good and bad way. Another example is one participant informing he had a headache talking to an academic. This can mean he did have a headache, confused, stressed out, annoyed, or disappointed. The interpretation needs to consider the further explanation of the speaker. It is crucial to consider the previous and following conversation, topic, and other expressions, including body language, facial and tone of voice, to understand and carefully select the matching words for accurate transcribing. Some words cannot be accurately translated to English, such as 'เกรงใจ’ (pronounce Kreng Ci). The closest translation

is 'be considerate' or 'thoughtful', but it still cannot translate the real meaning. Due to this language barrier and to keep the accuracy, the data analysis was done in Thai.

Stage 8: Data analysis

The data analysis should start as soon as possible to avoid problems related to data staggering (Eisenhardt, 1989). Translation from one language to another might impact on data accuracy and given this the analysis was undertaken in the language used by the interviewees - Thai. Thematic analysis is the method used to extract themes and core issues by coding the transcripts (Bryman, 2016), and this process was undertaken using software that was compatible with the Thai language. The Thai language is not widely used internationally. It was important to use software to support the coding process that was compatible with the Thai language. A suitable program identified that is used to code interview transcription in Thai and that has been widely used by Thai academics. Many Thai researchers recommended NVivo for analysing transcription from interviews conducted in Thai and this programme.

The process of analysing started with reading through the transcription to find the theme and critical issues such as the distinction between new and existing businesses, the distinction between businesses located on and off SP, business agglomeration, a benefit for a researcher, academic spin-off, law and regulations, and other themes related to research interest. The key-related issues were grouped as nodes and labelled as business development, collaborative research, economic development, government policy, relationship, the role of a university, and SP policy implementation. One transcription contains several nodes, and some sections of the transcription were assigned to more than one node since the themes were overlapping. The use of NVivo allowed the coding to be done systematically. The themes were highlighted, and the data was grouped, showing each participant group's concerning issues and the main issues of

each transcription. The transcriptions were classified, such as on-park firms and off-park firms, businesses size, products, age of the businesses, types of university, and profession of the university researcher. The data then analysed and interpreted into three chapters (Chapter Four, Five, and Six).

One critical point is how success is measured in terms of firms and their involvement in a SP innovation project. Assessing or measuring project success is difficult. This could be measured by an assessment of risks versus rewards with a focus on investment returns. This type of finance approach is difficult, and the majority of firms interviewed for this study would have been unable or perhaps unwilling to provide this type of data. There is the added complication of lag times that exist between project completion and outcomes and this lag time will differ between projects. In addition, unexpected outcomes might result from a project. Both expected and unexpected project outcomes may include impacts that are impossible to measure. Question Three and Four of the interview schedule asked entrepreneurs to talk through one innovation project that they had completed within the context of NSP and its outcome. The question also asked interviewees to consider how this project was evaluated in relation to the company's expectations. Project success then reflects the interviewees assessment of project outcomes rather than a measure of success imposed upon each project by the researcher. Interview assessment was based on a project meeting the aims and objectives that has been set. The outcome is a classification based on successful projects, less successful projects, or project considered by interviewees as having failed to meet the aims and objectives. However, the interviews revealed more than one way to measure the success of an innovation project and this issue is explored in Chapter Seven.

3.4 Problems encountered with the research

Planning is a vital part of researching since it creates the framework on what must be done, when to be done, by whom, and how. Despite having a proper plan, an unexpected situation can occur. This research faced some minor problems during the data collection process. In this section, I will present the tense situations that occurred and how I overcame them.

Accessing to the participants

The problem of access to the participant happened during the recruitment process. Most of the private businesses did not respond to emails or letters. The first solution was calling them on the phone, informing my intention for interviewing, and asking them to reply to the email. However, this method is time-consuming and can be tiresome. I discussed this difficulty with my superior at SPA, who advised me to ask NSP to contact those potential participants on my behalf. I informed the NSP coordinator about the difficulty in contacting the business entrepreneurs, and they kindly agreed to assist with this matter. A list of potential business participants was sent together with the recruitment letter for the NSP director. The NSP coordinator helped coordinate further with the entrepreneurs. Both solutions solved the problem of accessing the entrepreneurs. However, the second solution, accessing through the gatekeeper, was more cost and time effective. Moreover, the participants were more cooperative in receiving a request from the NSP staff.

Technological problem

Collecting data from the entrepreneurs required travelling to their venues, and some places are remoted. Driving in the unfamiliar region, I prepared a GPS device that was upgraded

and using Google Map on my smartphone. The factory's address was confirmed, and its details include the factory name and address was checked by GPS device and Google Map before departure. I was a little concerned that the navigators led us (me and my companion) up to the mountain that looked like a deserted cornfield. There was no housing or anybody in the area, and the dirt road got narrower and narrower. However, since the appointment venue was an orange juice factory, I thought it might be near the orange garden. I kept driving until the car would not be able to pass through the dirt road. I decided to turn back, and we might have to do this interview by phone instead since it was too dangerous to drove further. At this point, I suggested having a life insurance policy before start going on a field trip. The road was narrow. I had to turn the car around at the cliff edge. I let my companion waited outside. In case I fell, she could get help. We finally made it down the mountain. The entrepreneur confirmed that the address was correct, but he then realised that it was mapped to the middle of nowhere. I reached the factory having the entrepreneur guiding the way over the phone. This problem can be prevented by not relying solely on the technology and always double-check with a paper map and never travel alone.

Balancing the sample size

Balancing the sample size is critical in preventing bias data collecting for the research that will further cause inaccurate analysis and data interpretation. After finishing the interviews in December 2018, the number of businesses locating outside of the SPs premise was 16, while only five businesses were locating on-park. The second recruitment was required to balance them. Due to the time constraint, the selection criteria were sent to each university SP's coordinator asking if any on-park firms match the criteria. The gatekeepers promptly assisted in coordinating with their tenants passing on the recruitment letter, participant information sheet

and consent form, and list of questions to the potential participants and gave me back the contact information of those who agreed to participate in the research. I accessed more participants through the gatekeepers because all firms that participated with NSP projects using in the first recruitment were last updated in 2017. There were more companies left unlisted by the data collection time. The second recruitment added 12 firms—the number of businesses on and off the park balanced at 17 and 16.

3.5 Ethical concerns

Every research design has to engage with ethical issues (De Vaus, 2001; Bryman, 2016). Concerning the consequence of participation, confidentiality is essential. The participants' names will be kept confidential. Personal information that can be used to identify the person was omitted from the thesis. Codes representing participants were used for the quotes and references from the interviews instead of their names and company name. Only the organisation's name will be presented in the report if agreed by the interviewees. The organisation's sensitive information include revenue, marketing data, capital, investment, supplier record, and customer detail, will be treated as the highest confidential. The decoding and interpreting of raw data will use code to represent the institution and firm, the researcher's position, sex, and age, instead of putting their names up. The name matching with a code will be kept in a separate folder.

The consent form and the list of questions were emailed or posted together with the participant information sheet. The potential participants had an opportunity to inquire before signing the consent form. The participants must give consent to having the conversation recorded and to be used in the thesis. All participants received the transcription allowing them to request to add or omit any information deemed confidential. However, the final decision was

up to my consideration. The executive summary of the research will be issued to each participant after the study has been completed. The hard copy of the data will be destroyed five years after finishing the research. The soft copy of the data will be kept at the University of Birmingham database and the Thailand Ministry of Science and Technology and destroyed ten years after research publication. Access to the statistical data had less barrier of access. The SPs annual reports and the data required from the government authorities were publicly available online in all relevant countries, the UK, the USA, and Thailand.

3.6 Conclusion

This chapter presents the method and tools used in researching the implementation of place-based innovation policies focusing on science park (SP) initiatives in emerging economies and their influence on firms' innovativeness and the regional economy. The data was collected as evidence for analysis. The quantitative and qualitative method was implemented and explained the detail at each stage of research, starting from pre-data collection to the tools and techniques used to analyse the data gathered. It appeared that an in-depth semi-structured interview was an appropriate tool to collect data from these groups of participants since they informed that talking was more preferred than writing the answer in the survey. Moreover, most participants preferred human touch and saw that this interview was another opportunity for them to promote themselves and support what the government requested.

Furthermore, planning is a crucial part of conducting the research, but alteration was unavoidable since other factors were out of my control. The problems encountered during the data collection process were revealed, including the suggestion to overcome them. The research method must be adaptable to the situation. Moreover, the researcher should be prepared for any difficulties and tense situations that may occur unexpectedly.

The next chapter explores the development of policy in Thailand intended to support regional innovation. The country's background and the development of national innovation policies will be explored to review the implementation of SP policy in Thailand and its influence on firm innovativeness and regional economic development.

CHAPTER 4

SCIENCE PARKS AND ECONOMIC DEVELOPMENT OF THAILAND

4.1 Introduction

This chapter explores the development and implementation of science park (SP) policy in Thailand. The Science Park Promotion Agency (2013) promoted the development of SPs, most of which are intended to be mechanisms and tools to support and encourage cooperation between entrepreneurs and universities related to research commercialisation. In the USA, the development of SPs is a model with the university as the base. The driving force comes from the needs of both the business and government sectors in the stimulation of local economies and prosperity by using cooperation mechanisms between the government, education, and business sectors as an essential tool. In the UK, the SPs establishment began with the university as the leading operator and played a significant role in the development of SPs to use as a source of income for the university. Meanwhile, the development of SPs in Asia concentrates more on enhancing the industries production capacity and economic growth and had less engagement with the higher education institutes (HEIs) at the early stage of establishment.

In general, there are three models of SP development (The Securities and Exchange Commission, 2013). The ‘science-push’ model is the first generation of SP development. SPs those established by this model developed further from the university’s research unit intending to transfer academic knowledge to the business sector and commercialise research result. Silicon Valley is one of the SPs that occurred by this approach. Next is the implementation of the SP policy adapted to ‘market-pull’ model. SPs was set up as a separate department and having its management team.

However, it still operates as part of the university, focuses on the needs of the business sector. The research reflexed directly to solve the difficulty in research and development (R&D) faced by the entrepreneurs. The example of SPs in this category is the Cambridge Science Park. The latest model to SP development is 'cluster-oriented interactive innovation'. SPs were established as an independent organisation as part of the local R&D infrastructure - the SPs in this category, usually located in the close distance to the community. The establishment aims to use a SP as a mechanism in supporting the industrial cluster development by being the coordinator for the government, university, and the businesses in doing R&D, and as a result to stimulate the economic activity.

The SP policy of Thailand is an attempt to overcome some weaknesses in Thailand's economy and try to break out of the middle-income trap that the country has been facing for decades (Pisalnupong, 2014). Policymakers in Thailand have explored the developed and developing countries to identify policy interventions that could be adapted to meet Thailand's context and has identified that the development of industrial clusters is an appropriate policy to improve entrepreneurs' capability and to maximise the efficiency of existing local industries. In supporting businesses by enhancing product value creation through the application of science, technology, and innovation (ST&I) and by encouraging the development of industrial clusters considered that this could stimulate regional and national economic growth and increase national competitiveness. In doing so, SPs were considered as an essential mechanism to support businesses. The government has implemented the SP policy in each region of the country to assist entrepreneurs in developing products and services through encouraging R&D as part of an incubation program that tries to match the needs of firms with the university expertise. The focus is on encouraging collaborative research and the commercialisation of research. Moreover, regional science parks (RSPs) in Thailand are intended to be the location

for technology-based businesses and to encourage new firm formation. Thus, proximity to similar types of businesses is a vital element of this policy with an emphasis on cluster formation that may occur adjacent to the SPs.

This chapter explores the development and implementation of the SP policy in Thailand in the context of an appraisal of the national economy. The first section starts with the background of the Thailand economy and what needs to be improved. Then, the study will lead to the national development policy include strategies for science and technology development and the cluster development policy. The focus is on understanding regional policy development and policy interventions intended to enhance national competitiveness. The next section is about the SP development policy in Thailand highlighting the government's belief in the potential contribution small firms will play to regional economies. Emphasis is placed on encouraging an increase in capacity of small and medium-sized enterprises (SMEs) and startup businesses. The focus of Thailand's regional policy is on applying ST&I developed within HEIs to firms. Further, we will explore the implementation of Thailand's SP policy that requires cooperation between universities, the business sector, and government support. The last section will be the discussion and conclusion of this chapter.

4.2 Background of Thailand

Thailand is an emerging economy which is heavily export dependent. The industrial and services sector are the main drive of country's gross domestic product (GDP). However, since 2012, the economic growth rate of the country has never exceeded 4% (Bank of Thailand, 2019). The country still needs to be developed in many aspects. The long-term problems that prevent the country from further development are, namely, income inequality, labour shortage due to becoming the ageing society. The citizens of Thailand still lack knowledge, skills, quality

and attitudes necessary to realize the development potential of the country (National Economic and Social Development Board, 2017). Natural resources and environment have deteriorated due to unsustainable utilization, resulting in higher economic costs and lower quality of life. Furthermore, the public administration has been lacking in transparency, highly corrupted, and inefficient (National Economic and Social Development Board, 2017). In attempt to eliminate these obstacles, the Thai government put the focus on one of the strategic development plans lies under the 11th National Economic and Social Development Plan (2012-2016) and continues in the 12th National Economic and Social Development Plan (2017-2021) where priority is given to human resource development, the development of innovation for the domestic economy and to meet the country's sustainable development goals (SDGs), and to restructuring economic activities in accordance with the Thailand 4.0 policy.[i]

Table 4.1 Ten years comparison of Thailand economy

	2008	**2017**
Gross Domestic Product (GDP)	THB 7.7 trillion (USD 226 billion)	THB 10.2 trillion (USD 300 billion)
GDP growth rate	7.2%	4.0%
Income per capita	THB 12,197 / month (USD 359.4)	THB 18,618 / month (USD 548.6)
Total exports	THB 5,851,371.14 million (USD 172,403.4 million)	THB 8,006,265.18 million (USD 235,894.7 million)
Total labour force increase rate	2.05%	-0.44%
Total investment ratio per GDP	26.4%	23.2%
Increasing in Capital Stock	10.7%	3.5%*
Total Factor Productivity (TFP)	128.5	147.5**

*as of 2015 **as of 2016

Source: Website of the Ministry of Commerce and adapt from Mahapornprajak (2019, p. 2)

Studies by the Thai government (The Securities and Exchange Commission, 2013; Ministry of Industry, 2016) have highlighted that Thailand's economic growth was driven by

efficient production (efficiency-driven) based on low-cost labour and the use of technology to enhance production efficiency. However, the current drivers supporting Thailand's economy may not be enough to develop continued economic growth over the long term. Economic development was concentrated on economic aspects without fully considering resources. Production processes utilize all resources without sustainable resource management. That creates further problems such as pollution, social inequality, and limited capacity improvement in human resource (Ministry of Industry, 2011). Moreover, being an upper middle-income country, labour costs are increasing. One possible solution is to try accelerating economic growth through innovation and the development of an innovation-driven approach with an emphasis on science, technology, and R&D to restructure the economy towards sustainable growth and to enhance quality of life. By focusing on creativity, intellectual property, R&D, and human capital development, Thailand aims to take advantage of innovation to develop better applications to serve both commercial and social communities (The Securities and Exchange Commission, 2013).

Science Park Promotion Agency (2013) reported that the ranking of Thailand's competitiveness by the International Institute for Management Development (IMD) and the World Economic Forum (WEF)[9] highlighted Thailand's weakness in the areas of science and technology development includes insufficient R&D investment and in science and technology infrastructure combined with a limited number of employees supporting R&D (the researchers). In addition, there are problems with the quality and quantity of academic researchers, a long patent granting process, and limited intellectual property rights. These factors limit the growth of scientific knowledge and technology to support national competitiveness. In addition,

[9] In 2016, WEF ranked Thailand at the 49th place from 189 economic regions. IMD has ranked Thailand at around 30th position from 59 countries since 2012 and at the 27th place from 63 countries in 2017.

various agencies under the Thai ministries still lack collaboration and effective mechanisms to establish linkages between the private sector and the research community. The risk management and the allocation of benefits arising from research and commercial development still remain unclear (Science Park Promotion Agency, 2013). Research outcomes have not been applied to business and there are problems with commercialisation of R&D. Therefore, it is still difficult for Thailand to effectively apply research results to enhance the national economy and society.

In January 2016, the Ministry of Commerce partnered with the IMD World Competitiveness Center to arrange a workshop to analyse the country's weaknesses that obstruct further economic development. Potential improvements to enhance Thailand's competitiveness were explored combined with suggestions in the annual reports produced by the IMD and WEF. From the Science Park Promotion Agency (2013); Institute for Management Development (2016); and National Science Technology and Innovation Policy Office (2017), the weaknesses and the potential development for Thailand included four issues:

1. **Investment in R&D:** Thailand's investment in R&D is limited compared to other countries in the same region. There are very few venture capitalists and limited access to funding to support R&D, especially for the private sector. In 2016, WEF ranked Thailand at the 42nd in terms of the absorption of technology, private sector investment in R&D projects was ranked at the 43rd, and research cooperation between businesses and educational institutions was ranked at the 39th (Schwab, 2017)[10]. However, in 2017, the IMD noted that Thailand had increased R&D investment by the government and private sectors, and this was ranked at the 36th as part of an analysis of 63 countries. R&D investment by the private sector had increased from USD 1,061 millions in 2016 to USD 1,736 millions, or increasing by 73% from 2016 (National Science Technology and Innovation Policy Office, 2017).

[10] The Global Competitiveness Report (2017-2018)

2. **A favourable environment for the development and application of science and technology:** The establishment of an international centre for knowledge transfer and human resource development[11], the amendment of rules and regulations to better facilitate the commercialisation of research, such as better intellectual property laws and tax collection policies to support the development of technology and economic growth.

3. **Significant areas for improvement in cooperation from the relevant authorities in the industry:** The private sector, public sector, educational institutions, financial institutions need to work together including, for example, the Office of National Committee on Competitive Advantage (NCC), the National Economic and Social Development Board (NESDB*)*, the National Science and Technology Development Agency (NSTDA), the Ministry of Industry, Department of Industrial Promotion, Research Department of Thai Military Bank and the Kenan Institute Asia. Thailand still lacks linkages in supply chains between firms and educational and research institutions. In addition, there are many suppliers available, but of relatively low quality.

4. **The infrastructure for ST&I:** In 2017, from 63 countries, Thailand's ranking for scientific and technological infrastructure by IMD was the 48th and 36th respectively (National Science Technology and Innovation Policy Office, 2017). A study by the Science Park Promotion Agency (SPA), Ministry of Science and Technology, concluded that the state has a major role to play in the development of ST&I (Science Park Promotion Agency, 2013, 2014, 2017a).

To improve the country's national competitiveness, Thailand has developed solution to eliminate these obstacles. The Ministry of Science and Technology established the initial five-year SP development plan to build an additional three SPs in each region of the country to

[11] known as Center of Excellence or COE (Yimnirun, 2013)

enhance R&D facilities. This aims to create a favourable environment for scientific research and technological innovation, the development in industrial applications, and to promote the use of creativity and value-added in service and manufacturing sectors (Science Park Promotion Agency, 2017a) that will attract technology-based entrepreneurs and to develop industrial clusters.

4.3 National strategy for science and technology development

To increase national competitiveness and in response to the 12th National Economic and Social Development Plan,[ii] especially adhering to the 3rd, 8th and 9th Strategies[12] (Ministry of Science and Technology, 2016), the Thai government realized the importance of economic development by the application of ST&I knowledge. Additional three state-owned SPs were planned to be established to develop clustering around economic zones suitable for technology and innovation in each region. The Thai government considers that SPs are important infrastructure for driving national economic development by promoting R&D, incubating new entrepreneurs, and enhancing the use of new technologies. They also operate as a link between industry, the public sector, the education sector, and the local community. This will create new technology businesses, promote the implementation of R&D into commercial protection and utilization systems, and develop human resources in ST&I (Science Park Promotion Agency, 2013). The growth of regional industries will further develop collaboration among each other and establish clusters.

[12] Strategy 3: Strategy for Strengthening the Economy, and Underpinning Sustainable Competitiveness
Strategy 8: Strategy for the Development of Science, Technology, Research, and Innovation
Strategy 9: Strategy for Regional, Urban, and Economic Zone

To improve the national economy and to promote the implementation of science and technology, for the fiscal year[iii] 2017, the Thai government allocated a budget of THB 310,963,900 (USD 9,162,165.59)[iv] to support four main improvements in ST&I together with the development of industrial clusters (**Figure 4.1**). Furthermore, the government also concentrated on promoting and supporting the development of technology to increase productivity. R&D is relatively expensive[13] for firms, SMEs, and startup businesses. They find it difficult to invest in R&D without government subsidy and support from the financial sector.

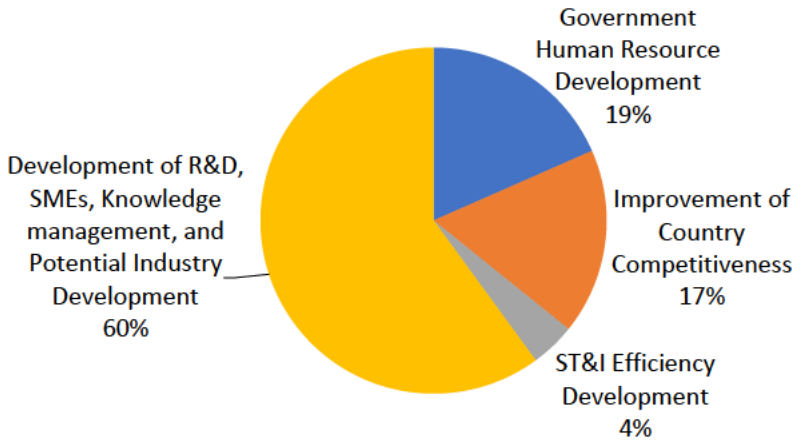


Figure 4.1 Budget allocated for science and technology development in 2017
Source: National Science Technology and Innovation Policy Office (2016, p. 1)

4.3.1 Thailand's cluster development strategy

One policy intended to promote economic and social development focused on the development of industrial clusters. The Thai government considers that clusters are an important tool and mechanism for increasing national competitiveness and economic development. The Department of Industrial Promotion, Ministry of Industry, was the key unit to support the creation and development of clusters. A Memorandum of Understanding (MOU)

[13] The costs of R&D include but not limited to the cost of investment capital, equipment and machinery, and human resource development.

dated 10th of June 2004, under the framework of the NCC, highlighted the need to promote the development of industrial grouping and network creation since 2003 (Department of Industry Promotion, 2007).

> A cluster is concentration of interconnected businesses and related institutions that operate within the same geographic areas. The aim of promoting business clusters is to boost the level of support and cooperation in all facets of the business, both vertical[v] and horizontal,[vi] in order to strengthen the industrial value chain, enhancing Thailand's investment potentials and competitiveness, and expand socioeconomic development to regional and local levels (Thailand Board of Investment, 2015, p. 2).

The emphasis in this policy is on developing value chains, capacity building and investment, and the intent is to enhance inclusive prosperity in the regions and the rural borders (Sukviwatsirikul, 2015; Thailand Board of Investment, 2015). Cluster development is directly related to strengthening a national competitiveness (Porter, 1990; Regione Emilia-Romagna, 2013). In addition, the cluster policy aims to increase productivity for related business activities for a whole industry and to stimulate spin-offs from existing companies (Porter, 1990). The concept of competitiveness states that the country will have the ability to compete by starting at the lowest level of the economy (Office of the National Economic and Social Development Board, 2013; Sukviwatsirikul, 2015; Sikkabandit, 2018).

> If Thailand can increase productivity, not only reduce cost, but this will also provide the country with an advantage over competitors. The intention is to increase productivity in firms, and this will then increase productivity across an industry. Therefore, this will contribute increasing the national competitiveness over the long term (Office of the National Economic and Social Development Board, 2013, p. 2).

The Thai government has realised the significance of cluster in the development of the national economy (Thailand Board of Investment, 2015). The Cabinet and the Thailand Board of Investment (BOI), therefore, developed a cluster-based special economic development zones policy. This is known as the 'cluster policy' and this came into effect on 16 September 2015. The plan is to establish eight innovation clusters over the next five to ten years. The cluster policy is intended to leverage potential areas and serve as a base for target industries to support

high technology and future industries. There will be links with various elements in the cluster area. These include manufacturers involved in the value chain, education and research institutes, and public and private sector organisations. There will be public sector support in areas such as human resource and technology development, basic infrastructure and logistics development, providing tax and non-tax benefits, financial support, and modification of some measures those obstruct the mentioned development. These will help the cluster to be strong and competitive at an international level and will encourage more investment in the cluster and the surrounding areas (Thailand Board of Investment, 2015).

The government sets target to enhance the development of two types of industrial cluster (Thailand Board of Investment, 2015; Kotchanan, 2016)[14] those are:

Super clusters refer to clusters for advanced technology and future industries including:

- Automotive and parts: target businesses that use advanced technology such as motorcycle production of over 248cc (in the case of moulding of engine parts), production of key parts that have not yet been manufactured or have only a few manufacturers such as safety parts and energy saving car accessories, parts for fuel system/ transmission system/ engine system/ and manufacture of tires for vehicles.
- Electronic appliances and telecommunications equipment: electronic products and components using advanced technologies such as telecommunications equipment, electronic components for automotive and medical equipment, as well as high-tech appliances those connected to the internet.
- Digital: the government will invest in two potential provinces, Chiang Mai and Phuket, to support the development of digital centres for software production, cloud service centre, movie production, and services to the filmmaking business.

[14] Within the first five years from the effective date of the Cluster Policy.

- Petrochemicals and chemicals that are environmentally friendly: the investment prioritizes petrochemicals or specialty chemicals, the production of environmentally friendly polymers or chemicals, bioplastic products and biodegradable paper packaging.
- Food Innopolis: the establishment of a food innovation city.
- Medical center or medical hub.

Other potential clusters include industries that Thailand has the potential to develop.

- Agro-processing: the target are regions that provide a variety of raw materials. The targeted businesses will focus on plant and animal breeding, active ingredients, medical food, food grading, preservation of vegetable, fruit and flower using advanced technology. Promote the trade in agricultural products and natural rubber products.
- Textiles and clothing: the focus is on natural and artificial fibres, yarn or fabric with creative designs and developed through R&D processes.

Furthermore, Thailand plans to invest in ten industries that will further acquire knowledge from ST&I and will develop industrial clusters with the purpose of building an innovation-driven economy (Ministry of Industry, 2016). These ten industries can be classified into two groups (**Figure 4.2**). Each group contains five industries (Sangsubhan, 2015; Ministry of Industry, 2016).

The first group, called *the First S-Curve*, to be promoted are industries in which Thailand has existing advantages. They have potential to generate economic and commercial value, but without modern technology, these industries will gradually be outcompeted. The industries in this group include automotive, electronics, medical and wellness tourism, agricultural and biotechnology, and food processing.

The second group, called *the New S-Curve*, are new industries which are knowledge intensive and require technology and innovation. They have potential for significant growth in the future, but still there are very few Thai manufacturers. For Thailand, their economic value is not as great compared to the first group. These industries include robotics, aviation and logistics, biofuels and biochemicals, digital, and medical hubs.

Other industries in Thailand include leather, wood, cement, petrochemical and plastic, ceramic, glass, textile and cloth, gems and jewellery, and metal. These industries have used traditional technology in their production processes and there are limited capabilities for growth. Some have low economic value compared to the first group. Therefore, new industrial reforms are required, such as integration into large industrial clusters and an increase in the application of modern technology. To improve the country's economy and national competitiveness, the Thai government set a priority to develop the first and second industrial groups (Ministry of Industry, 2011).

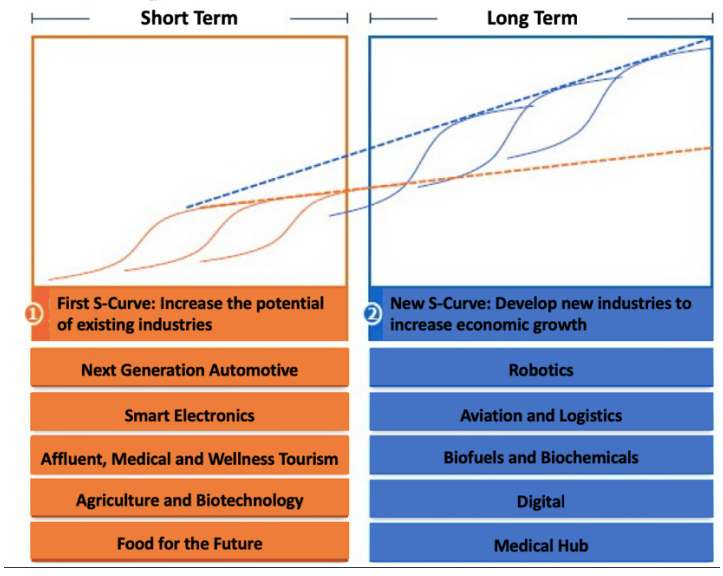


Figure 4.2 5+5 Potential industries for further development
Source: Adapted from Sangsubhan (2015, p. 3); Office of Industrial Economics (2017, p. 11)

The Ministry of Science and Technology, the BOI, and the Ministry of Industry were mandated by the national government to study cluster development in Thailand. The Ministry of Science and Technology conducted a study to develop cluster-based industries from countries with advanced R&D in ST&I focusing on the USA, Sweden, Denmark, South Korea, Singapore, Taiwan, Japan, China, and Italy (Kenan Institute Asia, 2008; Kotchanan, 2015). The results showed that the integration of technology clusters in developed countries is often due to the coordination of private sector organisations. Developing countries often need support in terms of government policy, linking entrepreneurs from upstream [15] to downstream [16], infrastructure development to increase productivity and to perform R&D, funding operations, and the support of individuals employed by private sector organisations (Kotchanan, 2015). The study also noted that cluster development always occurs in areas with an existing industrial concentration, and it should have a connection with educational or research institutions, sources of raw materials, and sources of employment (Kenan Institute Asia, 2008).

The core of general cluster development is to build partnerships on a competitive basis. To increase the efficiency and productivity of the cluster, those involved in the clusters need to plan, set goals, and develop joint strategies, exchange information, knowledge, and resources. Strategies need to be developed to support cluster integration (Department of Industry Promotion, 2007; Kotchanan, 2015) and these include:

- Integration must be based on the initiative and the needs of the private sector. The government acts as a supporter.
- There must be a core industry acting as a cluster leader.

[15] The upstream part is to link the farmers with the suppliers to supply raw materials. At the production process is to link the manufactures to the R&D organisations and also with labour providers.

[16] The downstream part concerns with the product distribution. It is to create a link between the logistics companies and the merchants/distributors.

- The cluster should have the potential to be developed and can eventually become self-reliant.
- Attitudes, trust and confidence among group members.
- The strength and knowledge of those who have played a role in the development of the cluster such as a cluster leader, coordinator, and the consultant.
- The strength of the business development service organisations in providing their services and establishing cooperation of local agencies.
- There is fair sharing of the benefits, which contributes to the satisfaction of all parties as part of a Win-Win strategy.
- The cluster policy should be linked to, and consistent with, provincial and regional development policies.

Thailand has over 150 clusters with more than 50% are at the formation stage (Kenan Institute Asia, 2008). Ministry of Industry (2016) declared that the development of industrial clusters requires the initiation of measures, structures and management schemes. Furthermore, it is necessary to promote the development of cross-sectoral cooperation networks at a national and regional level to build a quality industrial ecology through the development of a systematic industrial structure. This is the foundation for creating competitiveness. The development model must be modified to suit each cluster and the nearby community. The creation of linkages to educational institutes adjacent to each cluster was considered to be important as this would develop links with the supply of human capital and support the commercialisation of the research as well as strengthening the industrial R&D to increase market opportunity (Kenan Institute Asia, 2008). Along with this suggestion, SPs were considered to be a mechanism for increasing the capability of potential entrepreneurs, especially for businesses that were related to the ten industries identified for development. The RSPs were expected to support the growth

of local entrepreneurs and to encourage the development of strong clusters as said by Dr Pichet Durongveerot, the Minister of Science and Technology, at the interview on 24 September 2015:

> As one of economic driven Ministry, the Ministry of Science and Technology applies ST&I to increase the capacity of SMEs, build a new generation of business entrepreneurs. Also supporting the operation of super clusters, which has passed the Cabinet resolution on 22 September 2015, include the industries those apply advanced technology and future industries such as electronic cluster, automotive and parts cluster, medical cluster and Food Innopolis or food innovation city. In addition, the Ministry of Science and Technology will support the operation of high-impact clusters such as processed agricultural clusters for rice, rubber, shrimp and energy clusters, etc. (Ministry of Science and Technology, 2015).

The development of science and technology in Thailand aims to enhance the capability of potential industries that already existed by the aid of technology and innovation. The development plan of ST&I is in line with the industry development strategies of the Ministry of Industry in stimulating the growth of industrial clusters, both electronics and agricultural-based clusters, throughout the country. In doing so, the development plan focuses on improving the entrepreneurs, the smallest component of the cluster. They must acknowledge that further development of the products can occur by applying the knowledge of ST&I that can be obtained from the academic and the research facilities those available in the universities across the country. Moreover, SP is the critical mechanism in matching the entrepreneurs to the right researchers.

4.3.2 The SP policy development in Thailand

A SP, known as a research community by the Thai government (Science Park Promotion Agency, 2013), is an area designated for scientific R&D activities based on cooperation between research institutes and HEIs, the private sector, and the government under the triple helix model (Science Park Promotion Agency, 2013). Usually, a SP provides high-quality research tools and laboratories for members and tenants and focusses on the links between R&D

activities and agencies involved to develop research activities for commercial results. It should be beneficial to society and the community. It supports and promotes research, development and innovation and technology-based businesses through technology business incubation programs or spin-offs or other processes that are intended to stimulate more innovation-based business within the country, including providing other services and facilities to support lifestyles and to increase the productivity of the people working in the area of a SP (Pisalnupong, 2014; Science Park Promotion Agency, 2014).

The Thai government acknowledged the importance of SP in the country's economic and social development. Therefore, it has established a clear policy to expand and strengthen the operation of SPs (Science Park Promotion Agency, 2013). The development of a SP policy recognized SPs as critical infrastructure that would enhance regional and national development and increase competitiveness (The Securities and Exchange Commission, 2013). The need to establish the first SP was identified during the 6th National Economic and Social Development Plan. To increase country competitiveness, Thailand needs to develop its science and technology infrastructure and innovative systems. The government developed a strategy to establish and develop SP and assigned responsibility to three agencies: The Ministry of Science, Technology and Energy,[vii] the Bureaucracy of University Affairs,[viii] and the Ministry of Education. On 4 July 1989, the Cabinet approved the implementation of the Thailand Science Park (TSP) project on the area of 320,000 square meters at Pathum Thani province. The Ministry of Science and Technology is responsible for promoting the development of the country's future science and technology infrastructure to support the national economic and social development and to strengthen national competitiveness (Science Park Promotion Agency, 2013).

From the success of TSP, the Ministry of Science and Technology has promoted the establishment of RSPs to expand the development of ST&I infrastructure at the regional and local level. The project was approved by the Cabinet on 23 December 2003 to implement the Northern Science Park (NSP) project during 2004–2006, assigning the Thailand Institute of Scientific and Technological Research (TISTR) to be responsible for its operation. Furthermore, on 20 February 2007, the Cabinet approved the implementation of the North Eastern Science Park (NESP) project for the year 2006–2008 and the Southern Science Park (STSP) project in 2006–2009 with responsibility held by NSTDA. Along with the approval for the establishment of the RSPs, the National Science and Technology Strategy Plan (2004-2013) was approved on 10 February 2004 to establish RSPs as part of the development of science and technology's basic infrastructure and to develop the country's innovation system at the regional and local levels (Science Park Promotion Agency, 2013). The Ministry of Science and Technology collaborated with the Ministry of Industry in supporting potential entrepreneurs and encouraging existing and new industries to develop and form industrial clusters. The establishment of RSPs was expected to add value to existing agricultural production processes by encouraging the adoption of new technology (Science Park Promotion Agency, 2017a) and to support new technology-based businesses (Science Park Promotion Agency, 2013).

The Securities and Exchange Commission (2013); and Science Park Promotion Agency (2017a) identified four aims to support the establishment of RSPs in Thailand:

- Being an intermediary and supporting mechanism for linkage creation between the private sector, the public sector and the educational institutes to work cooperatively. For example, to perform collaborative research, engage in technology transfer, knowledge exchange, development of innovation, bridging the research to

commercialisation divide, as well as connecting firms to regulators and financial and tax advocates.

- Entrepreneurs will be able to apply R&D to product innovation more rapidly, with reduced risks, costs, but with higher value creation. Thus, this will promote the emergence of new businesses which rely on technology development.
- Promote the development of science and technology and generate knowledge to the community.
- Promote product commercialisation under the protection of an intellectual property system.

In Thailand, SPs need to be constantly developed and promoted to provide operators with information and knowledge in the effective management of the parks. Mr Abhisit Vejjajiva, the 27th Prime Minister of Thailand during 2008-2011, signed the regulations of the Office of Prime Minister on Science Park Promotion 2011. This was published in the Government Gazette on 10 May 2011 and emphasized that this was an important issue and expected to see the creation of SPs to meet expected national and regional goals. The regulations also agreed to the establishment of a Science Park Promotion Agency (SPA) as a department within the Ministry of Science and Technology in collaboration with the National Science Technology and Innovation Policy Office (STI) and NSTDA in developing plans and guidelines for the operation of SPs. The management of RSPs was also transferred from NSTDA and TISTR to SPA to reduce complexity and delays in the government management system (Science Park Promotion Agency, 2013). STI established the first National Science, Technology and Innovation Policy (2012-2021) that clearly identified the issues in promoting SPs in the 5th strategy: Promoting and supporting the development of infrastructure and contributing factors of ST&I to increase country competitiveness. The goals were to develop

and expand the roles and responsibilities of ST&I infrastructure, creating a network for providing services, to increase the number of research commercialisation projects, to increase the proportion of private sector R&D investment, and to spread prosperity thoroughly (Science Park Promotion Agency, 2013)

SPA studied the establishment of SPs in many countries such as the USA, the UK, Singapore, Japan, Taiwan, South Korea, Malaysia, India, and China to explore similarities and the differences in SP policy implementation between each country (Science Park Promotion Agency, 2013). The study paid more attention to the establishment of SPs in developing countries in Asia as these were considered to have similar levels of economic development compared to Thailand. These countries had some similar issues in developing SPs. They concentrated on the development of science and technology, including the transfer of research for industrial development. The public sector played a critical role in promoting the development of SPs. However, there was limited participation from the education sector and the use of university resources in the development of SPs compared to Western countries such as the USA and in Europe. The future operation plan for SPs in these comparator countries included increasing the engagement of local governments in supporting and promoting the development of SPs, differentiating the incentive scheme for each SP in the same country, and increasing the technology business incubation units in each SP. In setting up the initial Science Park Development Plan, SPA suggested adapting the best practice that was identified from an analysis of Taiwan and South Korea (**Table 4.2**) (see Science Park Promotion Agency, 2013, pp. 5-12).

Table 4.2 The best practice of SPs establishment in Taiwan and South Korea

Taiwan	**South Korea**
Purpose of SP(s) establishment	
To enhance the technological capabilities of the industrial sector. This is because the cost of production in Taiwan	To use the Science Parks as the hub of regional innovation system in creating

was increased causing the foreign companies moving their production bases to countries with cheaper land and labor costs. Taiwan therefore needs to adjust its policy from supporting foreign investment to increase country competitiveness.	cooperation between the private sector, government, education institutes, and local communities to create 3 innovative systems, namely (1) S&T Innovation (2) Production system innovation and (3) Business service innovation
Best practices	
- Building a network at the local level and national level, together with creating the network with foreign countries. Resulting in the transfer of modern knowledge and up-to-date changes in the rapid progress of technology - Supporting foreign investment - Set up policies for the development of science and technology together with the policies of Industrial economy development. That is to say, science and technology development must be in order to enhance the capabilities of the industry. - Having environmental policies those support R&D activities such as tax privileges for the Science Park, patent, and business incubation center. Providing support on financial, education and technology. Improving the research contract and government procurement, etc. - Set a goal to develop a specific industry to be a serious export industry (Electrical and electronic industry) - The goal of each government agency is set in the same direction. - Have assessed its own technological potential and direction, and develop to be part of the world innovation system - Providing investment support and tax privileges that help reduce the risk of doing R&D and attracting the private sector to use the space in the Science Park, approach to research institutes or knowledge sources. - There is an organisation dedicated to the development of science parks, Science Park Administration or SPA, to support the upgrading of technology by transferring knowledge from the research institute to create a competitive capability for the tenant companies. It also has duties to strengthen the cooperation between the industry, government, educational institutions, and research institute to create potential for R&D, improve the park to have an investment atmosphere by doing a service business effectively	- Having a development strategy consisting of (1) creating, stimulating and managing knowledge and technology (2) development of incubation centre (3) Cooperation in R&D (4) supporting the entrepreneurs (5) creating suitable environment for innovative businesses and (6) develop the key industries. By dividing the development into 3 phases, creating the infrastructure of innovation (1999–2007), policy implementation (2008-2012) and creating sustainable innovation systems (2013-2017) - Develop incubation centers and mechanisms for related support programs such as finance, personnel training, consulting in various fields and marketing services - Establish a strategic industry which looks primarily at the needs of the local community, then consider about the capability, existing infrastructure, support and motivation programs, as well as, investing in human capital, research infrastructure, and market trend. - Create a culture for management that reduces dependence on government support, transfer the management from the public sector to the private sector. - The management team must have a concept and innovative thinking in developing the Science Parks to be successful, create profit, and operated sustainably

Source: Science Park Promotion Agency (2013, pp. 8-11)

On 29 May 2012, the Cabinet approved the Science Park Development Strategy for 2013-2017 as the framework for major development, which will encourage the private sector to invest substantially in R&D,[ix] promoting Thailand as an R&D investment base for multinational companies and domestic companies, encouraging the private sector to invest and establish privately-owned SPs, maximizing the utilization of public sector R&D resources and infrastructure, linking the RSPs to local economic development, and creating an integrated network of SPs. At the same time, measures would be introduced to support SP growth over a five-year period including financial and tax benefits for businesses participating in SP programs (Science Park Promotion Agency, 2013).

SPA suggested that investment in SP development would be divided into three stages with five-year implementation periods for each stage (Science Park Promotion Agency, 2013). In the first stage, the state would be the main investor in both infrastructure and operations. The private sector might co-invest. This can occur by encouraging private research institutes and public universities that have already strengthened their R&D to establish SP based on existing resources and to invest in infrastructure that is still required. From the sixth to the tenth year, the government will consider reducing the annual support and increasing the proportion of infrastructure and operating investment from the revenues of SPs. Then, from the tenth year onwards, SPs should seek additional co-investors such as local private organisations. In addition, for rapid development and to reduce public spending, the state should encourage the private sector to establish privately owned SP, along with the establishment of state-owned SPs. Financial risk can be reduced by encouraging cooperation between the government and private sectors in the form of public-private partnership (PPP) to encourage private investors to establish and develop SPs (Science Park Promotion Agency, 2013).

During 2013, the training programs were launched to strengthen the knowledge and understanding of the personnel involved with SP operation. These programs included curriculum development and workshop training. SPs cooperated with the Association of Business Incubators of Thai Science Park (Thai BISPA) to develop courses, seminars and training for human resources development. The project called 'Enhancing Science Park Management' was intended to build understanding at the management level for the agencies involved in the implementation of the SP policy and to develop potential operators. It provided real-life experiences in the management and operation of SP to the participants. As a whole, the government expected that the SPs would be able to meet the goals of economic and social development based on knowledge and innovation at both regional and national level (Sikkaburana, 2013).

4.4 Implementation of SP policy

In 2019, four state-owned SPs were established in Thailand and one RSP was in the planning process. Each was located and covered different areas of the country; central, northern, northeastern, and southern Thailand. They were managed and funded by the government. The private sector proposed an establishment of one privately-owned SP located in the industrial zone in the central area. However, this privately-owned SP was still at the planning process (JSB Market Research, 2018).

4.4.1 State-owned SPs

In June 2019, there were four fully operated state-owned SPs in Thailand. All were operated by the management of the Ministry of Science and Technology. To be more specific,

TSP was established in 2002 and managed by NSTDA. The other three RSPs are under the management of the SPA.

4.4.1.1 Thailand Science Park (TSP)

TSP is the first SP established in Thailand, located at Pathum Thani province, close to Bangkok, Thailand's capital city. TSP was officially established in 2002 with a budget of THB 7,000 million (USD 206.2 million) (Pisalnupong, 2014). It is a research-based facility with state-of-the-art R&D services, consisting of both research-based public sector and private companies in the area. It was operated under the management of NSTDA that was also located in the TSP area. The research units are under the management of the NSTDA include the Technology Management Center (TMC), the National Center for Genetic Engineering and Biotechnology (BIOTEC), the National Metal and Materials Technology Center (MTEC), the National Electronics and Computer Technology Center (NECTEC), and the National Nanotechnology Center (NANOTEC). Those provide R&D infrastructure services including prototype manufacturing. There are rental spaces and facilities provided for the private sector to support research commercialisation. Moreover, it also provides business service support and stimulates the development of technology-based business (Science Park Promotion Agency, 2013). Its location is in close proximity to the Asian Institute of Technology (AIT), Thammasat University, and Sirindhorn International Institute of Technology (SIIT). It provides an opportunity for tenants to access highly-skilled personnel, including 2,000 full-time NSTDA researchers those over 500 were scientists with PhDs (Thailand Science Park, 2017a). TSP employed over 500 people, about 60% were researchers and engineers. It was expected that the economic contribution value will be around THB 3,000 million (USD 88.4 million) annually.

The main focuses of the research for the TSP was on (1) food and animal food and (2) electronics and automotive parts (Pisalnupong, 2014).

By the end of 2016, the first phase of TSP included 140,000 square meters. There were over 90 corporate tenants of which 30% were international companies and over 473 projects had been commercialised. TSP had performed 1,026 R&D projects and increased R&D personnel to 2,078 (Thailand Science Park, 2017b). To meet with the increasing demand, TSP completed the development of its second phase in 2019, called *Innovation Clusters 2*, that adds a further 127,000 square meters of rental space for private companies and make TSP the biggest R&D hub in Thailand (Thailand Science Park, 2017a).



Figure 4.3 Location of TSP and nearby research institutes

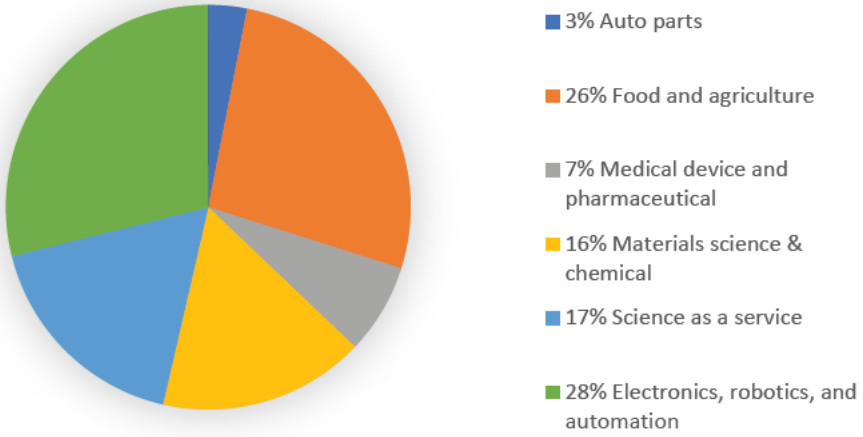


Figure 4.4 Corporate tenant ratio of Thailand Science Park by industry (as of March 2018)
Source: Thailand Science Park (2018)

4.4.1.2 Thailand RSPs

The operation of the RSPs is currently under the management of the SPA. The purpose was to enhance the potential and capacity of local economies. In 2004, the NSP started its implementation plan, followed by the NESP and STSP in 2006 (Pisalnupong, 2014). Operations commenced from 2007 with the activities hosted by the lead university of each region including Chiang Mai University in the north, Khon Kaen University in the northeast and Prince of Songkla University in the south, and each RSP also create a network with other educational institutes. The flagship projects are to develop innovation-based businesses related to rice, poultry, and rubber products. During the construction period of the RSPs, research activities were carried on the universities' premises (Wongpridi and Sudhipongpracha, 2017).

On 29 May 2012, the Cabinet approved the Strategic Development of the National Science Park (2013-2017) and the Regional Science Park Project 2013-2016 and assigned the lead university of each region to host and manage the project with a budget of THB 8,642 million (USD 254.6 million). The budget was allocated through the Office of the Permanent Secretary, Ministry of Science and Technology. The full amount of this budget was provided in the fiscal year 2013. SPA acts as the coordinator of all stakeholders for the RSPs establishment project. Since establishment, the RSPs were managed by the host universities. The RSPs' directors were appointed by the chancellor of each host university. The management team were assigned by each of the universities linked to each RSP (Chiang Mai University, 2017). The universities in the RSP network established their own SP as a department under the management of the university. Their main duties were to support local entrepreneurs in creating business through the business incubation program and to match businesses with academic personnel to support product R&D through the Collaborative Research and Industrial Research and Technology Capacity Development (IRCT) Programs. The RSPs created strong linkages

between educational institutes with the firms, provided technology transfer to the private sector, commercialised research, and created new technology-based entrepreneurs. The private sector has increased its efficiency since it participated in the incubation programs (The Securities and Exchange Commission, 2013; Science Park Promotion Agency, 2017a).

The estimates and target investment in the infrastructure and operation of the SPs in Thailand over the five-year period (2013-2017) (**Table 4.3**) did not meet actual implementation. By June 2019, only two RSPs had completed building construction and were fully operational.

Table 4.3 Science Parks investment plan for 2013-2017

Science Park investment	Fiscal year					
	2013	**2014**	**2015**	**2016**	**2017**	**Total**
Number of science park (cumulative)	4	4	5	6	7	7
Construction budget (million USD)	33.0	86.0	100.8	43.3	39.8	302.9
Science parks operation budget (million USD)	13.8	28.0	36.8	38.3	39.8	156.7
Fiscal frameworks to strengthen science park governance (million USD)	4.7	5.0	5.9	7.4	8.5	31.5
Total budget (million USD)	51.6	119.0	143.5	89.0	88.1	491.2

Source: Adapted from Science Park Promotion Agency (2013, p. 65)

The construction of the NSP and NESP commenced in 2015 and were completed in May and September 2018 respectively. The STSP's construction commenced in 2016 and was completed in September 2020. During the construction period, all RSPs activities were carried out by the universities in the networks (Wongpridi and Sudhipongpracha, 2017). These activities varied by the needs and differences in regional economies and in the local agricultural products produced. However, according to Intellectual Property Management and Innovation Office (2019); and Tridech (2019a), the main operations of each RSP included the provision of the same services including:

1. R&D services (service platform) include providing research space, innovation design service, intellectual property management service, database of experts, researchers, research papers, laboratories and scientific instruments that are available to the private sector, and consulting services in ST&I business development as well as coordinating with the public and private agencies in the area.

2. ST&I business incubation: the program incubates new businesses (registered the business for no more than five years) through mechanisms and activities to create new technology-based entrepreneurs. The goal is to bring university research into commercial use through appropriate management processes enabling entrepreneurs to develop sustainable businesses.

3. IRTC: assisting registered businesses in the manufacturing industry by promoting the use of technology in the development of production, matching technical experts as consultants to solve technical problems, improve production process efficiency, develop product quality to meet international standards, and develop new products targeted at international trade.

4. Collaborative research: encourage the private sector to conduct R&D in the form of joint research with universities in the RSPs network. The budget for this activity will be partially supported by the SP. The private sector will invest in the form of cash and non-cash investments.

5. SPs infrastructure development

The RSPs have the same aims and provide the same core services to businesses including SMEs and startups, but each has its own focus on R&D activities. Each build on its local regional economy including industries and technology and the expertise in local research institutes. The regional context plays an important role in shaping the activities of each Thailand’s RSP.

During 2013-2017, businesses located in three RSPs that had completed the business incubation program increased their revenue to THB 33.37 million (USD 983,205.7). Private sector investment in R&D program increased to THB 256.41 million (USD 7.6 million) with a THB 140 million (USD 4.1 million) increased in revenue. Over 37 R&D laboratories were developed to meet international standard and 1,500 requests for SP services (Science Park Promotion Agency, 2017b).

Table 4.4 Thailand RSPs operation result (2013-2017)

Activity (project)	NSP	NESP	STSP	Economic Value (USD million)
Business Incubation	107	117	101	Revenue increases 0.98
Joint research with the private sector	45	26	15	Private sector investment in R&D 3.1
Industrial research and technology capacity development	224	115	35	Revenue 4.1 Private sector investment in R&D 4.4

Source: Science Park Promotion Agency (2017b, pp. 12-14)



Figure 4.5 Location of SPs in Thailand

The Northern Science Park (NSP) is in Chiang Mai province with Chiang Mai University acting as the host university. It performs collaborative research with six other universities in the northern region of Thailand. Those are Maejo University, Mae Fah Luang University, University of Phayao, Naresuan University, Pibulsongkram Rajabhat University, and Uttaradit Rajabhat University (Pisalnupong, 2014; Chiang Mai University, 2017). The NSP covers the service area of 17 provinces (Science Park Promotion Agency, 2013).

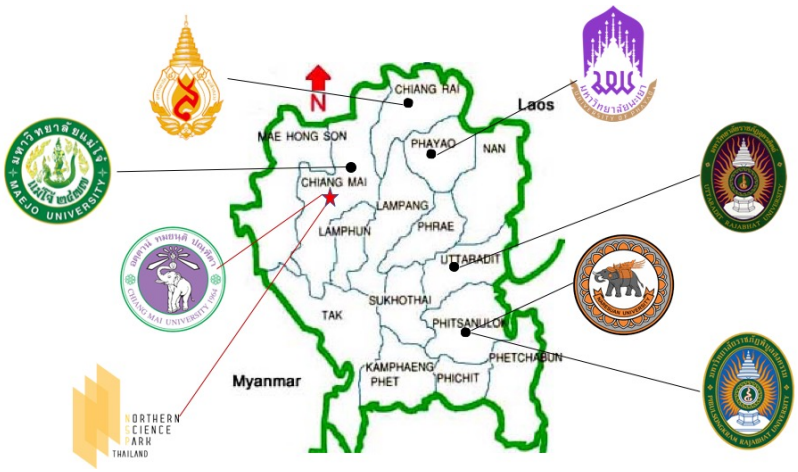


Figure 4.6 The location of NSP's network universities

The research activities of NSP focuses on the encouragement of cluster development for four industries: (1) agricultural and food processing industries include the production and processing of vegetables, local herbs, and rice, (2) information technology (IT), software and digital content, art and craft, tourism, and design and creative businesses, (3) medical and biotechnology, and (4) alternative energy and materials innovation (Pisalnupong, 2014; Thailand Northern Science Park, 2015).

In 2017, NSP received a budget of THB 76.7 million (USD 2.3 million) to conduct its activities. They consist of the main SP's services including (1) a service platform (2) ST&I incubation program (3) IRTC and (4) collaboration research program. There were additional activities to strengthen the acknowledgement and cooperation of the private sector such as NSP

Innovation Fair, NSP Innovation Award, and knowledge sharing (Chiang Mai University, 2017). The operation of NSP during 2013-2017 are shown in **Figures 4.7 to 4.9**.

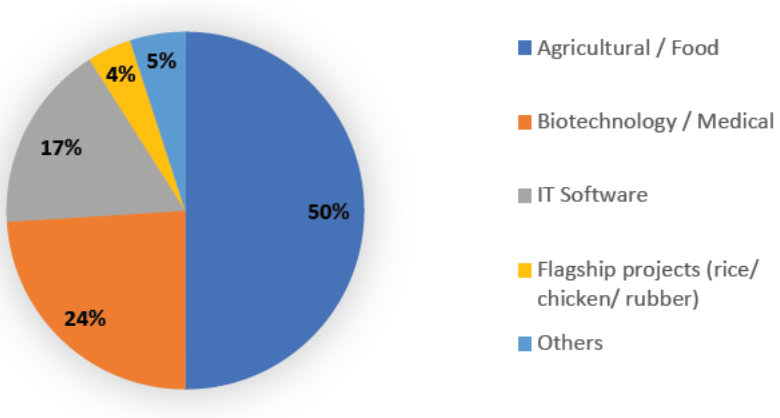


Figure 4.7 NSP's STI business incubation project by industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 12)

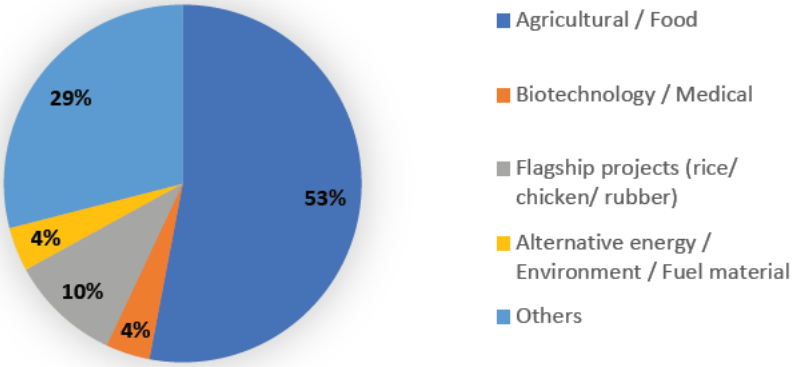


Figure 4.8 NSP's collaborative research project by industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 13)

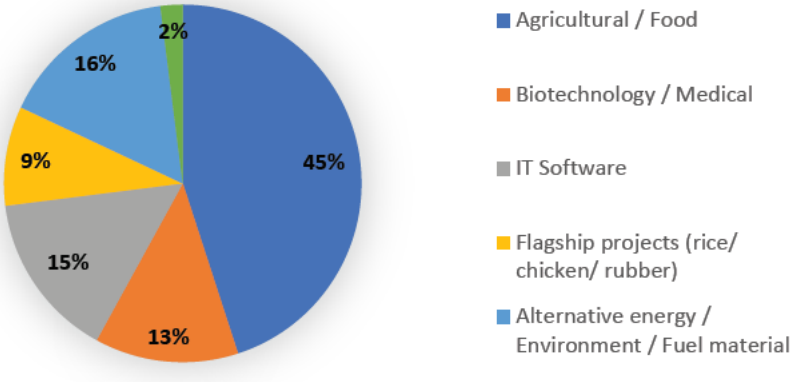


Figure 4.9 NSP's industrial research and technology capacity development by industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 14)

The interviews with 33 private businesses engaged with NSP projects identified that NSP was considered to be the most successful SP in Thailand, even compared with TSP. All participants from the business sector appreciated the services and the aggressive management style of its director that has resulted in a clear implementation plan for the park. In general, the entrepreneurs were very satisfied with the management of NSP, especially the speed of service, attention to their projects and activities that are beneficial to the entrepreneur development. The selection of participants and tenants was transparent and fair. The staffs were attentive to facilitate the program, suggesting sources of funding, and following up closely with the business and researchers. The entrepreneurs are satisfied with the facilities of the building. However, as the location is not close to the city centre, they suggest that NSP should have more facility such as shops, food vendor, bank, postal service and other related services. This is not only to facilitate the current tenants, but also to attract the new potential tenants too.

Even though receiving positive feedback from private businesses and researchers, NSP and its network universities may need to improve their degree of cooperation. Chiang Mai University is the host of NSP. It has duties to manage the operation of NSP as well as the distribution of government funds to each network university. The funding may not be equally divided as the allocation process is based on the performance and KPIs of each university. However, as Chiang Mai University always receives largest share of the fund, some universities suggested that the distribution should be more transparent.

The Northeastern Science Park (NESP) is in the area of Khon Kaen University, covers about 56,000 square meters and contains 18,000 square meters. The administration building was completed in September 2018 within the budget of THB 489 million (USD 14.4 million) (Otton, 2018). Khon Kaen University is the host university. There are other three

universities in the network include Suranaree University of Technology, Ubon Ratchathani University, and Mahasarakham University and this RSP covers the service area of 17 provinces, two-third of the country (Science Park Promotion Agency, 2013). The research activities focus on promoting the development of clusters in industries along their value chains focussing on agricultural and food related to economic crops such as rice, sugarcane, chili, local herbs, and livestock, pigs and chickens. It also focuses on electronics and IT industries such as hard disks, enterprise software and embedded software. Moreover, the research also focuses on natural resource-related industries in the region and in the Greater Mekong Sub-region, especially the Lao People's Democratic Republic, such as rock salt, copper, gold and hydropower (Pisalnupong, 2014; Thailand Northeastern Science Park, 2015).



Figure 4.10 The location of NESP's network universities

The operation of the NESP for the fiscal year 2015 had a budget of THB 66.6 million (USD 2 million). There were six activities including three main activities provided by every RSP. Those are (1) service platforms (2) ST&I business incubation and (3) IRTC. There were three additional activities to promote the NESP for public acknowledgement include NESP Innovation Expo, NESP Innovation Awards, and knowledge sharing for collaborative research activity (Thailand Northeastern Science Park, 2015). The operation of NESP during 2013-2017 is be shown in **Figure 4.11 to 4.13**.

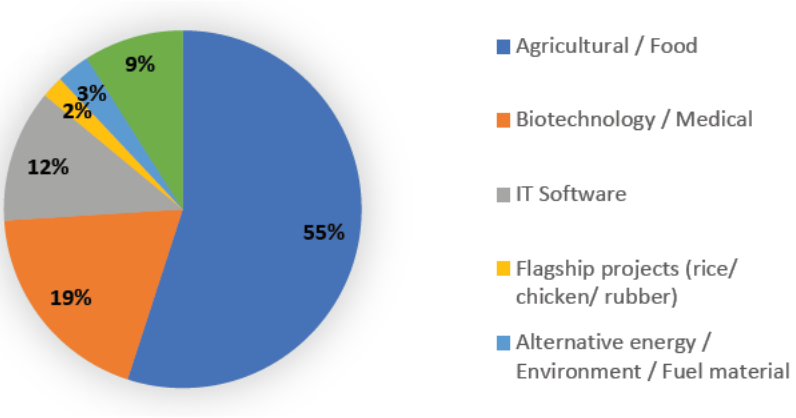


Figure 4.11 NESP's STI business incubation project by industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 12)

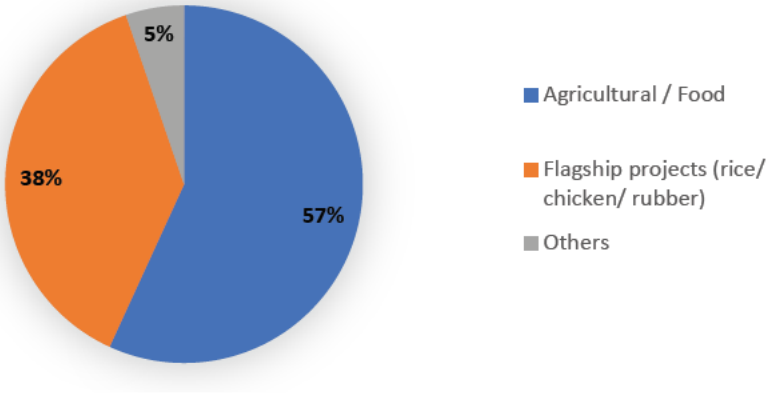


Figure 4.12 NESP's collaborative research project by the industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 13)

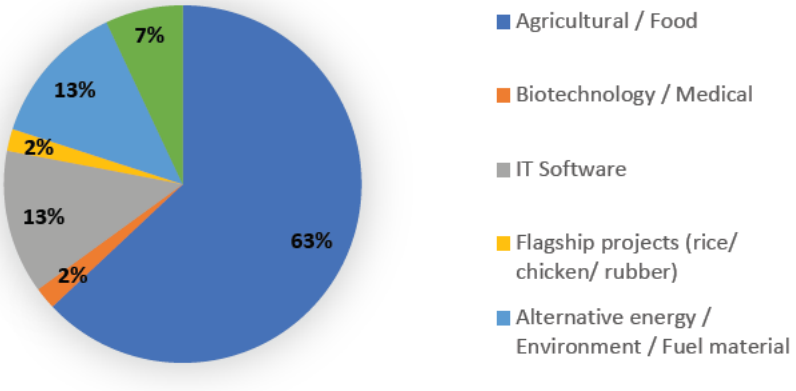


Figure 4.13 NESP's industrial research and technology capacity development by the industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 14)

The interviews identified that NESP has the strongest linkage between the host and the network universities. Although operational management and funding was officially under the provision of Khon Kaen University, the management was considered to be transparent to all stakeholders. For example, the representatives of all four universities discuss any decision about the operation of the NESP and how to distribute government funding to each university. They set a clear development plan by targeting big companies, such as Mitr Phol Sugar, in doing collaborative research and in co-investing in building the research centre in the park area. The operation plan of NESP relies with the city's plan in converting Khon Kaen into a Smart City.[x] Thus, besides supporting agriculturally related businesses, NESP also encourages the growth of IT, digital, and technology-based businesses.

The northeastern region is the largest part of Thailand covering 33% of the country. There is only one RSP in this area. NESP has operated at its maximum capacity, but still could not reach out and support all potential entrepreneurs due to the distances between the NESP or network universities and businesses. To cover a larger service area and be able to respond to more business requests, on March 2019, the Ministry of Science and Technology agreed to establish the second RSP in the northeastern region with a construction budget of THB 559.6 million (USD 16.5 million) (including the pilot plant). **The Lower Northeastern Science Park** will be hosted by Suranaree University of Technology in Nakhon Rachasrima province. The expected network universities consist of four potential universities in the lower northeastern region. The building of its infrastructure is to be completed by 2021 (Science Park Promotion Agency, 2019; Wechakarun, 2019).

The Southern Science Park (STSP) was complete its construction in September 2020 with a budget of THB 425 million (USD 12.5 million). It is located at Hat Yai, Songkhla province, covers an area of over 160,000 square meters at the extended area of Prince of Songkla University (Prukudom, 2018). Prince of Songkla University (Hat Yai campus) acts as the host university. The network research institutes and universities include Walailak University, Phuket Software Park, and three campuses of Prince of Songkla University covered the service area of 14 provinces (Science Park Promotion Agency, 2013). The projects under STSP focus on developing the cluster for industries related to rubber, palm oil, and other potential industries such as herbs, cosmetics, biomedical and alternative energy (Pisalnupong, 2014).

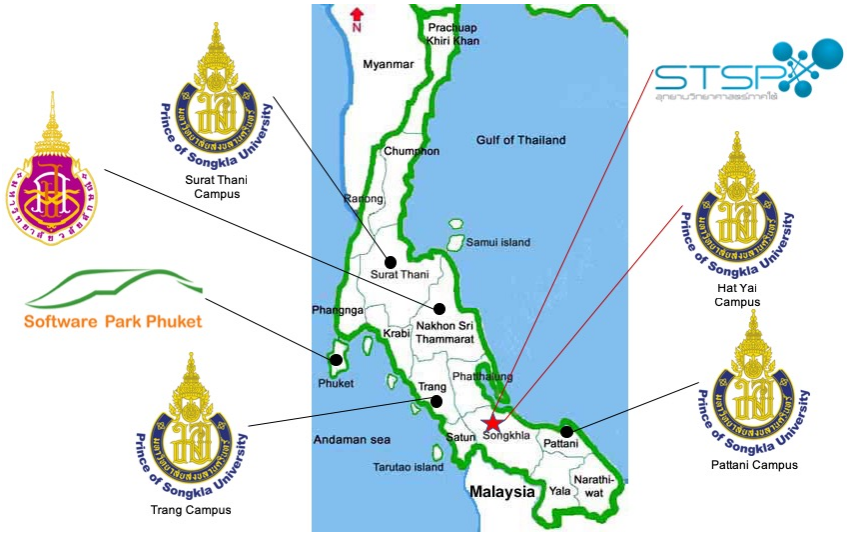


Figure 4.14 The location of STSP's network universities and research institute

The operation of the STSP for the fiscal year 2016 involved a THB 31.5 million (USD 928,108.4 million) budget. There were four main activities provided by all RSPs. Those are (1) ST&I business incubation (2) collaborative research with private sector (3) services platform and (4) IRTC. There were three additional activities according to the needs of local entrepreneurs and to promote the STSP include STSP Innovation Expo, STSP Innovation

Awards, and knowledge sharing for business incubation activity (Thailand Southern Science Park, 2016, p. 1). The operation of STSP during 2013-2017 is shown in **Figure 4.15 to 4.17**.

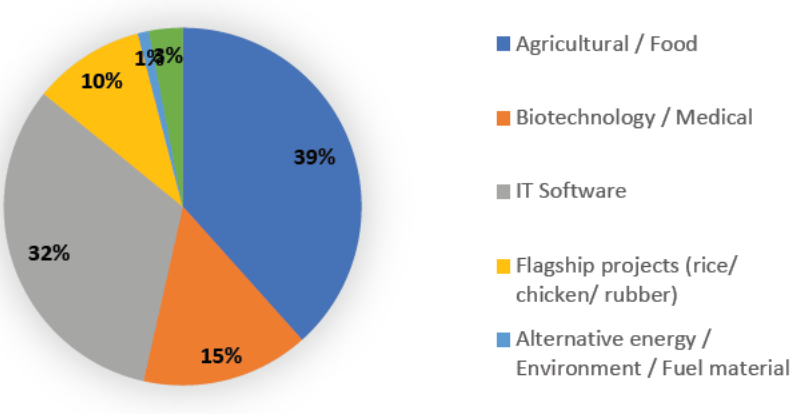


Figure 4.15 STSP's STI business incubation project by industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 12)

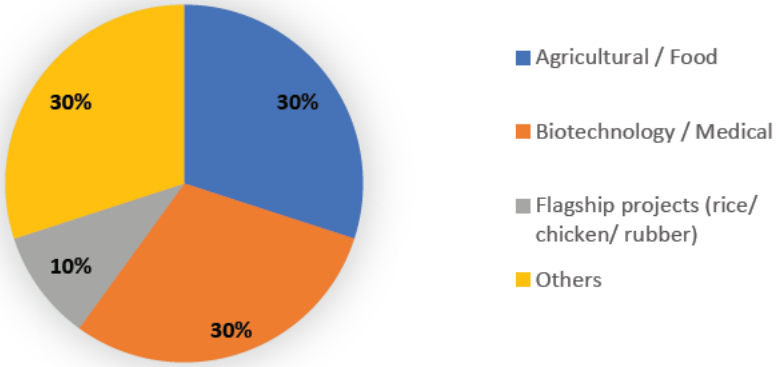


Figure 4.16 STSP's collaborative research project by industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 13)

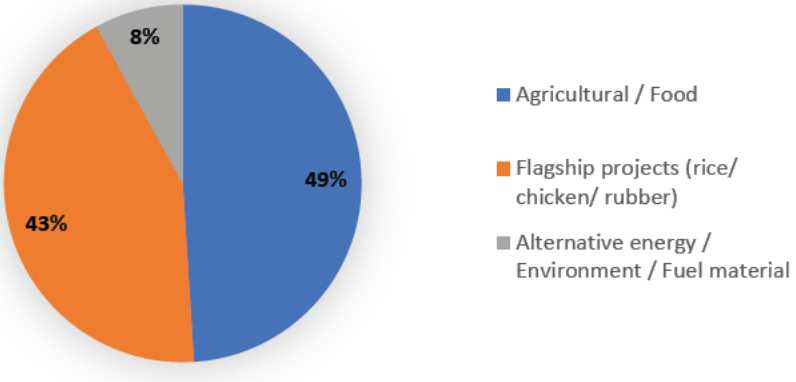


Figure 4.17 STSP's industrial research and technology capacity development by industry (2013-2017)
Source: Science Park Promotion Agency (2017b, p. 14)

In June 2019, STSP operated by using the universities' facilities because the RSP building was still under construction. An interview with the STSP manager identified that STSP still struggles with its operation.

> The entrepreneurs in the southern region seem unaware of the necessity of product-based R&D. They prefer to engage in business without taking steps for further improvement. The executives of the host university are conservative. They avoid taking risks or making changes. This may be affected by geography. The southern region of Thailand is fertile, surrounded by the sea at the west and east coasts with the border connected to Malaysia. The economy relies mainly on tourism-related business as well as rubber plantations and fishing. The nature of the local people is not so competitive. They tend to be relaxed and take no risk. This is one obstacle in promoting the STSP (STSP, 2018).

This comment was supported by the entrepreneur saying that the management and operation style of STSP was still conservative. The service was slow in terms of processes and requires much supporting documentation. The intellectual property management of the host university obstructed research commercialisation. The researchers focused on their own research and did not want to share knowledge with business. Transparency seemed to be another problem with STSP. Entrepreneurs questioned the selection process as there would always have one certain group who was selected to receive the funding. Despite this, the operation results of STSP still exceeded the target. However, STSP will need to work harder in creating awareness in the local area to stimulate R&D. SPA, as the coordinator between the government and the RSPs, has to overcome the conservative management style in order to accomplish the objectives of establishing the RSP.

4.4.2 Privately-owned SP

There is a need in Thailand to transition and over dependence on production-based industries to industries involved with R&D. Given this one of the strategic development plans for SPs in Thailand is to promote cluster development and to encourage the private sector to

establish SPs. According to this, Amata Cooperation PCL under the management of Mr Vikrom Kromadit, the founder of the Amata Group, and his son Mr Viboon Kromadit plan to develop **Amata Science City**, located in the area of Amata City Chonburi Industrial Estate. It is at the heart of the Eastern Economic Corridor (EEC) project which is the driving mechanism for Thailand's 4.0 policy. The expected area covers over 1,600,000 square meters, which will be devoted to scientific research for the private sector, and to create an environment where governmental agencies, research institutes, and private companies can work cooperatively. The main aim of Amata Science City is to encourage the private sector to engage in product innovation, especially for the application of R&D to manufacturing. The master plan for this scheme includes four zones: academic zone, R&D centre, innovation zone and residential zone (The Securities and Exchange Commission, 2013; Amata Corporation PCL., no date). According to JSB Market Research (2018), the construction includes small to medium scale industrial units and manufacturing centres, laboratories, testing centres, and joint research centres. This project is establishing under a PPP scheme between the Ministry of Science and Technology, the universities, and Amata Cooperation PCL. The agreement was that the Ministry of Science and Technology and the universities will provide R&D and human capital, while Amata will provide the land and facilities for establishing the Amata Science City. Amata started negotiating with the government sectors in March 2016. Currently, this project is still at the planning stage with an expected budget of USD 152 million (JSB Market Research, 2018).

4.5 Conclusion

Thailand's economy has been heavily based on agricultural products, tourism, and the export of electronic parts that do not require the use of high-technology or new innovation. The country was struggling to shift from an upper-middle income country to a higher stage due to a

lack of knowledge and resources. Trying to increase the country's competitiveness and to spread the wealth of the nation, the government has developed and implemented plans to help SMEs add value to their products and services by applying new technology and innovation. SMEs represent more than 90% of all businesses in Thailand and improving their productivity and competitiveness will hence improve the regional and national economy as a chain reaction.

The Thai government has established SPs as a mechanism to support SMEs by providing the resources required to encourage higher-value production including R&D laboratories and equipment, knowledge and expertise from university researchers, business management training, financial support, and a focus on encouraging the formation of industrial clusters. Four SPs were established with a focus on different industries according to the potential of each region. The government expects that the establishment of RSPs will stimulate business growth and contribute to the development of industrial clusters that will strengthen industries and increase local economic growth.

In all three RPSs, NSP was considered as the most successful in increasing awareness of entrepreneurs of the need to add value to their product, create linkage between university researchers and industry that would encourage technology and knowledge transfer, and stimulate the local economy through business activities. Despite the delay in the construction of the RSPs, the implementation of them, to date, seemed to be accomplished as it was expected. Each of the RSP had exceeded the targets set each year those corresponded with the capacity and budget provided. The cooperation between the government, university, and the business sector, according to the triple helix approach, was implemented as planned. As in the early stage, they succeeded in raising awareness of the establishment of RSPs and how ST&I can improve efficiency in performing R&D. The number of entrepreneurs engaged in the operation has increased as well as the overall success rate of the participants. The host and their network

universities have been working systematically to achieve the same goals. Those are increasing the potential of entrepreneurs to be able to compete in the market by applying ST&I knowledge from the universities to products R&D and improving the production efficiency. However, the services still difficult to reach for entrepreneurs in distance to the network universities. The government should improve the capacity of local universities and educational institutes to be able to be part of the network for wider service area.

The interviews of universities representatives and the director of the RSPs shows that the state's R&D facility and the professionals have been utilized to solve problems based on the real needs of the private sector. However, there is no evidence showing that Thailand's RSPs had contributed to the formation of a new industrial cluster or strengthen the existing one yet. The result of RSPs operation helped to increase the capacity of businesses, but they were too small and new to the market. Besides, it was still too early to measure the long-term effect either to the businesses or to the regional economic development. There was no participant from the firms those were not engaging to the SP. However, the interview with 33 participants from business sector informed us that without the support of the SP, they may not be able to do the R&D, or it would take too much time, cost, and effort to complete just one project. In this study, we will discuss deeper about the role of the university and researcher in the establishment of the RSP in the next chapter.

Notes

[i] Thailand 4.0 policy, according to Say-On (2016); Sikkabandit (2018); and Royal Thai Embassy at Washington D.C. (no date), is an economic model raised to public interest in 2015 by the General Prayuth Chan-ocha, the current Prime Minister of Thailand. The policy aims to release the country from economic challenges include 'a middle-income trap', 'an inequality trap', and 'an imbalanced trap' those resulted from economic development models in the past which the main concern was on agriculture (Thailand 1.0), light industry (Thailand 2.0), and advanced industry (Thailand 3.0). The use of technology and innovation were expected to add value to the products and services and develop the agricultural-based industry of Thailand.

[ii] 12th National Economic and Social Development Plan was written by adhering to the 20-year National Strategy framework (2017- 2036), the country's SDGs, the Thailand 4.0 Policy with the focusing on preparing human resource, society and the economy for future challenges. The development plan of science, technology, and regional economy was developed relying on strategy 3 (Strategy for Strengthening the Economy, and Underpinning Sustainable Competitiveness), strategy 8 (Strategy for the Development of Science, Technology, Research, and Innovation), and strategy 9 (Strategy for Regional, Urban, and Economic Zone)

[iii] Fiscal year is the government budget year which, in Thailand, begins in October until the end of September of the following year. For example, the fiscal year 2015 covers from 1 October 2014 to 30 September 2015. The fiscal year 2016 starts from 1 October 2015 to 30 September 2016.

[iv] The exchange rate of 2017 (THB 33.94: USD) was applied to the whole document.

[v] Vertical linkage is an association of entrepreneurs from upstream to downstream.

[vi] Horizontal linkage is linked to the support of various industries, including business services, trade associations, educational and training institutions, R&D as well as government agencies concerned.

[vii] Ministry of Science, Technology and Energy (1979-1992) later became the Ministry of Science, Technology and Environment (1992-2002), then the Ministry of Science and Technology (2002-2019). It was merged with the Office of the Higher Education Commission and the National Research Council of Thailand and became the Ministry of Higher Education, Science, Research and Innovation from 2 May 2019.

[viii] Bureaucracy of University Affairs (1972-2003) later became the Office of Higher Education Commission in 2003 and was merged with the Ministry of Science and Technology and the National Research Council of Thailand and became the Ministry of Higher Education, Science, Research and Innovation from 2 May 2019.

[ix] In 2000, the investment in R&D of Thailand was at THB 12,406 million (USD 36.5 million) (Office of the National Economic and Social Development Board, 2017, p. 43) and increased to THB 11,400 million (USD 33.6 million) or 0.78% of GDP in 2016 with the investment ratio of private sector to public sector was at 70:30 (Tuantranont, 2018). The government set the target to increase the R&D investment to 4% of GDP in 2036 (Ministry of Science and Technology, 2016, p. 2).

[x] Smart City is a model of the city that is designed with the focus on three main elements: the development of the style and structure of the city that conforms to the concept of intelligent city, promoting energy and environmental preservation, and promoting the

use of renewable energy together with the introduction of information technology to help manage the resources of the city for maximum benefits such as power network management system, automatic metering system, traffic control system, building control system, and pollution monitoring system (Maison, 2017)

CHAPTER 5

THE TRIPLE HELIX MODEL AND SCIENCE PARK DEVELOPMENT IN THAILAND

5.1 Introduction

Thailand remains trapped in the middle-income group of national economies (National Economic and Social Development Board, 2017). The domestic challenges which contribute to restricting growth and economic development include income inequalities, labour shortages, skills gaps, quality problems and attitudes, lack of transparency in public administration, and unsustainable utilization of natural resources resulting in higher economic costs and lower quality of living (UNCTAD, 2015; National Economic and Social Development Board, 2017). Trying to overcome those barriers to economic development, the government of Thailand has formulated strategies to develop an innovation-driven approach emphasizing science, technology, and innovation (ST&I) to restructure economic activities towards meeting the United Nation's Sustainable Development Goals (SDGs). To Schiller (2006), countries which complete on low labour costs may be able to upgrade through technological innovation. Thailand's science park (SP) policy was developed as a tool for driving national economic growth to promote research and development (R&D), incubating new entrepreneurs, enhancing the use of new technologies, and cluster development.

The establishment of SPs in Thailand applied a triple helix approach requiring cooperation between three primary actors: the government, higher education institutes (HEIs) or universities, and private businesses (Asheim and Coenen, 2005; Science Park Promotion Agency, 2013; Nakwa and Zawdie, 2016). The private sector's role is to undertake R&D, the universities are to engage in research commercialisation and to assist with private sector R&D, and government to promote and support projects that are too risky for a firm without public

sector support (Schiller, 2006). Without the cooperation of these three actors, a SP would be unable fully to develop a localised knowledge-based community (Etzkowitz and Zhou, 2018).

The Thai higher education system has developed limited links between universities, business and industry and there was also limited commercialisation of research. Some limited technological transfer occurred to existing or emerging industries, but this was at a low rate compared to developed market economies. Nevertheless, perhaps, more importantly, business spin-offs or entrepreneurship formation, directly from universities was unusual (Office of the Higher Education Commission, no date). The Thai SP initiative has a similar aim compared to the Cambridge Science Park; both were intended to create collaborations between universities and firms' R&D departments and to encourage clustering of high-technology based companies facilitating knowledge exchange (Tweddle, 1984).

The expectations regarding the establishment of Thai Regional Science Parks (RSPs) were to eliminate the gap between universities and the business sector, encouraging research commercialisation, and supporting local agglomerations and network creation across regions. The nature of university-industry linkage is not a new thing as it has been internationally promoted since 1980 (Schiller, 2006). Nevertheless, across Thailand, university-industry research links were intended to differ by SP reflecting regional differences. Creating connections between firms and universities is essential to match the needs of firms with the knowledge and facilities available from local universities (Massey, 1992).

This chapter explores the application of the triple helix approach to understand the implementation of SP policy by the Thai government. The first three sections of the chapter highlighted the importance of government as a policymaker, HEIs as providers of technical knowledge and research facilities, and businesses involved in commercialisation. The relationship between them was analysed to examine the application and evolution of Thailand's

SP policy. Section Four explores the role SPs play in supporting entrepreneurs in product and service R&D by facilitating the application of university resources and encouraging research commercialisation to achieve government targets in enhancing regional economic growth and in stimulating national economic events. The last section is a discussion and conclusion.

5.2 Government and science park

To Garnsey and Heffernan (2005), SPs in developed countries did not require government support to establish and grow. However, in a developing country, the implementation of SP policy and the triple helix requires government intervention (Etzkowitz and Leydesforff, 1995; Gibb, 2001 cited in Nakwa and Zawdie, 2016; Hladchenko and Pinheiro, 2019). The government is an essential mechanism in driving regional innovation by supporting business growth and enhancing relationships between universities and firms (Etzkowitz, 2012). Sufficient funding and continuous support are critical in creating a new SP (Etzkowitz and Zhou, 2018). Nevertheless, SP development strategies must be in line with national and other government policies.

5.2.1 The role as a policymaker

SP policy development can be either attracting existing research units within the private and public sectors to relocate or establish activities within a SP, or to concentrates on incubating new firms while being supported by government-funded projects (Etzkowitz and Zhou, 2018). To Lundvall (2007), developing a national innovation system requires firms to be innovative and to develop competences. Recruiting innovative firms increases a SP's prestige and will attract other firms and skilled personnel and contributing to forming a local agglomeration (Cadorin, Johansson and Klofsten, 2017). Furthermore, smaller firms may be more open to

innovation compared to larger and more bureaucratic firms (Florida and Kenney, 1990; Anselin, Varga and Acs, 1997). Thus, supporting new businesses is essential for stimulating regional innovation and economic growth.

The SP concept emerged in Thailand from the necessity to develop scientific and technological (S&T) infrastructure. The aims were to promote and support the private sector in building competitiveness and strengthening the national innovation system, especially the links between education and production sectors, and the interconnections between productive sectors. Economic policy focused on developing an effective mechanism to strengthen the infrastructure and fix existing weaknesses.

For successful SP policy, the policymakers should understand the operational plans of SPs that have been developed in other national contexts to create models to inform the development of context-informed SP policy (Guadix *et al.*, 2016). The Thai government researched SPs in the USA, Europe, and in Asia with a focus on adapting best practice from different models to Thailand. The first SP, *Thailand Science Park* (TSP), was established in 2002 and managed by the National Science and Technology Development Agency (NSTDA). The primary mission was to promote innovation, support R&D in the private sector by developing S&T infrastructure intended to enhance Thailand's innovation system. TSP cooperated with NSTDA and its five research institutes. TSP did not include the university research commercialisation nor support local community development while the proposals to establish RSPs included these activities. Thus,

> TSP is not part of the university. Our strategies are to attract national and international companies into the premises and to match businesses to the research of NSTDA or other institutes as requested. Our mission is not about research commercialisation since it was responsible by another NSTDA's department…Moreover, we do not have a mission to help the community. Unlike the RSPs, those were established to commercialise university research and help the local community (SP1, 2018).

TSP aimed to match businesses with appropriate service platforms provided by NSTDA such as business incubation, joint research, and intellectual property (IP) management. However, during the interviews, the view emerged that TSP paid more attention to increasing the number of innovative businesses to its premises. TSP had 40% international firms on site (Thailand Science Park, 2018). Smaller firms were likely to receive less attention according to one participant who finally turned to the Northern Science Park (NSP) for assistance. Thus,

> I have rented a space in TSP for two years to be closer to the research institutes. Nothing concrete was created. It was like they are a property management agency. The support team seemed not to know how to begin with the small businesses. Their policy made it difficult too. The researcher looked at us as a competitor. They may work well with government authorities, but not with the private sector (C29, 2019).

This entrepreneur expected assistance with the development of an AI technology but did not receive much support. The researcher acted as if he was a competitor trying to invent something better. On the other hand, he considered that the NSP was more supportive and was considering withdrawing from TSP over the next three years.

In 2003, the government approved the establishment plan for three RSPs to be in the northern, northeastern, and southern regions. The purpose was to stimulate R&D in businesses by utilizing resources from adjacent universities, including academic expertise and R&D facilities. The RSPs were situated close to famous local universities and had other smaller universities in their networks. Each university established a SP as part of the university structure. The management of the NSP was first assigned to Thailand's Institute of Scientific and Technological Research (TISTR), and to NSTDA for the Northeastern Science Park (NESP) and the Southern Science Park (STSP). However, TISTR did not have experience in managing SPs. One interviewee reflected that,

> TISTR did not understand what a SP is. They sent some executives to make us become their branches, not a SP. Just gave funding to the entrepreneurs and transferred technology. It seemed that the image of a SP in TISTR's mind was only that. They did

> not consider infrastructure nor other services. Their management confused us, the university SPs in NSP (U3, 2018).

The operation of the SPs, under the management of TISTR, focused on transferring technology to entrepreneurs but did not provide other SP services. The message sent to local businesses was misguided. The SP activities did not perform as they should. At the same time, SPs in the northeastern and southern parts received guidance from NSTDA which had already researched SPs internationally and had experience from managing TSP. The universities in the NESP and STSP networks developed management skills, including preparing personnel, adjusting regulations, and offering proper support for the work of the SPs.

In 2011, the Ministry of Science and Technology established the Science Park Promotion Agency (SPA) to take over responsibility for developing operational plans and managing the RSPs. Taiwan and South Korea's best practice informed the development of the RSPs with an emphasis on establishing regional innovation hubs enhancing the technological capabilities of industrial sectors by encouraging cooperation between the private sector, government, universities, and local communities. China established new SPs by copying the models of existing ones (Etzkowitz and Zhou, 2018). In Thailand, although the establishment of RSPs followed the TSP, there were differences.

The operation plan of the RSPs, developed by SPA, included three stages over 15 years. The government would fund operational budgets for the first five years. This budget would be reduced between the year sixth to tenth from the establishment. Then, the RSPs should be financially self-supporting. Thus, the RSPs must create connections with other funding sources and utilize rental space effectively.

The RSP development policy aimed to stimulate economic growth through firms' R&D. However, this policy did not engage with Thailand's Food and Drug Association (FDA) certificate process. This was a barrier to SP firms, given the emphasis placed on innovations

within the food sector and the need for food products to be certified. The FDA was reluctant to process applications rapidly. Problems with food certification was a major obstacle as one SP director noted that:

> We encouraged the businesses to sell abroad because they do not have an FDA certificate. It takes a long time to get. Most food innovation companies would take international standards and sell their products to the international market first. If this obstruction could not be improved, we will lose competitiveness because the time to market the products in the country is slow (SP2, 2018).

The Thailand FDA certification process can take years. Businesses will resort to selling internationally before domestically. The failure to market products in Thailand due to certification problems initially prevented local direct and indirect spillovers emerging. Moreover, businesses unable to sell abroad may try to sell products illegally locally.

Furthermore, the intellectual property rights (IPR) were not well protected. Certified products can be easily imitated. Thus, one firm noted that:

> We had been doing R&D for this product for a long time. Nevertheless, someone compressed the gas in this beverage and sold it under another name, even though we had the patent forbidding this to be used as a component in other beverages. The worse thing was, they did better marketing than us (C05, 2018).

Taking legal action is expensive and time-consuming. This problem of IPR protection requires government action. According to Stoneman and Diederen (1994), policymakers should also consider IPR as patent protection and law enforcement encourages firms to be more innovative. Thus, the SP policy development requires collaboration from relevant authorities to eliminate the bottlenecks identified that reduce the impacts of SP policy.

Moreover, one barrier to R&D by firms, and to the support provided by universities to develop private sector R&D, is limited capital investment availability. Policies need to be developed to provide access to finance to support R&D.

5.2.2 The role as a budget provider

Despite having developed policies to increase national competitiveness through the application of ST&I, the annual budget allocated to the Ministry of Science and Technology for R&D during 2011-2018 accounted for only 0.01178% of the national budget, or 0.1849% of gross domestic product (GDP). This annual budget, however, has increased continuously with an average growth rate of 1.88 (Policy and Strategy Department, 2018).

The Thai government provided USD 88.39 million to support the establishment of each RSP (UNCTAD, 2015), most of which was for the construction of the administrative building. SPA received and allocated an annual budget to each RSP. In 2020, SPA received USD 17 million to support the development of ST&I infrastructure and business capacity, and this was a reduction of 39% from 2019. However, 89% of the 2020 budget (USD 15.17 million) had been allocated to support RSPs operations - an increase of 2019 by 49% (Ministry of Higher Education Science Research and Innovation, 2020). The host received the budget for each RSP's development that then allocated it to the network universities based on KPIs. This strategy transferred power to the host universities. The government is not involved with the management of the budget within the network.

From the interviews with seven universities in the NSP network, it emerged that there was reluctance in developing KPIs and budget allocation. None would discuss the size of the budget approved by the government and the allocation process to the universities. Thus,

> SPA sent the budget to the hosts of RSPs. Each host has its way of allocating budgets. For example, NESP announces the total amount and holds a meeting to assign KPIs and budgets to its network universities. A small part of the money went to the host for management purpose. STSP has two universities[17]. The money mainly went to the host. However, STSP tried pulling in other HEIs and assigned KPI and budget. For NSP, the network universities had to submit the KPI proposals. The host decided on budget allocation without calling for a meeting. None of the NSP network universities knew the total budget and how much each of us received. Our university SP received half of

[17] As of November 2018.

> the budget we requested for the same KPIs we had proposed. Less money but expected the same amount of work. Moreover, we did not know about the KPIs assigned to the host university (U3, 2018).
>
> The host does not discuss with us anymore. We used to hold a meeting for funding allocation. There has been no such meeting for three years already. We do not have information on what purposes the budget has been used, or the budget allocation ratio comparing to the total budget (U7, 2018).

The provision of limited information regarding the budget allocation process, and comparing themselves to the NESP management style, meant that the network universities in the NSP considered the process was unfair. The expectation was that there would be greater transparency in the budget allocation and management process. SPA acknowledged this issue, but no immediate action occurred. The advice over the budget allocation process was that this responsibility was already assigned to the host university (U3, 2018) and the university SPs should find additional funding from local authorities (U7, 2018). Some universities, those who had created active networks with local supporters, found it easier to raise additional funding from other projects rather than relying on more funding to be allocated from the SP project (U2, 2018).

5.3 Universities and science parks in Thailand

Thailand established the first university in 1916 (Schiller, 2006). By 2019, there were 155 universities (Ministry of Higher Education Science Research and Innovation, 2018). To Schiller (2006); and Goddard, Robertson and Vallance (2012), universities are a critical mechanism for connecting with the community, providing a highly qualified workforce, excellent research, and appropriate services and technologies according to the needs of businesses including incubation and SP services and to the ability to adapt research and teaching activities to meet regional needs.

Universities undertake multiple roles including teaching, research, and different types of end-user engagement or impact. However, in Thailand, cooperation between private businesses and academic researchers was limited (U5, 2018) and there had been limited research commercialisation (Office of the Higher Education Commission, no date). Existing academic research did not reflect the needs of industry (Nakwa and Zawdie, 2016). People outside the HEI sector tended to be unaware of the services offered by universities (C06, 2018). To encourage university research commercialisation and the development of solutions to the real problems of businesses and local communities, the government launched several projects, including the *University Business Incubation* (UBI) and RSPs.

5.3.1 Roles of universities in the establishment of SPs

The Office of the Higher Education Commission (OHEC) initiated the UBI project in 2004, offering business incubation services for university personnel, and current and former students, to develop spin-off companies from university research to generate a revenue cycle benefiting universities and the economy. The operational structure of UBI involved an integrated management system with university employees providing technical expertise, and external personnel with business experience in supporting new entrepreneurs (University Business Incubator Rajamangala University of Technology Lanna, no date)

OHEC provided funding to aid the universities interested and capable of providing these services and to ensure that they can facilitate innovation by establishing a UBI unit. Each university had to contribute to the operating budget. There were business support mechanisms to accelerate the growth rates of companies that are ready to create spin-offs. Therefore, participating universities had to be well-equipped with facilities, business consulting services, expertise, and management plans (Office of the Higher Education Commission, no date). From

2004-2015, over 4,000 university employees and 500 businesses participated with the UBI generating revenues of approximately USD 8.8 million with over 2,000 employments (Thaninkullaporn and Mingmalairaks, 2018). In 2019, 62 universities were involved in the UBI program (University of Phayao Incubator, no date).

In 2003, the implementation plans for three RSPs were approved. Networked universities had to establish a SP working under the RSP umbrella. Each university has its local community network. Thus, entrepreneurs can use the SP services provided by their nearest university.

It was vital to recruit universities with diverse expertise and the facilities to engage in R&D with businesses. Most universities that joined the RSP initiative has already been engaged with the UBI. They had experience in business incubation and supporting university research commercialisation, and that also included the aims and services offered by the RSP. It was easier for universities and academics to understand their roles when they became part of the RSP network. The potential universities were divided into two groups. The first group included universities that had the potential to perform full SP services. The second group involved universities requiring a transition period before being able to establish a fully functional SP (**Table 5.1**).

The selection process based on the readiness of a university to create collaborative research projects with the private sector. A university must have had an experience of receiving requests from businesses to provide support and academics must be willing to respond to such requests. The criteria also required a university to experienced providing research services to private companies. Furthermore, the universities in this first group must have proper organisational structures and policies that are ready to respond to the establishment of a SP

including policies towards joint investment with the private sector, IP management, and strategies to support personnel to work in the private sector.

Table 5.1 Qualifications of HEIs to establish a SP

Qualification	Developing full functions SP	Entering the incubation program to develop SP
(1) Having entrepreneurs who wish to conduct R&D and are ready to invest in SP,	Yes	(1) or (2)
(2) Having entrepreneurs who request for the supports in R&D, IPR, technology transfer, technology upgrade, and technology business incubation	Yes	
(3) Conducting joint research or contract research with the private sector, providing technology development activities	Yes	-
(4) Ready to provide infrastructure services for R&D, laboratory services, and test analysis to the private sector	Yes	Yes
(5) Having an organisational structure responsible for the SP operation and can show the personnel readiness in the SP management (contained with knowledge, understanding, experience, skills and competency) or having experience in the technology business incubator or business incubator for at least two years	Yes	-
(6) The readiness of place for establishing a SP	Yes	-
(7) Having the policies and guidelines for establishing a system to support the SP operation (such as policy in joint investment with the private sector, IP management, and strategy to support its personnel to work in the private sector)	Yes	Yes
(8) Having a stable policy connection with other local agencies (such as governing bodies, industrial and commercial organisations, and government organisations related to SP development).	Yes	Yes

Source: Adapted from Science Park Promotion Agency (2013)

In 2007, 13 universities were selected to be part of the RSPs network, included seven universities in the NSP, four universities in the NESP, and two universities in the STSP. The host had to manage the budget and the operation of the RSP and the network universities. By the end of 2019, only three universities had established fully functional SPs (Chiang Mai University, Khon Kaen University, and Prince of Songkhla University) with twelve universities running partial SP services (Tridech, 2019b).

Each university in the RSP network established a SP unit on their premises, monitored by university management. During the construction phase of RSP building, all SP activities were located in the networked universities. The management of the RSP, including KPIs and budget allocation, was the responsibility of the host university and was governed by a cooperation agreement with the SPA (Thailand Northeastern Science Park, 2018; Thailand Northern Science Park, 2018). The operations of a university SP relied on the university's rules and regulations, as well as mechanisms to facilitate access to services for the private sector, external agencies, researchers, and students to work cooperatively with the SP. The administrative structure of the RSP relied on a Working Group (WG) which was appointed by the Vice-Chancellor of each host university, under a sub-agreement with the other networked universities. The host university's director chaired the WG. Each networked university assigned representatives to the WG. The WG's duties were to plan operations and the budget, monitoring, and evaluation of the network university SPs' activities to ensure that they followed the policy. The host university prepared the agenda for universities in the network to jointly consider planning, operations, management, and brainstorming solutions to operational risks and the development of the network's potential.

5.3.2 Role of university personnel

Director of SP

The director of the Thai university SP is a university employee and was appointed by the university board. The role of the director requires an understanding of conducting academic research and the university's rules and regulation. Creating a network between the director and the researchers is critical in matching the business problem to the appropriate researcher. The director needed to create good relationships with SP supporters and government agencies. The

connection with local supporters, such as regional trade association, and the provincial industry federation is part of this process of reaching out to local firms. Establishing a network with government agencies increases the ability of a SP to match entrepreneurs with appropriate funding sources. Nonetheless, the director should understand the needs of entrepreneurs. For example, the manager of the Intellectual Property Management and Innovation Development Office at MFLU who was involved in managing the operation of government funded projects, including the SP project, had previously owned a business (U2, 2018).

The vision of each SP director had a major impact on the success rate of entrepreneurs involved with the SP. One aim of Thailand SP policy is to utilize university resources in helping businesses develop products. The interviews showed that a SP usually matches business problems with researchers and funding will be partially provided. Lastly, a SP may help to promote final products on to markets or in finding partners (**Figure 5.1**).

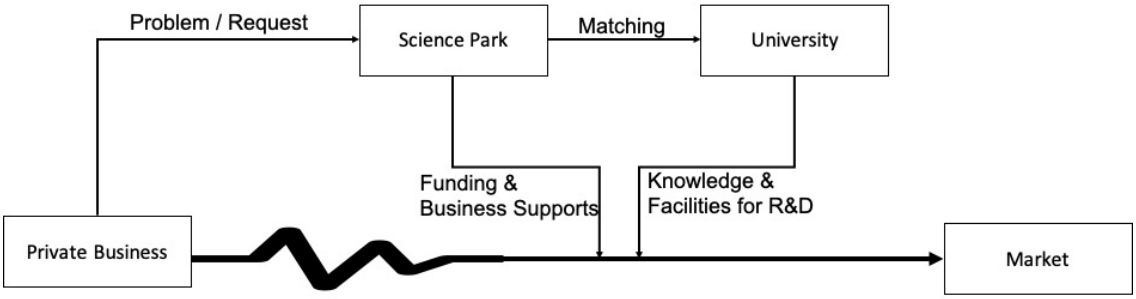


Figure 5.1 A business-driven approach to the operation of SP

Alternatively, a SP may operate by considering market demand. Once a supply opportunity, if identified, then a SP offers its expertise and capabilities to develop a solution (Etzkowitz and Zhou, 2018). Science and Technology Park, Chiang Mai University (STeP) applied this approach by researching demand before setting up projects. Potential businesses registered with STeP would be contacted and supported by university researchers, including the provision of sufficient funding to support R&D. By this method, STeP was able to commercialise products by market targeting. The director involved noted that (**Figure 5.2**):

> We brainstormed and worked together on the projects. For example, we planned to produce innovative and expensive products for the rich in Malaysia, Indonesia, and Singapore. We explored the actual needs of these countries. Then assigned the projects to the companies and brought in the university researchers to support. We went back six months later with the products to the buyers. It is an innovative way of thinking. Instead of doing what businesses thought they should do, we explored the market, focusing on high-value products for high-income customers. We set up the plan, and the businesses were ready to join. Finally, we pushed ten companies to an international market (SP2, 2018).

An entrepreneur confirmed the NSP's application of this approach by noting that:

> Now, we [the businesses] review what the customers want and bring in the researcher to help developing it, not to develop based on what we think we should do. For example, we checked the Malaysian and Singaporean markets and developed accordingly (C31, 2019).

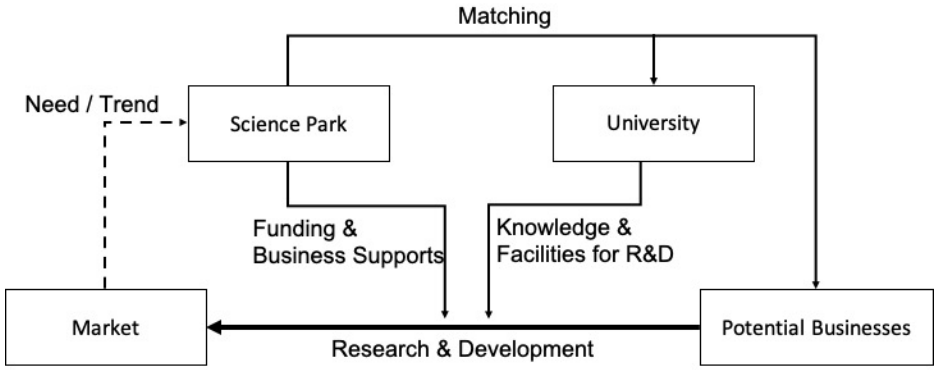


Figure 5.2 A market-driven approach to the operation of SP

A SP director plays a significant role in assisting businesses and encouraging research commercialisation. The firms were sometimes unable to identify market opportunities. A business-driven approach may overlook other perspectives including competitors, trends, or other potential market opportunities. A market-driven approach requires organisations to explore the market environment identifying opportunities. Product development plans will then be informed by an assessment of potential opportunities to enhance a firm's competitiveness. A firm must be able to invest in product development and to design products for commercial production. A SP has to carefully select the firms participating in this approach. Furthermore, helping businesses involves not only solving their struggles but also directing them toward real

market demand. Nonetheless, matching opportunities to firms is an essential part of the SP operation and then matching firms with university researchers and facilities.

University Researchers

The primary duties of a university involve teaching, research, and helping to solve societal problems. In 1990, the focus of Thai universities was extended from teaching to contributing to local and regional economies (Schiller, 2006). University employees, especially in state universities, were uncomfortable with working with the private sector and preferred to focus on teaching. Furthermore, academics focused on activities intended to support their academic promotion rather than providing services to business (Schiller, 2006). Thus,

> Each teacher must submit the research paper for levelling up in the academic career path. If any research can be useful for the local community, it is an additional benefit (U7, 2018).

The research was based on the researcher's interests and the need for publications. Reductions in government funding and student enrolment forced universities to seek additional income (Schiller, 2006). SP was the first policy initiative intended to encourage research commercialisation (U6, 2018). Universities expected that academics would develop networks with the local community leading to research commercialisation. Thus,

> The institute put priority over teaching duties. The lecturers did not understand why they had to answer unsolved problems from entrepreneurs since academic responsibilities already occupied their time. Until 2018 that is when the government launched the policy to support startups, and the number of students had declined. Then the university started pushing us [academics] to do more research with the private sector (R01, 2018).

Future research should reflect the needs of the private sector rather than academic interests. Interviews with 14 researchers and seven universities in the NSP network identified that only a handful of researchers had any experience of working with the private sector (**Table 5.2**).

However, despite creating a list of academics, SPs tended to focus on involving well-known academics. Thus, the:

> SP approaches the famous ones [researchers] first, although the project was related to the work of other researchers. However, they were not recognized. If I had not been famous, I would not have come in to contact with the SP. Within six years, I have done four projects with them. SP contacted other academics, but very few of the 20 of us in the Computer Department. The new professors are still unknown. Hence, no one approaches them. In the end, it has groups of professionals. That if the research is in this field, this person will be contacted first. I think this should be improved (R02, 2018).

The interviews identified the barriers to academic engagement with private businesses and these included teaching workloads, out-of-date skills, lack of equipment and funding, unattractive funding schemes, employees distracted by other higher-income activities and the management style of the state universities. Furthermore, the researcher may publish the research for academic purpose only if the entrepreneur agrees.

Table 5.2 Human resource in the NSP's network

University	All Academics*	Academics who experienced working with SP**
Chiang Mai University (CMU)	2,354	220
Mae Fah Luang University (MFLU)	573	32
Mae Joe University (MJU)	688	36
Naresuan University (NU)	1,463	19
University of Phayao (UP)	997	42
Uttaradit Rajaphat University (URU)	475	30
Pibulsongkram Rajaphat University (PSRU)	470	17

Source *Ministry of Higher Education Science Research and Innovation (2018)
**Wongpridi and Sudhipongpracha (2017)

The universities offered diverse expertise in all fields, including science, engineering, health, agriculture, and business. Most requests from the private businesses focused on food and agricultural products and processes. A researcher, for example, noted that he was ready to work, but there was no demand for his expertise:

> SP did not contact the Faculty of Public Health much. They usually approach the Faculty of Science, Engineering, and Pharmacy. The reason I do not work with the private sector is that my expertise is not that much in demand by a business (R10, 2018).

R&D projects can be based on existing research that is ready to be commercialised or projects that come from the private sector; an appropriate researcher is then identified to support the creation of a solution. One project may require multiple expertise inputs. The lead researcher will seek knowledge within and across research institutes. No request to become involved with a SP should require knowledge beyond the researcher's capabilities. At an early stage in the SP establishment, the awareness of the academic community in applying technology to product development was low. The researcher, pushed by the university, approached businesses with the potential to invest in R&D. Communications between researcher-entrepreneur and SP-entrepreneur was essential. It was vital to develop a clear understanding of the project's scope, expected results, and investment required. Some projects were identified, but it was not possible to agree terms of engagement. Nevertheless, some projects could not be commercialised. Businesses needed further investment in developing prototypes. In some cases, the researcher's ideas were too in advance of the market (U6, 2018). From the interviews with 14 researchers, five types of researcher-business relationships can be identified (**Table 5.3**).

Table 5.3 Researcher-entrepreneur relationships

Types of Relationship	Characteristic	Number of the interview (14)
Acted as consultant to the firm	A strong bond was created. The researcher gains trust and has a significant influence on further business operations.	1
Repeat projects with the same company	A long-term connection was created. The researcher and entrepreneur committed to further product development.	4
Retained personal contact	The light-level positive relationship occurred. The entrepreneur keeps a connection for informal consultation and light talk.	2
Retained formal contact	A researcher was supportive until commercialisation. The entrepreneur keeps contact only to consult on a specific project.	3

Types of Relationship	Characteristic	Number of the interview (14)
No further contact once the project concluded.	A non-supportive relationship occurred during R&D. The connection ended with the project.	4

Five types of relationships identified rank from high to low levels of cooperation between researchers and entrepreneurs. Seven researchers developed more formal relationships with firms. Three entrepreneurs still contacted the researchers occasionally for technical purposes. Another four stated that the entrepreneurs never contacted them once the project had concluded. These types of formal relationships did not encourage further academic support for the firms. Seven researchers had developed close relationships with firms. One developed a strong relationship with the entrepreneur and became an official consultant. Four researchers had engaged in repeat R&D. Researchers also approached entrepreneurs about new ideas. Another two stated that they remained in contact with the researchers for informal discussions. These positive relationships benefited firms as the academics were more engaged with the projects.

Furthermore, universities also encouraged employees to create spin-off companies. From the interviews, capital investment was not the primary concern for researchers. Although there were various sources of supporting funding available, academic spin-off rarely occurred. One explanation is that:

> Most university staffs are risk averse. They want the security of a monthly salary. They cannot accept the risk of unstable income. So, we rarely have spin-offs from university staff (U3, 2018).

Government regulations did not allow university employees to hold a managerial position in private companies. The Teacher Civil Service and Educational Personnel Act, B.E. 2547, section 43; states that civil servants in higher education institutions must not be a managing director, manager, or have other similar positions in partnership or in a company, except as a

civil service practice or assigned by the rector. However, this did not forbid them from holding shares in a company. Also, the researcher was preoccupied with teaching, publishing, academic research, and providing academic service. They had to decide to retain their university job or to resign to establish a firm.

Nonetheless, the primary concern of academic spin-offs required business knowledge. Researcher can create products, but they do not know how to compete in the market. Thus, researchers preferred to focus on their academic role and to act as a consultant to firms rather than taking risks related to doing business that is beyond their capabilities.

5.4 Private businesses

Private businesses were considered an essential part of driving the economy (Salder and Bryson, 2019). In Thailand, approximately three million SMEs contributed 43% to GDP (Office of Small and Medium Enterprises Promotion, 2019). The Thai government believed that increasing the capacity of SMEs can create a positive effect on national economic growth. Nakwa and Zawdie (2016) noted that the performance of firms became more productive after applying academic knowledge to processes. SP were established to act as a necessary bridge between academic expertise, business support, and funding.

5.4.1 The character of firms joining the SPs

Massey (1992) noted that the reputation of a SP plays an important role in attracting firms. Thailand's RSPs were linked to established universities in each region which had resources, expertise, high-technology equipment, and industrial connections. Firms would already be working with academics or a university, or they would approach a SP linked to an established university.

The character of the firms participating in SPs varied by size, product, and background. Firms joining the incubation program were newly established or startup firms that wanted to accelerate business growth. The Industrial Research and Technology Capacity Development platform (IRTC) aimed to increase the businesses' capacity and competitiveness. SPs supported part of the initial investment to undertake R&D. The firms had to co-invest in the project by providing funding or materials[18]. Thus, the businesses engaged with IRTC had experience of the market and could invest in R&D. There were not many firms in the Collaborative Research platform (Co-research) since it required firms to cover at least 60% of a project's cost, and the project value must be higher than USD 29,500 (Thailand Northern Science Park, 2018). Moreover, the firms should have the capacity for research commercialisation. Most of the firms involved with the RSPs operated locally. From the 33 interviews with firms, only two companies had more than 100 employees. Twenty-one micro-enterprises employed less than ten permanent staffs. Firms joining the NSP can be divided into four groups (**Table 5.4**). Although the firms operated in different industrial sectors (**Table 5.5**), 50% of participants were involved in the agro & food sector.

Table 5.4 Characteristics of firms working with the NSP

Character	On-park	Off-park
Existing businesses - existing product	-	4
Existing businesses - new product	3	8
Spin-off firms (new company from existing business)	3	1
Newly established firms	11	3

Table 5.5 Firms involved with the NSP by industry

Industry	Number of firms (33)
Agro & Food	16
Property & Construction	3
Industrials	1

[18] The investment of businesses can be in cash or in-kind depending on negotiations and the policy of each SP.

Industry	Number of firms (33)
Services	3
Consumer Products	4
Technology	6

The RSP policy was intended to stimulate the development of new emerging technology businesses but focused predominantly on supporting existing firms involved in agricultural and food production. Thus, another policy was required that would focus on technology businesses or it should be accepted that the RSP policy supports existing firms building upon existing regional resources.

5.4.2 Expectations and benefits of firms participating in SP activities

The sample of firms that were interviewed included 16 located within SPs and 16 linked to the SPs but located elsewhere. However, 87.5% of the on-site firms were new businesses, and 75% of off-site firms were existing businesses. Existing firms had already created localised networks with customers, partners, and suppliers. Relocating to a SP would impact on these localised relationships. Moreover, their locations were not so close, but not too far from the SP. Thus, these firms had no reason to relocate to the SP. In contrast, new businesses did not have many existing assets. It was easier to relocate or set up an office or small laboratory at the SP and build up their network from this:

> We had the opportunity to move in because we were in the SP incubation platform. At the first visit, it was interesting here. The environment is OK. Companies are doing similar business to us - technology and innovation businesses. There are government agency offices which are convenient to contact. I think setting up an office in a SP is appropriate in doing innovation business and having the opportunity to establish connections with other companies (C28, 2019).

Furthermore:

> Aside from the location, being in MJU is convenient for consultation that we did so often at the start, mainly about doing business, legal matters, and funding sources. Being near a professor made it easier when we needed help with programming. We arranged

> appointments with customers at the office. Locating on the park provided us with increased credibility. It is like we have a university as a supporter. Moreover, the cost is a lot lower than renting an office outside (C19, 2018).

A location in the SP helped create a network with other similar firms, being close to academic and business support, and provided reputational benefits for new firms. Entrepreneurs developed relationships with their partners not only to acquire access to resources at a reduced cost but also to create a network of alliances (Dicken and Thrift, 1992). New businesses had less experience with markets. Their products were still at the development stage. New entrepreneurs preferred being on the park to be close to the support available, such as academic knowledge, business consultants, and recommendations about funding.

Expectations of the firms about their participation with the NSP varied depending on the business's asset. Startup firms are new to the industry and do not have much R&D investment capital. They require support for business knowledge as well as funding for product development. Firms with more extensive experience required expertise from academics to help with product development.

Partial support with funding was an additional benefit, but not the primary concern. The benefits received from a SP were different depending on the characteristics and location of firms. Massey (1992); and Quintas, Wield and Massey (1992) identified that the formal link created between firms and a university did not differ between firms located on-site and off-site. However, the on-site firms developed a more informal relationship than off-site firm and received privileged access to university facilities (Quintas, Wield and Massey, 1992; Vedovello, 1997; Vásquez-Urriago, Barge-Gil and Modrego Rico, 2016). The distance between the business and the university/SP influenced relationship development between entrepreneurs and academics. Co-location between a firm and a university supported the development of two-way communications (Albahari, Klofsten and Rubio-Romero, 2019). Thus, one firm noted that:

> I conducted three R&D projects with three universities. One project had many problems. I had never met that researcher in person because the university was far from my usual route. We discussed over the telephone. The other two universities are in the same driving direction. I usually stopped by for lunch and chatted with the researchers. I think the cause of the problems was I did not create an informal relationship with that one researcher (C25, 2019).

Every category of firm benefited from academic expertise. However, new firms received more business support (**Table 5.6**) as they needed to learn how to survive in the marketplace while experienced firms concentrated more on developing products. Furthermore, this analysis is supported by existing studies (Vásquez-Urriago, Barge-Gil and Modrego Rico, 2016; Cadorin, Johansson and Klofsten, 2017) which identified that a location on a SP provides opportunities for firms to develop networks.

Table 5.6 Expectation vs the benefits firms received from SPs

	On park		**Off park**	
	Expectations	**Benefits**	**Expectations**	**Benefits**
Existing firms-existing products	N/A	N/A	Expertise Funding	Expertise Funding
Existing firms-new products	Network	Network Credibility	Expertise Funding	Expertise Credibility Funding
Spin-off firms	Expertise Network Business support Credibility	Expertise Network Business support Credibility	Expertise	Expertise Business support
Newly established firms	Business support Funding Expertise Network Facility	Credibility Business support Funding Expertise Network Location Facility	Expertise Credibility	Expertise Business support Credibility

Although the businesses were most concerned with accessing academic knowledge, the interviews showed that funding also attracted entrepreneurs to the SP. The firms had limited investment for R&D. With funding support, they could obtain better outcomes. Funding was

not the primary factor, but it was an essential supporting factor in stimulating the entrepreneurs to engage in R&D:

> Before joining with SP, I prepared USD 3,000 for one project with one researcher. With the SP, the USD 3,000 input were able to do more projects because there was additional financial support (C13, 2018).

Those businesses requiring technical skill, such as software engineering and cosmetic production, rarely needed support with academic knowledge. These firms did not expect knowledge transfer to occur since many of the skills required are specific and acquired from learning and experience, and these could not be easily transferred (Quintas, Wield and Massey, 1992). The nature of the business requires that founders have the know-how regarding production, such as developing the cosmetic recipes and coding software programs. Thus, these entrepreneurs required business consultancy and benefited from the reputation and network of the SP rather than academic support:

> We did not require academic assistance to do R&D. SP helped us a lot with marketing and legal issues. Some customers were from SP's promotion. We are stand out from competitors because we have an office in a SP. We have credibility certified by the university and the park. However, we must be clear that we are not a university organisation. Because customers, sometimes, expected us to promote products produced by a university (C17, 2018).

The expectations of the firms in joining with the SP were mostly met, especially the core services provided, such as academic expertise, funding, and business support. Furthermore, the firms received intangible benefits, including reputational capital and the credibility provided by their new location, creating a network with other firms and supporters and developing their personnel through learning processes. The relationships that the firms developed with the SP can be classified into five types (**Table 5.7**).

Table 5.7 Firm-SP relationships

Type of relationship	Characteristic	Number of firms (33)
Benefits more than expected	Firms received expected support (i.e., academic, business, funding) and realized additional benefits (i.e., reputation, network). R&D was successfully commercialised. Firms have a high rate for further participation and become a useful reference for SP.	13
Benefits matched expectations	Firms received expected support but did not acknowledge receiving additional benefit from SP.	11
Some expectations were met and received additional benefits	The firm did not receive all expected support but did receive additional benefit. For example, the R&D still required further development, but the company gained a reputation by SP promotion.	1
The expectation was not met but received other benefits	Firms did not acknowledge receiving the expected supports but obtained other benefits. For example, new firms moved in for business support, but instead, they benefited more from the SP location and an increase in the firm's reputation.	6
Learning occurred, but no research commercialisation.	Firms aimed to develop products, but no commercialisation occurred. The firms engaged in an R&D learning process.	2

Even though the businesses expected to apply academic knowledge to product development, not every project was successfully commercialised. Nevertheless, the firms still benefited from other aspects. All the interviewees were satisfied with the outcomes once the project had concluded. They were pushed to the market, created a network benefiting the business and increased their reputation by joining the SP even though some failed to commercialise. There were trade-offs between other benefits firms obtained from their involvement with the SP versus research commercialisation.

5.4.3 Problems encountered with research commercialisation

The SP matched firms with potential researchers to discuss the problem, scope of the work, investment, IPR, and further development for research commercialisation. Some entrepreneurs experienced difficulties in applying the project outcomes at a factory level. A

distinction needs to be made between academic-orientated solutions and those required to scale up production. Thus:

> The researcher process consumed much energy. We cut some processes out, and it worked as well. He tested with A4 size sheets. As a factory, we must produce large pieces. It is impossible to do. He is an academic. He may overthink. We understand. However, we cannot apply his way for business (C07, 2018).

Moreover,

> The management and coordination of SP and researchers were appropriate. Just the machine was not as we expected. The sketch looked good, but the students in the university workshop assembled it. The machine was too weak. It was a prototype and needed further development to use in the assembly line. We are not yet ready to invest (C04, 2018).

These two cases reveal some limitations of academic-orientated R&D. The tests were done within the laboratory and not within a factory setting. The machine was assembled by the students and not designed to meet factory conditions. Entrepreneurs needed to invest in further development, but they were not ready to do so. Company delays in developing the prototype to meet factory conditions slowed the research commercialisation process down. Furthermore, interviews with researchers and businesses indicated that the primary barrier during the R&D process was the quality of the relationship, or the development of a less supportive or negative relationship. In contrast, a positive relationship created further benefits for businesses, such as creating a pool of expertise and further new product innovations:

> I created a network with researchers. Once I had the idea, they discussed with me and referred to whom I should talk. That is, the network grew. Some researchers were passionate about their work. She convinced us to try when she found something new. We discussed in a group that now has experts from various universities, a mix of disciplines. Doctors and professors filled up this long table, talking and eating together. Then the R&D began, here at this table (C05, 2018).

A positive relationship between entrepreneur and researcher can drive R&D forward. Informal meetings, such as having lunch and friendly chatting, created a relaxed atmosphere, and positive relationships developed. A willingness by firms to invest and to engage in R&D encouraged

academics to identify other academics who were able to assist with a firm's problems, and the strength of the relationship ensured more contributions to the projects.

If a poor quality or negative relationship developed, then the project tended to move slowly and could be terminated at any stage (**Figure 5.3**). At the centre of a SP success is the establishment of strong positive and supportive relationships between academics and private businesses. Entrepreneurs and researchers need to agree upon the result including costs and time frames. All partners must commit continuing to work towards delivering the project. The outcome must be on time. Then, the researcher should keep supporting the commercialisation process by making any adjustment required and transferring knowledge to the business. Moreover, the SP should identify sources of funding for further development.

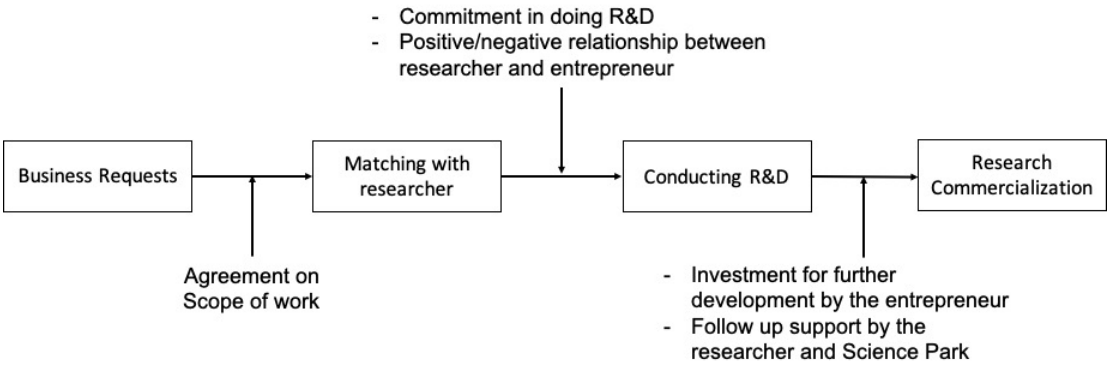


Figure 5.3 Inputs that affect the R&D process at each stage

5.4.4 Improvement of the firms

Despite having difficulties with research commercialisation, firms benefited from engaging with SPs in both tangible and intangible ways. Not only were products developed and certified, but they also enhanced their reputations from having academic research as a product guarantor. The firms increased sales.

The NSP Annual Report 2018 identified 20 IPs registration as a result of R&D projects involving SPs. Thirty-one firms in the incubation platform increased their revenue to a

combined total of USD 1,373,748 and 127 jobs were created. Investment in R&D increased to USD 428,698, and this created an economic impact of USD 10.9 million. The IRTC platform served 65 businesses and created an economic effect valued at USD 1.5 million. Two firms in the Co-research platform were involved with projects valued at three million dollars (Thailand Northern Science Park, 2018).

The interviews identified that 25% of on-park firms planned to expand and to move away from the SP. These firms were extending factory buildings at nearby locations. Although planning to move out, the entrepreneurs preferred staying close to the SP to ensure that on-going relationships could continue. Seventy-five percent of firms planned to stay on-site for at least three more years. Although it is rather early to measure the long-term success, Albahari *et al.* (2017); and Lamperti, Mavilia and Castellini (2017) showed that on-park firms have a dramatically higher rate of patenting with greater impacts on firms' innovativeness than off-park firms. However, this is not the case for the NSP; off-park firms registered IP more than on-park firm (**Figure 5.4**). This may be because the on-park firms were mostly startups with limited resources. The more developed firms located off-park were more experienced in undertaking R&D and thus further advanced along the pathway that led to developments that required IP protection. Moreover, the 33 interviews with firms involved in the NSP revealed that they had created value-added products and had increased revenues and they also benefited from an increase in reputation and credibility, personnel development, and business expansion.



Figure 5.4 The numbers of firms that improved in each area with the support of the NSP

5.5 Science parks and the regional economy

SPs make an important contribution to regional development by attracting talented personnel to a region and developing local entrepreneurs enhancing their performance (Cadorin, Johansson and Klofsten, 2017). Moreover, SPs support an increase in local economic activities. For example, rents for local property and shops may increase close to SPs as firms and employees move on-site (Massey, 1992). To develop a sustainable knowledge-based community, a SP should support the growth of the economy and society (Etzkowitz and Zhou, 2018), by mirroring needs at a local, national, and international level (Garnsey and Heffernan, 2005). The strength and weaknesses of the region should be considered by involving local authorities and not only the central government (Saxenian, 1994). Development strategies cannot be transferred from one place to another due to variations between places (Storper and Scott, 2016), and the success of a SP depends on the ability to engage with a region's functioning economic geography (Albahari *et al.*, 2018). Thus, a SP must consider its regional and local context. Thailand's economy is dominated by agriculture and tourism. SPs must

support the business improvement of these primary industries, together with developing new related industries and then try to focus on activities that are not yet regionally localised.

When should one measure the success of a SP? Perhaps the answer is over 15 years (Quintas, Wield and Massey, 1992). Nevertheless, between 2013-2018, NSP contributed to the regional economy by increasing R&D private sector investment to USD 4.9 million and increasing firm revenues to USD 20.2 million (Thailand Northern Science Park, 2018). The economic impacts created by RSPs in 2018 are shown in **Table 5.8**. Moreover, the success of SP related firms spilled over on to their partners. Thus:

> We developed the automatic watering system for the corn factory to stabilize the amount of raw material. The factory installed this system to 20,000 farmers. It helped to control and predict the corn delivered each day, decreasing the uncertainty cost. The farmers were happy as it reduced electricity costs, workforce, and increased corn quality. The factory paid upfront for installation and deducted later from the corn buying price for USD 0.01 per kg. It was a win-win project (R13, 2018).

Once the businesses grew, then suppliers grew with them. The operation of RSPs benefited businesses along the value chain. Moreover, it increased local employment and added value to agricultural production. However, it is too early to measure the longer-term effects on the regional economy.

Table 5.8 Economic impacts of RSPs, 2018

	Economic impact 2018 (USD)
NSP	13.4 million
NESP	3.5 million
STSP	7.3 million

Source: Thailand Northeastern Science Park (2018); Thailand Northern Science Park (2018); Thailand Southern Science Park (2018)

To Asheim and Coenen (2005), the regional economic system is an "interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems", and a cluster is "a concentration of 'inter-dependent' firms within the same or adjacent industrial sectors in a small geographic area". The development of a cluster, thus, affects the

regional economy and vice versa. The community and the cluster must have activities which support one another (Dovey, Rao and Pafka, 2018). Frenken and Boschma (2007) claimed that economic development was linked to product innovation. The establishment of a SP must support the development of existing industries to enhance local competences (Massey, 1992; Doloreux, 2002; Etzkowitz and Zhou, 2018).

5.5.1 RSP and cluster development

Clustering, or agglomeration, is critical for economic development as localised industries can attract similar and supporting businesses to an area (Scott and Storper, 2015). SPs play a role in cluster formation supporting and enhancing economic growth and competitiveness (Hobbs, Link and Scott, 2017). Moreover, firms benefit from agglomeration by sharing infrastructure, services, and technology (Storper and Scott, 2016). In Thailand, clusters emerged through the activities of private businesses and with support from the Industrial Federation and the Chamber of Commerce. Cluster development as a policy objective came under the responsibility of the Ministry of Industry and were not directly part of SP policy (SP1, 2018). However, the RSP development policy supported the cluster development plan (Ministry of Science and Technology, 2015). There was cooperation with the Ministry of Industry to stimulate knowledge exchange and to improve industrial clusters by using RSP as a tool.

A regional provides firms with an essential source of competitive advantage (Saxenian, 1994) and influences industrial clustering (Oakey, 1985). The most significant cluster in Thailand's northern area is a food-related cluster. The government is a primary source of funding for the universities involved in providing R&D support for clusters; the clusters themselves could not support the universities (Nakwa and Zawdie, 2016). NSP engaged with

the clusters by providing expertise and funding to support businesses' R&D activities including spending over USD 1.8 million to support entrepreneurs involved in the food cluster (SP2, 2018). However, NSP's industrial focus was also in line with the policy to develop clusters related to the automotive industry including parts, electronics, digital, petrochemicals, food and agro-processing, and textiles (Thailand Northern Science Park, 2018).

A SP is itself a cluster operated under the SP's policy and management team (Albahari, Klofsten and Rubio-Romero, 2019). Thailand's RSPs were expected to be hubs of technology-based businesses and a mechanism for stimulating agglomeration (SP3, 2018). The tenant selection criteria emphasized technology-based firms and highlighted that the SP should be the centre of network creation for new businesses. Activities included encouraging connections between tenants, starting with partnerships and developing eventually into a high-tech regional cluster. RSP provided a meeting place:

> NSP has activities for the tenants to meet each other. I am new here and want to discuss with other cluster members to create the same vision and mission. Then, we can drive the cluster in the same direction (C31, 2019).

An agglomeration occurs because companies seek support from other firms in an area (Scott and Storper, 2015; Dovey, Rao and Pafka, 2018) but still retain their uniqueness (Anderson and McFarlane, 2011). Nevertheless, the clusters in Thailand could not create strong connections between companies because there was a lack of trust and knowledge sharing amongst members. A cluster is more likely to be a broker links between members (Nakwa and Zawdie, 2016). Thus:

> The concept of the cluster by [Department of Industrial Promotion] DIP was good. The obstruction was the entrepreneurs' mindset. They were secretive, no sharing in the group. They do not consider learning with each other. In the agglomeration of similar business, they set themselves as competitors, not partners (U6, 2018).

The clusters were more likely to be an information pool of what was going on in the marketplace and contributing to increasing negotiation power (R09, 2018). Only seven entrepreneurs

identified themselves as being members of clusters while the other 26 firms considered themselves as not belonging to any clusters that supported by DIP. Furthermore, the clusters did not create a network across disciplines, as the:

> Clusters promoted by the DIP are not focused on finding customers. There was no connection between clusters. For example, does the textile cluster want to use IT? We know the other groups exist, but we do not have matching [of firms] across clusters (C26, 2019).

To Cooke, Gomez Uranga and Etxebarria (1997), factors linked to the success of a regional agglomeration include connections with other clusters, service specialization, and government support. The absence of connections between clusters can create lock-in and obstruct development. RSP may help encourage network creation between entrepreneurs in different industries by matching activities for the tenants within and across RSPs to stimulate knowledge sharing and partnerships between regions.

SP contributes to stimulating cluster formation by producing spin-off firms in the area that will attract other firms and support and increase regional economic activities (Etzkowitz and Zhou, 2018). However, Thailand RSPs were at the implementation stage and had just started tenant recruiting. Thus, the RSPs require more time to become embedded in Thailand before it is possible to explore the wider impacts of this policy. There is a scale issue here – a cluster is forming within the RSP that will then disperse to the locality as firms grow and relocate. The key issue is the relative contribution the RSP plays to enhance the regional economy.

5.6 Discussion and conclusion

To increase businesses competitiveness and encourage research commercialisation, the Thai government launched projects designed to build upon HEIs resources in applying ST&I to R&D (**Table 5.9**). Each project was controlled by different government departments with similar but different objectives.

Table 5.9 Government projects supporting ST&I to businesses

Project	Implementation	Lead ministries	Purpose	Management
TSP	2002	Ministry of Science and Technology, Ministry of Education	Applying NSTDA research to increase business capacity and competitiveness	NSTDA
UBI	2004	Ministry of Education	Drive university research commercialisation through spin-off company of university staffs, current and former students	OHEC
RSP	2007	Ministry of Science and Technology, Ministry of Education	Drive university research commercialisation through business and community R&D	SPA (From 2012)

The RSP policy in Thailand was informed by the application of the triple helix approach. The RSPs were intended to operate based on the interaction between three actors: government, HEIs, and private businesses. Different types of relationships were identified between these three types of stakeholders and the nature of the relationships influences project outcome. The policy implementation can be successful if the relationships of the three helixes have been developed and all stakeholders are mutually supportive of one another (U.K. Science Park Association, 1986; Etzkowitz and Zhou, 2018). Positive relationships between the stakeholders enhances project outcomes and commercialisation. Moreover, entrepreneurs that created supportive relationships with researchers were more likely to engage in more R&D. Meanwhile, negative relationships did not encourage research commercialisation and entrepreneurs became less interested in government funded projects. It is important to understand the nature of the

relationships that form within a SP and their impacts on outcomes. Government policy, in the development of RSPs, must consider the creation of linkages by encouraging collaborative working between actors.

The relationships between the universities and other stakeholders took different forms depending on their roles and activities. Formal links between business, government (through the SP), and the university were created. The establishment of the RSP was expected fully to utilize the university's personnel and infrastructure. The management of the university is essential in driving research commercialisation through the SP (Nakwa and Zawdie, 2016). The outcome of each university SP is varied due to differences in management styles of the directors, local economic geography, and the support from the university in term of finance, facilities, personnel, and policy.

The role of the university as the main actor in the establishment of a SP is critical. In Thailand, government policy and the reduction in student enrolments pushed the universities to seek additional income. Hence the organisations should be ambidextrous to survive changes (O'Reilly and Tushman, 2004; and Tushman and O'Reilly III, 1996 cited in Lis *et al.*, 2018), exploration and exploitation should become a vital part of university policy. Universities may exploit their current assets by producing scholars but also enhance capabilities by exploring further opportunities by engaging with the private sector. Universities should develop existing strengths, but also innovate to develop new capabilities.

To respond to the demand for academic service, universities must encourage professional development amongst academics, including attitudes toward their new roles (Evans, 2008) and encouraging them to engage in research which supports the local economy. This requires balancing teaching with other societal contributions. A network of expertise must form around a SP, allowing new researchers to participate in R&D projects.

The firms involved with the SPs have different characteristics and expectations. The new firms required business support while existing companies required support with innovation. SPs should have separate strategies serving both groups – new and existing businesses. Access to academic knowledge was the first concern of established firms. Location and proximity matter here given the need to form strong relationships based on trust between businesses and academics (Hess, 2004). Entrepreneurs should engage with their closest SPs before searching further away. Furthermore, socialization helps learning and knowledge transfer (Nakwa and Zawdie, 2016). SPs may arrange activities catalysing their supportive relationship.

RSPs also have a duty to maximize the utilization of their buildings. Having the large companies on park increase the prestige of a SP and act as a magnet to attract other companies (Cadorin, Johansson and Klofsten, 2017). However, the balance between trying to attract talented firms and supporting small businesses should be considered. SMEs are over 90% of the businesses in Thailand, and they require financial support (UNCTAD, 2015). The RSP policy acknowledged and focused on helping local SMEs, and this might mean that they overlooked large companies. One RSP director noted that:

> We must consider that a new company [to a RSP] can be a magnet to attract other businesses or not. With one case we had a problem. The research centre of company X wanted to move in. It will be beneficial for the RSP because it is a large company that we can use their supply chain or supporting industry for S&T development. However, the committee questioned why this company does not build its own building, instead of considering the benefits this company can bring us (SP3, 2018).

Tenant selection should consider the benefits of having large companies located on the park as they will attract other firms in related businesses. Moreover, more substantial companies may act as consultants, customers, or partners to smaller companies.

Funding and subsidies are essential in attracting entrepreneurs with limited R&D investment, but it was not the main reason for engaging with the SPs. The amount of financial

to support R&D should not be too high to screen potential businesses. The availability of too much funding may attract firms with low levels of commitment to doing R&D. Nevertheless, too little funding may obstruct smaller companies that have growth potential. Large firms may be less concerned with financial support. It is essential to have different policies to attract larger firms as they can enhance financial sustainability. There is a balance between the financial sustainability of a RSP compared to wider regional impacts. The key issue is the extent and timing of public subsidy required.

This analysis of the implementation of RSP policy in Thailand identified some problems those require government attention. A key barrier to the development of RSPs involved decision regarding assigning an inappropriate authority to manage the RSP. Misunderstandings about the concept of the organisation sent misleading information to employees, entrepreneurs, and university personnel. At the beginning of the RSPs' establishment, TISTR that manage NSP did not understand the background and expected roles of RSPs in Thailand. This led to problems with the overall direction and operation of the NSP and led to mission creep. Later, the implementation plan came under the management of the newly established department, SPA. All three RSPs had the same goals and objectives. The operation plans went in the same direction, using the same evaluation systems.

The FDA certification process and law enforcement regarding problems with IPR were barriers to marketisation. The time required for FDA certification was an obstacle to product entry to the local market. Launching food-related products was much easier internationally rather than domestically. Thus, the SP policy cannot be developed alone. It requires government departments to work collaboratively to identify and address bottlenecks. Business R&D must be supported by all processes including product development, production and marketisation.

Completed R&D projects may fail to commercialise, mainly due to financial problems in supporting further development (Nakwa and Zawdie, 2016). The scope of R&D project should cover the research commercialisation stage, or the SP may suggest that funding might be available from other agencies or low-interest bank loans. Those firms that failed to commercialise their research still benefited from increasing their reputations and credibility, acquiring technical knowledge, network creation, and knowledge of doing business. There were both direct and indirect transfers of knowledge and learning locally.

The RSP's duty is as a coordinator bridging the gap between businesses and university expertise. The government provided sufficient funding and subsidies through the supporting programs of RSPs. However, government funding is limited, and this means that the SPs must create strong relationships with other possible partners to search for additional income, for example, the cooperation between the SPs and the DIP. SPs received extra funding and achieved a higher rate in bringing entrepreneurs to the market while DIP fulfilled its mission regarding cluster development.

Policy plays a role in supporting regional innovation, and businesses need to keep improving their strengths and capabilities (Cooke, Gomez Uranga and Etxebarria, 1997). The development of ST&I must cooperate with industrial development and adopt the same goal - to improve business competitiveness. The Thai government, and the cluster leads, tried to stimulate knowledge transfer to businesses to improve clusters. Agglomeration is an on-going process that involves combinations of ideas or activities performed by various agents in a group to create relationships benefiting all stakeholders (Dovey, Rao and Pafka, 2018). It varies depending on the relationship with each element, including alliances between businesses and newcomers involved with a cluster (Anderson and McFarlane, 2011). It not only binds businesses together but has wider socio-economic effects (Scott and Storper, 2015). RSP is not

the leader in cluster development but supports businesses by offering university expertise and government funding for R&D to improve business capacities and provide network creation opportunity. The exchange of information within the cluster benefits its member through repeated interactions with related businesses (Bathelt, Malmberg and Maskell, 2004). However, the relationships between businesses in the Thai clusters are loose. Entrepreneurs still needed to be educated to realize the benefits of knowledge sharing. Furthermore, to stimulate regional economic growth, it is necessary to encourage interactions between regions to trade and share knowledge to support innovation (Bathelt, Malmberg and Maskell, 2004; Scott and Storper, 2015). RSPs can fulfil this role by encouraging collaborative activities across regions.

Thailand's engagement with RSP policy is a relatively recent occurrence. Given the timing, many of the impacts are still emerging. The interviews have explored some of the problems of applying a triple helix-informed policy to an emerging economy. These problems are related to weaknesses that exist in the wider framework conditions that exist to support economic activity, including certification processes and IPR protection. A SP must build upon local geography. Geography matters and local geography is critical. Each SP is an amalgamation of relationships between people. These relationships are between people employed by the SP, by the university and by private businesses. It is important to begin exploring the nature and differences in these relationships between SP projects. It is to these differences that we now turn our attention.

CHAPTER 6

INTRANETWORK SCIENCE PARK RELATIONSHIPS IN THAILAND

6.1 Introduction

A triple helix is a set of relationships between agents that come together to facilitate some type of firm-based outcome. Research on regional science parks (RSP) established in Thailand has revealed different forms of intranetwork relationship within the framework of the triple helix. These intranetwork relationships involve universities, government (through the science park (SP) management), and private sector businesses. This chapter explores the configuration of relationships created to facilitate R&D projects. The focus is on exploring how the nature of these relationships affects the innovation processes of private sector businesses within a triple helix relationship framework. There are relationships within the triple helix or intranetwork relationships and other kinds of relationships between SPs intranetwork and other networks. These are internetwork effects, or spillover effects, from a SP into other parts of a regional or national economy.

The relationship with external knowledge sources is essential as firms, and incredibly small and medium-sized enterprises (SMEs) have limited resources to create innovation from within the firm (Tomlinson and Fai, 2013). Without in-house ability, firms must draw upon external technical knowledge, and this may include participation in SP related activities. A distinction has been made between two innovation modes: ‘science, technology and innovation’ (STI), and ‘doing, using and interaction mode’ (DUI). These are introduced in this chapter and considered as model of firm learning processes (Jensen *et al.*, 2007). The application of an innovation value chain (IVC) approach to SPs highlights the benefits that come from conceptualising a SP as an intranetwork of relationships between a firm and a set of non-firm

actors. This approach emphasises that a triple helix is a set of evolving relationships or dyadic encounters or interactions between people. It is during these dyadic encounters that trust is created, and this trust involves three different, but related flows of expertise–learning, developing a new good or service and then commercialisation. These dyad relationships may be unstable as they depend on interactions between two parties that will be influenced by their interests (Andres and Bryson, 2018). The IVC approach is an alternative to the triple helix, but both approaches can be combined as the IVC approach adding dimension to the triple helix approach and vice versa.

This chapter explores the relationships within the triple helix and is informed by the application of an IVC approach. The next section explores the configuration of 33 Northern Science Park's (NSP) research and development (R&D) projects including the inputs provided by different stakeholder; the firm or entrepreneur, the university or researcher, and the SP within the NSP that operates as an intermediary linking a firm to other resources and networks. The third section analyses the typical patterns of inputs by each actor flowing through an IVC within the triple helix setting of a SP that may support the creation of outcomes. The last section is the conclusion of this chapter analysis.

6.2 Innovation Value Chain and R&D projects

The key to firm and country competitiveness is learning and innovation, and the development of firms, including upgrading within a value chain (Pietrobelli and Rabellotti, 2011). Love, Roper and Bryson (2011) noted that different types of relationship create different effects on a firm's innovation value chain. The IVC is an approach developed by Hansen and Birkinshaw to explore innovation within firms based on the appreciation that innovation is the outcome of a set of linked processes (Hansen and Birkinshaw, 2007). The innovation process

consists of three stages including acquiring knowledge or gathering useful information to support development, applying information and knowledge to develop products or services, and then commercialisation of the developed product (Hansen and Birkinshaw, 2007; Love, Roper and Bryson, 2011). A SP either operating as part of a university or a stand-alone organisation can accommodate knowledge transfer between the university and entrepreneurs (Goddard, Vallance and Puukka, 2011). A positive correlation between academics and entrepreneurs must be created to drive the innovation process along the value chain to improve firm competitiveness.

The relationships created within an individual firm-based SP project can be positive or negative depending on several factors including the expectation of the entrepreneur, the ability of an academic to respond to the firm's request, and the services offered by a SP. The interactions between each element of a helix affect the success or failure of R&D projects. For example, the nature of the dyadic relationship which develops between researcher and entrepreneur helps stimulate the learning process and knowledge exchange benefiting both sides (Pietrobelli and Rabellotti, 2011; Nakwa and Zawdie, 2016). Moreover, it creates mutual understanding regarding the project's expected outcomes and influences further commercialisation by the firm. The relationship between the university and external partners within the SP intranetwork does not only help support private sector businesses, but it also stimulates university personnel to develop community-based collaborative skills and their ability to apply their research to meet the needs of local businesses (Goddard, Kempton and Vallance, 2013). The university researcher also benefits from working with the private sector businesses by applying the firms' problems to teaching (Etzkowitz, 2012). New theory can be developed from collaborative work between universities and industry (Etzkowitz, 2008). Furthermore, the policy to develop a region via encouraging SP related clusters stimulates the

use of higher education institutes (HEIs) resources that are connected via some intermediary such as a SP and fosters relationships created between HEIs, industry, and drivers of economic growth and development in the region (Goddard, Vallance and Puukka, 2011). Although HEIs play a critical role in regional development, they require the cooperation of local authorities and relevant stakeholders in the community (Perry, Wiewel and Menendez, 2009; Isaksen and Karlsen, 2010).

Firms are an essential part of regional innovation and economic development (Taylor and Asheim, 2001; Lundvall, 2007). SPs try to encourage local economic activity by influencing firm growth, and this includes the circulation of knowledge within firms and knowledge diffusion and encouraging HEI spin-off (Taylor and Asheim, 2001; Etzkowitz, no date). The implementation of a RSP policy is intended to offer support for local firms to increase their business competitive advantage. The core services offered by a SP are intended to facilitate business R&D projects, including matching firms to university academics and the use of university facilities, financial support, and business consultation. Firms also benefit from having an opportunity to create networks with other participating firms and supporting agencies, as well as increasing firms' credibility and reputations by engaging with SP operations. Although some firms connected to a SP expect only to benefit from relocating to the SP's premise, most firms still want to gain access to university resources either to develop products and services, to use academic research as a guarantor for products, or to upgrade production processes.

A firm usually comes to a SP with problems. However, is the firm's idea feasible and would it benefit from involvement in a SP? The request raised by the firm must be evaluated before funding is allocated. To Hansen and Birkinshaw (2007), developing ideas across units requires informal relationships to develop between teams. The innovativeness of a firm can be

enhanced via positive relationships developing within an innovation value chain, and the firm's strategy should encourage the development of a supportive network amongst partners (Tomlinson and Fai, 2013). Organisation culture is critical as it may support or obstruct innovation (Smit, 2016). The process of decision-making by business owners should include business factors such as cost-saving and also emotional aspects (Vanchan, Mulhall and Bryson, 2018; Salder and Bryson, 2019). The development of positive relationships between the RSP, entrepreneur and researcher have to be promoted to enhance cooperation from the negotiation phase including the scope of R&D projects, the match with the researcher's ability, the services offered by the RSP and entrepreneur's expectation.

The 33 firms interviewed for this study engaged with the NSP in different programs. Each program required different qualifications regarding firm participation, and each operated over a different duration. Businesses participating in the *incubation platform*[19] had to be newly registered, and participation on the program took three years. The incubation platform included educating entrepreneurs as if they had no fundamental understanding of how to engage in business while assisting with product development. The *Industrial Research and Technology Capacity Development Program (IRTC*[20]*)* matched academics to business problems and required firms to invest in the R&D project partially. The duration of the R&D project under the IRTC program was only one year. The project focused on the development of products and processes. Entrepreneurs might still require support with marketing, but this was not an essential aspect of the program. The *Collaborative Research Program (co-research)* required over 60% of project investment from the firm, and the project value must be higher than one million Baht. The co-research is usually a long-term project. There was no limitation on the age

[19] The business incubation project was first launched in Thailand in 2002 by the Department of Industrial Promotion, Ministry of Industry.
[20] IRTC program was introduced during the implementation of the RSP policy in 2012.

of business in participating in the IRTC and the co-research programs. Firms had very different expectations regarding participation in these programs, and the inputs of each helix during each R&D project were varied. The innovation value chain is formed around a project and a firm, and there are different solutions to product realisation. The best practice of one firm and how the HEI performs toward one project, thus, cannot be imitated (Hansen and Birkinshaw, 2007; Isaksen and Karlsen, 2010)

6.3 Exploring each actor's inputs at each stage of the IVC

A triple helix is a set of relationships between firms and non-firm actors, and different types of relationships emerge or are configured, within a SP setting. The triple helix and the IVC approach are alternatives, but complementary approaches to understanding innovation. As part of the analysis, an IVC framework has been applied to explore the 33 firms involved in the NSP (**Appendix 6.1**). Three stages have been identified within the IVC approach, but an additional stage has been added in this analysis regarding idea development, or ideation, as a pre-IVC process. R&D project begins with the question ‘what needs to be achieved or what is the problem that requires a solution?’. For all 33 firms, the ideas behind the R&D came from the firms.

Nevertheless, for only 16 projects, this idea identification stage only involved the entrepreneurs. The other 17 firms developed R&D ideas as part of a process that was influenced by other actors, and this involved collaborations from all parties of a triple helix for six projects. Seven projects involved entrepreneurs working together with a researcher to develop the project idea. These cases represent a process of cooperation based on personal relationships that had developed between the entrepreneurs and the researchers without SP matching. Entrepreneurs developed four projects with assistance from NSP in business issues, including training to

identify market opportunities for the product under development (**Table 6.1**). It means this research has identified that there are four ways in which a SP project originates, and these differences reflect how firms are differently embedded within the SP's triple helix.

Table 6.1 Sources of R&D project ideas

Source	Number of projects	Percentage of 33 projects
Firm alone	16	49%
Firm and researcher	7	21%
Firm and SP	4	12%
Firm, researcher, and SP	6	18%
Total	33	100%

The firms were the main actors in developing the ideas to create products and services since the innovation investment must relate to the business and be based on the firm's capacity to produce and commercialise the final product. Some firms were persuaded to join the SP by researchers, but the project's origins were based on problems that firms could not solve without external support, including technical knowledge and funding. For some firms they were able to identify problems, but were unable to specify causes and thus;

> There was a problem, and the researcher clarified what the cause of it was. We put our team to design the system, and the researcher used his method. Then we combined the work of us to fix that problem (C08, 2018).

Researchers that became involved in the idea development stage tended to continue to provide support throughout the IVC process. Moreover, an innovative idea can be obstructed by limited funding, strict funding criteria, and narrow-minded management styles (Hansen and Birkinshaw, 2007; Smit, 2016). A firm can overcome an innovation gap by configuring a network to obtain advantages from working with partners (Tomlinson and Fai, 2013). External relationships can help generate ideas to develop products and processes (Hansen and Birkinshaw, 2007) and to identify sources of funding, and technical knowledge and business support.

In 70% of all cases, the initial stage of an ideation process may occur before participation within a SP program. However, the idea will be developed and refined during discussions with the researcher. The discussion may include feasibility and market potential of the new product. Once the terms and conditions are agreed, then the R&D can commence, and the project shifts into the first stage of an IVC process.

First stage: Acquiring knowledge

Acquiring knowledge or learning is the first stage of the IVC process. It is critical to identify relevant information to support the knowledge production process in developing the idea that informed product development. Information and knowledge are interrelated. The difference is that knowledge is a transformation of information into something that has additional value (Zins, 2007). The firm and researcher must identify which information is relevant and inform the development of knowledge that will enhance the product development process. Firm-level innovation processes differ from industry to industry, and there are variations in the knowledge acquisition process (Asheim, 2007). The STI and DUI innovation modes were developed as an approach to classify different firm-level approaches to innovation. According to Jensen *et al.* (2007); and Isaksen and Karlsen (2012), STI orientated firms acquire knowledge primarily from academic research and can absorb codified knowledge without a proximity burden. For DUI orientated firms, knowledge acquisition is more localised and tacit. The approach to learning revolves around day-to-day situations including product improvement based on feedback from customer and suppliers. The firms that combine STI and DUI approach to learning have a higher chance in creating innovation and launching new products than those firms that apply only one approach (Jensen *et al.*, 2007; Isaksen and Nilsson, 2013).

Furthermore, the required information and knowledge may be classified as available in-house, or the firm acquires it externally by developing some blend of information sources (Isaksen and Karlsen, 2012). According to Ganotakis and Love (2012), external sources of knowledge include customers, suppliers, competitors, and universities and research centres. The STI and the DUI modes of innovation are different approaches to how a firm utilises external sources of knowledge. Products and processes are becoming more sophisticated, and this implies that companies have to rely on blending information available from different sources increasingly and this partly explains the role universities play in industrial R&D (Etzkowitz, no date). A firm seeks expertise from a university, and positive linkages occur when expectation are met (Etzkowitz, 2008). The firms may also take advantages of locating on park by learning from other tenants (Ganotakis and Love, 2012). However, very few NSP's tenants mentioned discussing potential product development with other firms in the NSP premise. Instead, they took the opportunity of creating a partnership, as one firm stated that:

> We have met many businesses in the same sector. We have already become partners with a cleaning company to provide service for our client's apartments and do the revenue sharing (C28, 2019).

The activities to promote network creation and knowledge sharing amongst tenant firms thus must be encouraged. The interviews showed that firms played an essential role during this learning stage of the IVC process. In 18% of cases, the entrepreneurs went through this stage without help from other actors. For 30% of all projects involved both firms and researchers acquiring additional knowledge or information to undertake R&D. For 33% of cases, firms gathered the necessary information while NSP supported this process by matching the company with potential researchers and by providing related business training. Only 18% of cases involved all three actors during this learning stage. Both researchers and entrepreneurs needed

to access information that was required to support an innovation process, and the SP played a supportive role (**Table 6.2**).

Table 6.2 Participation in acquiring knowledge

By whom?	Number of projects	Percentage of 33 projects
Firm only	6	18.2%
Firm and researcher	10	30.3%
Firm and SP	11	33.3%
Firm, researcher, and SP	6	18.2%
Total	33	100%

The inputs or activities undertaken by each actor to the R&D process varied depending on the project (**Table 6.3)**. Twenty-one percent of all firms capable of undertaking product development relied on in-house knowledge. The NSP and the researcher may assist with other issues, including undertaking a feasibility study and setting up the business. The remainder cases – 79% - required external expertise to fill information or knowledge gaps. The firm may perform more than one activity to acquire knowledge. In some cases, researchers had to access additional knowledge. For 51% of cases, the firms already have some technical knowledge, but the NSP still supported them on other issues helping firms to undertake R&D, including matters related to business. The 79% highlights that these were firms that needed some form of external assistance with the innovation process, and it is these types of firms that one would expect to be involved in a SP initiative.

Table 6.3 Activities involved in acquiring knowledge process by the main actors involved in NSP's R&D projects

Actor	Input / Action	Number of projects*	Percentage of 33 projects*
Firm	Able to develop a product based on in-house knowledge	7	21%
	The founder has basic production knowledge but needed advance expertise for further development	10	30%
	Learn from another producer/competitor	2	6%
	Learn from existing academic research	1	3%

Actor	Input / Action	Number of projects*	Percentage of 33 projects*
	Contact the professionals directly	8	24%
	Consult with SP for assistance	7	21%
	A friend recommended to researcher	1	3%
	Research commercialisation	1	3%
Researcher	Learn from existing product/ research	7	21%
	Contact other researchers	4	12%
	Learn from firm to adapt with his knowledge	2	6%
	Do not acquire additional knowledge	5	15%
SP	Match the firm to the university researcher	10	30%
	Introduce the firm to other research institutes	1	3%
	Help to check the requirement for standard	1	3%
	Business training (incubation)	3	9%
	Business support	3	9%

* An actor may perform multiple activities in a project.

From all 33 projects, 49% relied solely on the external researcher to undertake R&D. There were different activities undertaken to access knowledge. The firms may learn from competitors, and academic research and this type of learning may inform the internal product development process. They may ask for support from their network, including from friends, contact a university researcher directly, or ask the SP to find professional inputs. As far as the 33 firms that were interviewed are concerned, then 30% had some knowledge but still needed to access advanced knowledge to develop products. Furthermore, 24% of firms preferred to approach the researcher, and 21% sought advice from the NSP regarding accessing additional knowledge.

The firms played a dominant role in the learning process required to support product development compared to academics. Fifty-two percent of all projects involved researchers participating in the learning stage. Only 15% of researchers applied existing expertise to conduct the R&D project without additional learning. Forty-two percent applied a variety of

methods to access information in which learning from existing products and other research was used. At best, the NSP acted as the bridge between the firm and the university researcher. Of the 17 firms that requested support from NSP, then ten matches with academics were completed, and six firms were provided with business training.

Second stage: Building innovation

At this stage, the product development based on the information and knowledge that was assembled during the learning stage. Missing information and knowledge may be identified, and this building innovation stage may also involve identifying more learning and information inputs. Private businesses still played an active role at this stage as 32 projects (97%) involved firms during the building innovation stage (see **Table 6.4**). Researchers participated in 30 projects (91%) as two firms developed products using internal resources, and one firm had not finalised the R&D project at the time of the interview.

Table 6.4 Participation in the building innovation process

By whom?	Number of projects	Percentage of 33 projects
Firm only	1	3%
Researcher only	1	3%
Firm and researcher	4	12%
Firm and SP	2	6%
Firm, researcher, and SP	25	76%
Total	33	100%

Of the 33 cases, 76% of them went through a knowledge adoption process which involved all three actors within the triple helix. There were four cases, or 12% of firms, that worked together with researchers in developing products without support from the NSP. One of these firms only wanted to relocate on to the NSP but required no support from it, and the other three firms were technology-based companies involved with the incubation program. Six

percent of firms developed the products by themselves with no involvement from HEI researchers, and NSP provided support in necessary machines and equipment and by suggesting appropriate funding sources. Moreover, another critical supporting role played by the NSP to 27 SMEs involved investing in the project and suggesting additional funding sources.

There is one firm (3%) that the researcher was the one who built the innovation for the company. This firm had completed the product, and it was ready for market but decided that additional R&D inputs were required. Also, the entrepreneur did not know about R&D. Thus, the researcher took the lead role at this stage for this firm. Another three percent of firms developed the product without support from either a researcher or SP. This firm was located on one of the NSP network university SP's premises and participated with SP activities only to create a connection with other businesses and to benefit from an on-park location as:

> The primary factor of joining with the SP was that we wanted to be in the ecosystem that allows us to meet others. Here, it has a variety of organisations from the private and government sectors. There is the opportunity to receive assistance, such as knowledge, research papers, personnel, and advanced technology. We think that locating on park will benefit our company in many ways (C23, 2019).

The primary rationale for this firm's location on the SP was to benefit from being on the SP. An idea for an R&D project was still under discussion with a potential researcher and was not finalised. However, the owner still created inputs as well as engaging with other firms in the NSP programs. The roles each actor played varied depending on the firms' resources, the R&D project proposal, and agreement with the researcher. The researcher may play the lead role in this development process, but only when the firms cannot conduct the R&D by themselves. Otherwise, the researcher may take part as a consultant giving necessary advice while the firms developed the products. The inputs of each stakeholder are categorised in **Table 6.5**.

Table 6.5 Activities undertaken by the main actors in the building innovation process in NSP's R&D projects

Actor	Input / Action	Number of projects*	Percentage of 33 projects*
Firm	Invest in in-house R&D (staff, equipment)	2	6%
	Invest money in the R&D project	13	39%
	Supply raw material	5	15%
	Conduct R&D by themselves (no academic support)	4	12%
	Conduct R&D by themselves and consult with the researcher	6	18%
	Regularly consulting with the researcher on the expected result (tell what he wants)	2	6%
	Develop the product together with the researcher	10	30%
Researcher	Product tested at the university lab	8	24%
	Product tested at the factory	4	12%
	Conducting R&D cross institutes	2	6%
	Student involvement	2	6%
	Develop the product together with the entrepreneur	7	21%
	Transfer knowledge of existing research to the firm	3	9%
	Giving consultation for product development	5	15%
SP	Partially support on funding	19	58%
	Funding support under Business Incubation program	3	9%
	Suggest appropriate funding resource	4	12%
	Discount or waive the space rental fee	2	6%
	Provide on-site privileges (i.e., using lab facilities)	2	6%
	Support in business issues (create a network for form up business, package design)	2	6%

* An actor may perform multiple activities in one project.

At least 39% of firms had invested in their R&D projects. This investment was in cash or in-kind and depended on negotiations with each networked SP. Six percent of firms hired R&D employees and purchased new equipment to support the R&D project. Some entrepreneurs who were capable of conducting R&D using their knowledge only required some advice from academics. Twenty entrepreneurs (61%) participated in this building innovation process focused on R&D, and four firms required no academic inputs from the HEI. Eighteen

percent of entrepreneurs took the lead role in the product development process, and for 30% of the cases neither the entrepreneur nor the researcher took the lead role, but instead, the project was co-created. In six percent of cases, the researchers did all the work while providing the firm with progress updates.

There was only six percent of cases where the lead researcher brought in other professionals to contribute to the project. Twenty-one percent of all cases were undertaken in close collaboration with the entrepreneur and the researcher. Nine percent involved transferring knowledge to the firm as part of a research commercialisation process. In 15% of cases, the researcher only acted as a consultant for the firm at this stage. In only 12% were the research results tested at the factory.

At this stage of the IVC process, NSP kept its supporter role and provided funding advice. NSP partially invested in 58% of the projects and supported all expenses for three projects (9%) under the business incubation program. Suggestions for additional funding sources were provided. Six percent of firms received a special office rental rate, and the other six percent also mentioned having access to lab facilities. Moreover, SPs also provided support with business issues related to product development, including package design and finding a partner to provide additional product-related services.

Third stage: Commercialisation

Innovation occurred when the invention was commercialised (Lundvall, 2007). The R&D project, with the support of the SP, concluded with the building innovation process. Some firms decided not to commercialise the outcomes of the R&D process. The researcher's role during this stage included modifying the developed machine to meet factory conditions. Problems with the degree of investment by the firm may obstruct the commercialisation stage.

The SP cannot force the firm to sell the product but can only offer support if they are willing to do so. Moreover, since the ultimate goal of implementing the RSP policy was to stimulate economic growth, the NSP encouraged the entrepreneur to bring products to market. The contribution of the firm, researcher, and the NSP in commercialising the research results is presented in **Table 6.6**.

Table 6.6 Participation in the commercialisation process

By whom?	Number of projects	Percentage of 33 projects
Firm only	1	3%
Firm and researcher	2	6%
Firm and SP	13	39%
Firm, researcher, and SP	12	36%
No commercialization or use of research	5	15%
Total	33	100%

Research commercialisation occurred with the involvement of the firms. Thirty-six percent of the 33 projects had the SP and researcher assist the firms with the commercialisation of the R&D process outcome. Forty-two percent did not require the researcher to be involved in launching the product. There was six percent of firms which continued working with the researcher to deliver the product to their customers. Only one firm, or three percent, was able to launch the product on to the market without external support. However, this was an experienced firm that had been in business for over 20 years. Five firms (15%) did not have any input in this process as two firms had not completed the product development process by the time of the interview, and three firms decided not to commercialise the research. The researchers tried to push the commercialisation forward in two of these three firms. However, the firms were not ready to make any further additional investment at this stage.

The commercialisation process requires knowledge of doing business, knowing how to promote the innovation to the target market and the resources for implementation. The input of

the firms varied depending on experience and resources. The roles played by the researchers and SPs in the commercialisation process was more on providing support (**Table 6.7**).

Table 6.7 Activities of the main actors involved in the commercialisation process

Actor	Input / Action	Number of projects*	Percentage of 33 projects*
Firm/ Entrepreneur	Improve factory/product standard, invest in a necessary machine	4	12%
	Produce new product by OEM	1	3%
	Export the new product	3	9%
	Open physical shop to distribute the product	1	3%
	Distribute the product in supermarket and hypermarket	7	21%
	Promote the business via online marketing	11	33%
	Promote the business by word-of-mouth	2	6%
	Promote new products through competitions	2	6%
	Promote new product in trade exhibitions	2	6%
	Promote new product to existing customers	3	9%
	Promote the new products on the existing channels	5	15%
	Promote the business via RSP network	1	3%
	Promote the business in the cluster	2	6%
	Contact the potential clients using a personal connection	7	21%
	Choose not to commercialise the research	3	9%
University/ Researcher	The researcher installs the machine to the real use	5	15%
	The university gave priority for the firm to commercialise the research results	4	12%
	The university allows the firm to commercialise the research result without charge	2	6%
	The university agrees for a firm to own IP.	1	3%
	Take consultation role	2	6%
	Help to contact the authorities	1	3%
	Fail to help commercialisation (certify product standard)	1	3%
SP	Encourage and support firm to participate in the competitions	5	15%
	Support firm matching with the customer in a trade exhibition	15	45%
	Support on product/factory standard registration	3	9%
	Training in marketing and other business issues	4	12%

Actor	Input / Action	Number of projects*	Percentage of 33 projects*
	Training as part of a business incubation program	2	6%
	Help promote the business in the SP network	4	12%
	Increase the firm's reputation from locating on-park	3	9%
	Increase the firm's reputation from participating with SP	1	3%

* An actor may perform multiple activities in one project.

The firm's input in this commercialisation stage concentrated on promoting the developed products or the businesses to the market. The extent of this marketisation process varied depending on the firm's resources. Online marketing was the most popular method used by 33% of firms given the relatively low cost and accessibility for customers. Selling the products in a supermarket and hypermarket was used by 21% of firms. There were 45% of firms that promoted their products and businesses within the localised cluster, RSP, existing customers, their networks, and via personal connections. Twelve percent of businesses invested further to improve their factory. In nine percent of cases, the new products were sold internationally. In most cases, the research commercialisation appeared to be successful.

The HEIs have an exact role in allowing the use of research facilities and personnel in undertaking R&D projects with private businesses. At the commercialisation stage, the universities gave the firms priority to commercialise the research result and, in some cases, without charge. Twenty-seven percent of researchers supported the firms by installing and modifying machines in the factory and acting as a consultant or contacting authorities.

NSP provided direct and indirect supports to the firms during this commercialisation stage. There were 45% and 15% of firms promoted their businesses and products in trade exhibitions and competitions, and the NSP paid for some expenses, including the booth rental fee and travel costs. The support also included training on pitching the idea to potential clients. There were 18% of entrepreneurs who confirmed that they had received training from the NSP in marketing and other business issues that will help them commercialise the research results

effectively, two of these firms were participating in the business incubation program. Nine percent of firms received consultation regarding standards and registration of the product and the factory. The indirect benefit that the firms received from NSP, including reputational benefits obtaining from their location on-site or by researching with the SP. Moreover, 12% of businesses were promoted to other firms in the NSP's network.

The application of an IVC approach to a SP and the triple helix reveals that not all three actors contributed to every stage of the IVC. In only six percent of cases did the entrepreneur, researcher, and SP contribute to all IVC stages - learning, building innovation, and commercialising the product. However, it is worth noting that some projects did not need support from all three stakeholders at every stage. For example, the project being developed by company C04 required the full participation of all three stakeholders in a triple helix in all stages, but the SP played a more limited role in the commercialisation process. However, this project involved developing a machine for use in the factory. The commercialisation process involved setting up the machine in the factory and did not involves any marketing. Thus, the SP had no role in the installation process.

The IVC approach reveals how innovation required a different combination of inputs and that the various actors involved in each project played very distinct roles. In many cases, these roles evolved as those involved in the project became used to working together. A key issue is to explore the different combinations of activities or patterns that emerged and the impacts on product outcomes focusing on success and failure.

6.4 Understanding the project outcomes

The interviews with 33 business entrepreneurs uncovered five types of relationship which emerged around their participation in the NSP business development program. In Chapter Five, positive or more negative relationships or interactions between entrepreneurs, researchers, and the NSP were identified. However, a key issue is understanding what combination of activities and relationships contributed to the outcomes of a R&D project. Exploring the pattern of input flows through the IVC process will assist policymaker in identifying the types of support which should be offered to firms involved with the SP at different stages of the IVC (Ganotakis and Love, 2012), and this includes budgets and cooperation from the university.

In this section, we present the flow of input by each actor during the IVC process. Each project is identified by a colour. The flow of activities along the value chain then can be observed by following the lines from top to bottom as each stage is linked to other stages.

6.4.1 Firms' inputs to the SP innovation projects

The input flows from private businesses during the IVC process related to R&D projects are shown in **Figures 6.1 - 6.3**. Using the IVC approach, considering how the firms acquire the necessary knowledge for product development reveals that firms have three different approaches to participating with the SP. Thus, the 33 firms which participated with this research can be separated into three groups based on their sources of knowledge acquired: in-house or internal sources (7), external sources (16), and the firms acquiring knowledge from both internal and external sources (10).

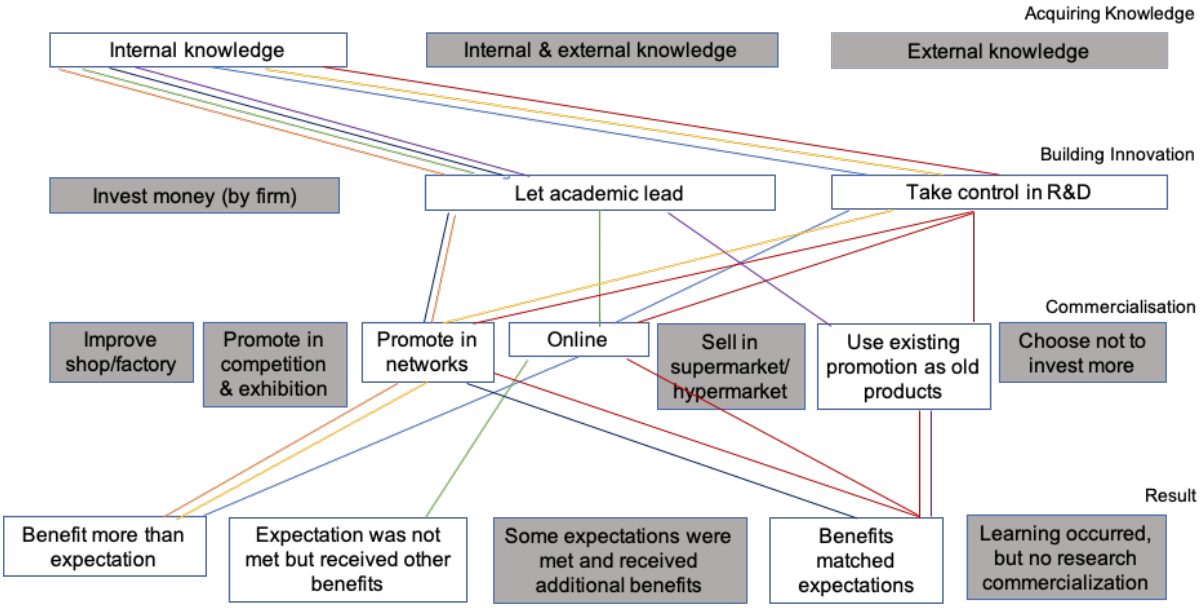


Figure 6.1 The flow of firms' activities within innovation value chain toward the output (acquiring knowledge from internal sources)
Note One colour represents a flow of one project.

Of the 33 firms, 21% (seven firms) acquired knowledge from in-house resources. At the building innovation stage, the number of firms was balanced between letting the academics lead the R&D (four firms) and taking control of the project by themselves (three firms). The firms that acquired knowledge from internal sources preferred promoting their new products within the networks (four firms) and by online marketing (three firms). Two firms applied the same marketing tool used to promote their existing products. The result of the R&D projects for the firms that used internal knowledge was positive and equal between receiving benefits more than expectations, and the benefits received were matched with expectations. One firm (three percent) commercialised the product using online marketing and did not receive the expected benefits. However, this firm still confirmed that it had obtained other unexpected benefits from locating on the NSP premise such as increasing a firm's credibility and creating a network with other tenants.

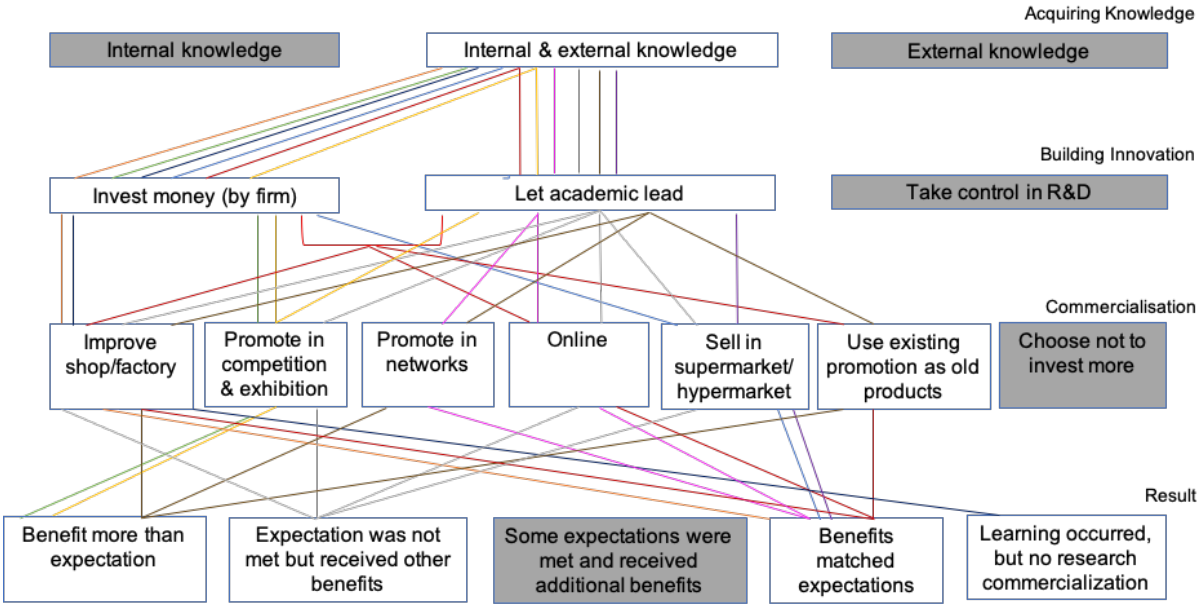


Figure 6.2 The flow of firms' activities within innovation value chain toward the output (acquiring knowledge from internal and external sources)
Note One colour represents a flow of one project.

There were ten firms, or 30% of all cases, which obtained knowledge from both internal and external sources. During the process of building innovation, 12% of all cases (four firms) invested money in the project, and another 12% (four firms) let the researchers act as project leaders. In six percent of cases (two firms), the firms invested money in the project and followed the lead of the researcher. Although the commercialisation methods are varied, this group of firms paid more attention to improving their physical shops and factory for research commercialisation (15% of cases, five firms). Promoting the product/business via online marketing, attending conferences and exhibitions, and selling in supermarket and hypermarket were equal at 9% each.

Half the firms in this group (15% of all projects) noted that the outcome of the R&D project matched their expectations. Nine percent received more benefits than expected. There was three percent experienced a negative outcome of the projects. There was one firm invested money in the process of building innovation and had the developed technology installed at its

workplace. However, due to the firm's restructuring, all employees were replaced, and the developed product was uninstalled.

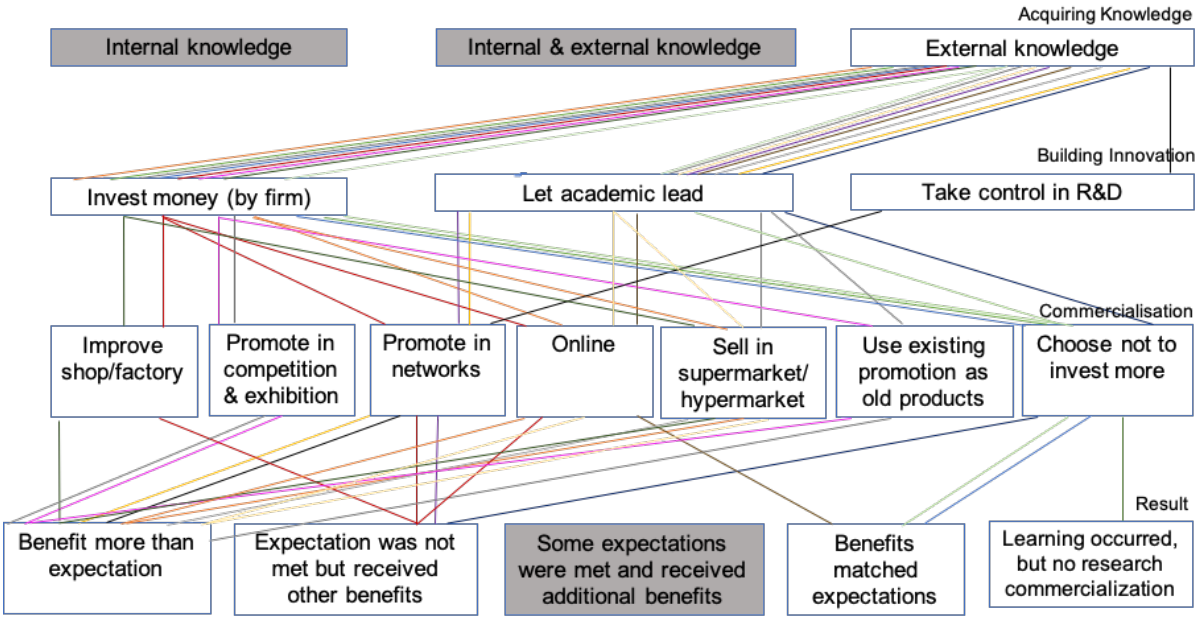


Figure 6.3 The flow of firms' activities within innovation value chain toward the output (acquiring knowledge from external sources)
Note One colour represents a flow of one project.

There were 48.5% (16 firms) of all cases acquired necessary knowledge only from external resources such as from the university researcher and competitors. There is one firm took control of the building innovation process. The rest were equally split between partially investing in the R&D project or let the researcher lead the R&D (24% each, eight firms). There is no clear pattern regarding how the firms in this group commercialised the products. Their choices in selecting marketing channels were distributed equally between promoting in the networks, online, and selling in supermarkets and hypermarkets (12% each). In six percent of cases, firms invested further in improving their factories, and six percent promoted the product in competition or exhibitions. Moreover, there were three firms (9% of all cases) did not commercialise the products, and one firm did not have the final product by the time of interviewing. Despite that, three firms confirmed they receive benefits provided by the NSP

while another firm only learnt how to do the R&D. There are 36% of firms (12 out of 16 firms in this group) showed satisfaction with the received benefits.

From all of cases, 54.5% (18 firms) agreed to let the R&D project to be led by the academic during the building innovation process while 12% (four firms) were able to develop the products by themselves. There are 18% of all firms that invested money in the project. No clear patterns could be identified for the commercialisation process. This is because product commercialisation varies depending on the product, market condition, and the firm's investment. However, 33% of the cases (11 firms) promoted their products and businesses in the networks, including NSP networks, industrial clusters, existing customers, and the personal connections of entrepreneurs. The next popular methods were online at 30% (10 firms) followed by improving factory/shops and selling the product in supermarkets and hypermarkets at 21% (seven firms).

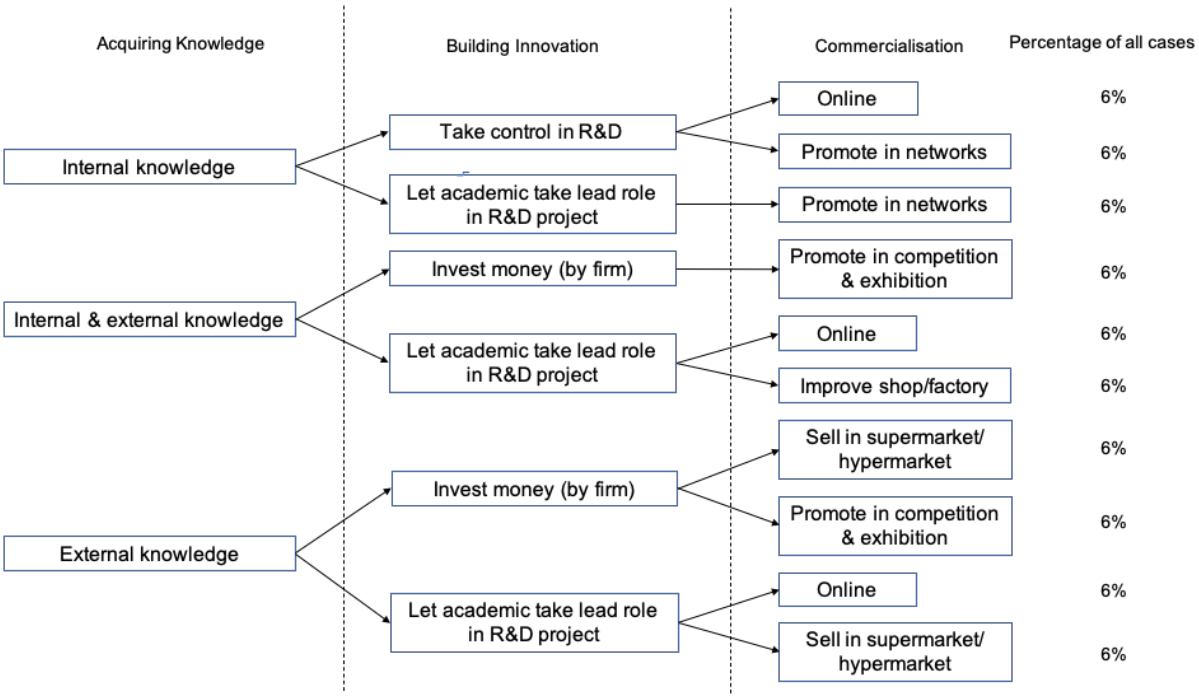


Figure 6.4 Patterns of firm's inputs to the R&D project during IVC process leading to positive outcomes.

Ten pathways can be identified that lead to the successful commercialisation of R&D projects (**Figure 6.4)**. These are:

1. Inhouse focused - firm-led - online marketing pathway
2. Inhouse focused – firm-led - network marketing pathway
3. Inhouse focused – academic-led - network marketing pathway
4. Learning focused - firm-invested - business promotion pathway
5. Learning focused - academic-led - online marketing pathway
6. Learning focused - academic-led - factory-upgraded pathway
7. DUI/STI focused - firm-invested - retail pathway
8. DUI/STI focused - firm-invested - business promotion pathway
9. DUI/STI focused - academic-led - online marketing pathway
10. DUI/STI focused - academic-led - retail pathway

The in-house focused pathway involves firms applying knowledge gained from internal sources to an R&D project. The learning-focused firms conducted R&D projects based on the firm's knowledge and also acquired knowledge from external sources, including customers, competitors, suppliers, and academic research. The DUI/STI focused pathway combines the STI and DUI innovation modes. Knowledge sources for the firms in this group included academic research and interactions with partners and customers. During a building innovation stage, R&D projects can be led by the firm or the academic, and the firm invests in the project.

6.4.2 HEIs' inputs to the SP innovation projects

In contrast to the firm, HEIs inputs did not seem to have a pattern linked to the result of the R&D projects. **Figures 6.5** and **6.6** display the flow of inputs provided by academics to the IVC product development process. Applying the IVC approach to consider how the researchers

acquired additional knowledge for R&D project reveals two ways of participating; applying only their existing expertise or acquiring knowledge from external sources including learning from existing research or similar products and acquiring expertise from other academics.

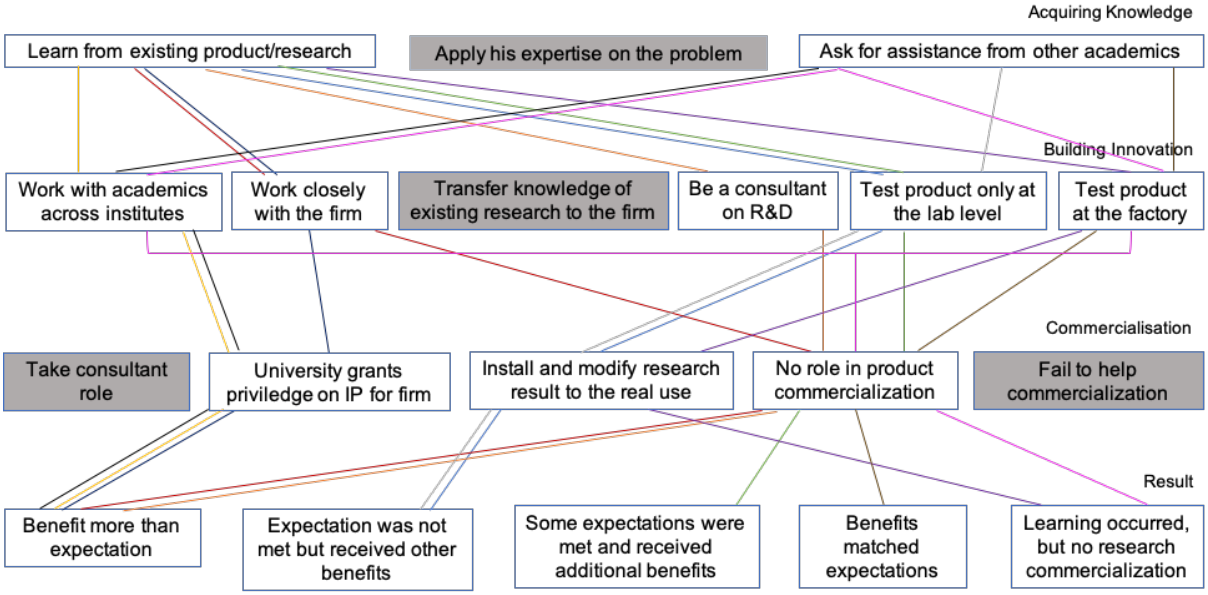


Figure 6.5 The flow of HEIs' activities in innovation value chain toward the output (acquiring knowledge from external sources)
Note One colour represents a flow of one project.

There were 33% of all researchers (11 cases) acquired additional knowledge for the R&D project from existing research or similar products and discussed the project with other academics. The academics' activities during the building innovation process were varied as they also depended on the firm's input. There was only nine percent of cases (three firms) in which researchers from different institutes worked together and two cases involved collaboration that continued from the acquiring knowledge stage. For two projects, the research results were only tested at the lab scale and installed at the factory with the aid of the researcher. However, the entrepreneurs were satisfied with the outcomes.

At the commercialisation process, the universities supported three entrepreneurs (nine percent of all projects) by permitting them to commercialise university research. There were five projects in this category (15% of all cases) that the researcher had no input. For 15% of the

33 entrepreneurs that received benefits, these exceeded expectations; two projects involved collaborative work with academics across institutes and were granted the intellectual property right (IPR) at the commercialisation stage. The other two projects involved working closely with the firms in building the innovation process but had no input from the academics during the commercialisation stage.

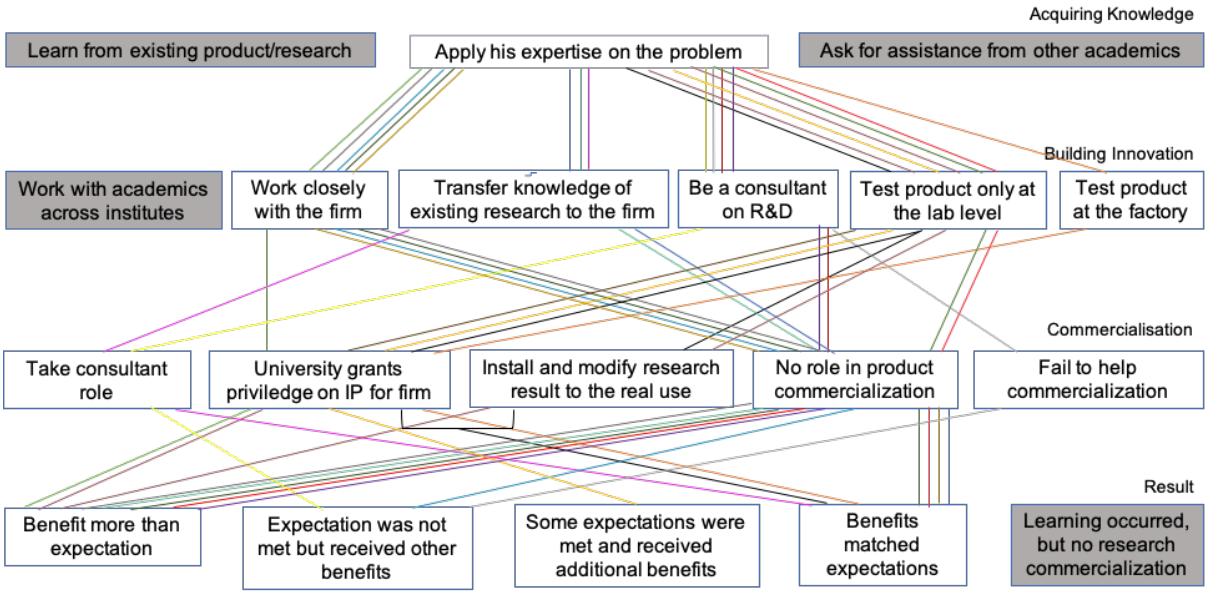


Figure 6.6 The flow of HEIs' activities in innovation value chain toward the output (acquiring knowledge from existing expertise)
Note One colour represents a flow of one project.

There were 58% of all cases (19 projects) that the researchers did not acquire additional knowledge from other sources. During the building innovation process, 15% of cases (five researchers) worked closely with the entrepreneurs in which four of them had no role in commercialisation while one project was granted IPR from the university. All these five projects were reported that the outcome exceeded the entrepreneur's expectation. There was nine percent of cases (three projects) that the researcher just transferred the knowledge to the firms. Then, two cases revealed that the researchers had no role in the commercialisation process, but one researcher continued the consultant role during product commercialisation.

The entrepreneurs were satisfied with these three projects' outcomes as the benefits they received, at least, matched the expectations.

There were 12% for firms (four firms) in which the researcher just provided inputs during the building innovation stage. Two were not involved in the commercialisation stage. However, the entrepreneurs were satisfied with the result. One researcher continued playing a consultancy role, and another one failed to help with commercialisation. The firms were dissatisfied with the outcomes of these two cases. Eighteen percent of all cases (six projects) only performed the R&D at the lab scale. Then, two cases were granted the IPR from the universities. There was one case that the university granted IPRs to the firm, and the researcher helped install the machines. All six projects reported that the outcome at least matched with what the entrepreneurs' expected. There were 10 out of 19 projects had no input from the academics during the commercialisation stage. However, 83% of the projects in this group showed a positive result as the benefits matched or exceed expectations.

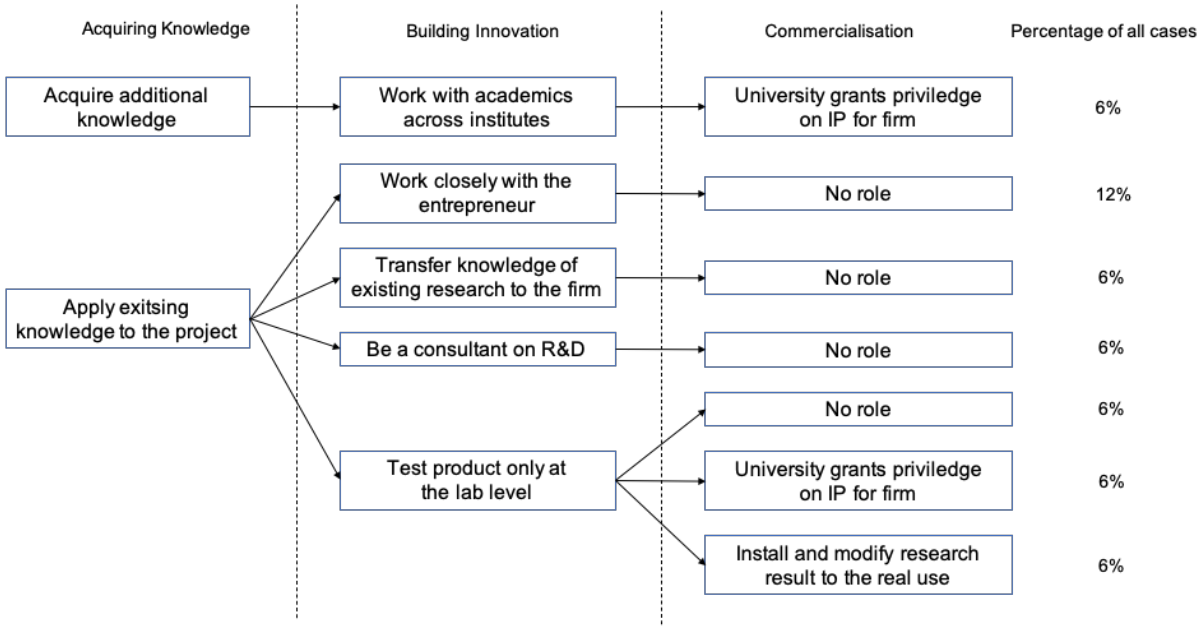


Figure 6.7 Patterns of inputs by HEI and researcher to the R&D project during IVC process that led to positive outcomes

Seven HEI input pathways can be identified, resulting in a positive outcome (**Figure 6.7)**. These are:

1. Incremental innovation – expertise-pooled – commercialisation focused pathway
2. Well-grounded expertise – firm-academic collaborative focused pathway
3. Well-grounded expertise – knowledge-transferred focused pathway
4. Well-grounded expertise – consultation focused pathway
5. Well-grounded expertise – lab-testing focused pathway
6. Well-grounded expertise – lab-testing – commercialisation focused pathway
7. Well-grounded expertise – lab-testing – research application-focused pathway

Four of these seven pathways highlight that the researcher and the universities did not have any contribution at the commercialisation stage. Moreover, there are six pathways in which researchers applied well-grounded expertise to the R&D projects without acquiring additional knowledge from other sources.

6.4.3 NSP's inputs to the SP innovation projects

The last actor that we need to explore which was involved in R&D projects during the IVC process is the NSP. The role of SP underpins the IVC process as a primary supporter. We categorise and draw out the pattern of NSP's inputs that are linked to project outcomes. Seventeen projects, 51% of all participant firms, had clear evidence of NSP support from the stage of acquiring knowledge (**Figure 6.8**). For the remaining 16 projects (49%) support provided by the NSP commenced during the building innovation stage (**Figure 6.9**). This is an important distinction as it suggests that for these 16 projects, the R&D process had already commenced before the NSP's involvement.

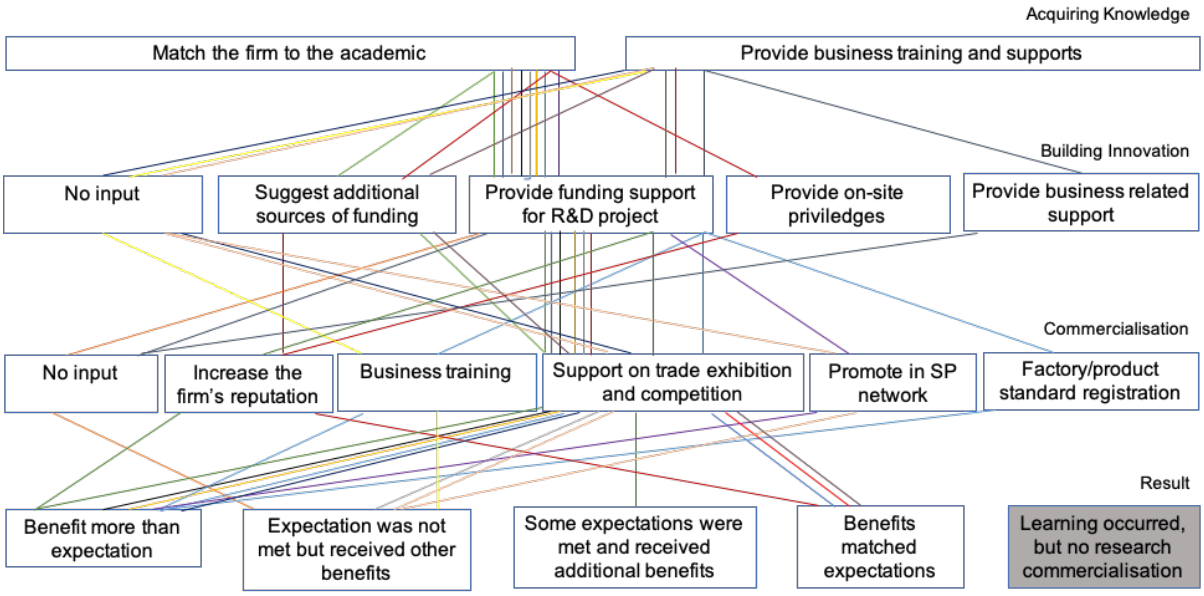


Figure 6.8 The flow of NSP's activities in innovation value chain toward the output (start supporting at acquiring knowledge stage)
Note One colour represents a flow of one project.

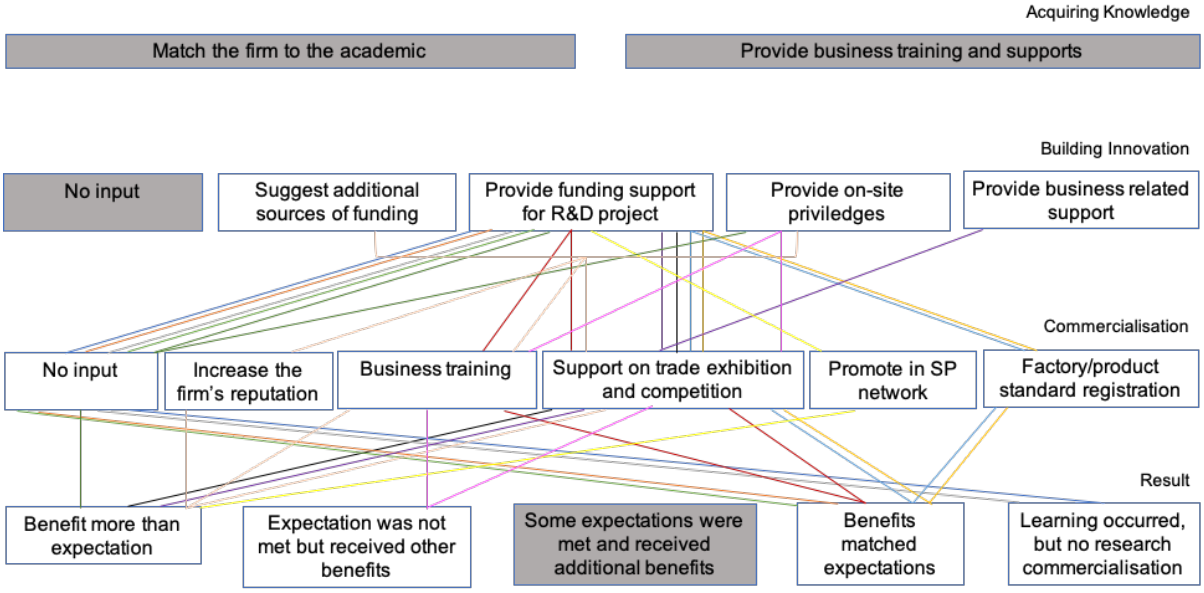


Figure 6.9 The flow of NSP's activities in innovation value chain toward the output (start supporting at building innovation stage)
Note One colour represents a flow of one project.

During the accessing information stage, NSP supported 18% of cases (six firms) by assisting with market research and setting up a company. The NSP introduced 27% of all participant firms (nine firms) to academics. Although matching the firms to the academics is

one of the primary duties of a SP in Thailand, the interviews confirm that most of the firms contacted the academics discussing the possibility of undertaking product R&D by themselves before contacting the SP. There were four firms (12% of cases) in this group which received funding support from the NSP at the building innovation stage and were supported in the trade exhibition and competition at commercialisation stage, then informed that the outcome exceeded expectation.

At the building innovation stage, NSP provided funding to 67% of the firms (22 firms) in which half of them received no clear evidence of support at the stage of acquiring knowledge. There were 12% of cases (four firms) in which the NSP did not allocate investment from its budget but suggested other sources of funding. Only 12% (four firms) mentioned the privilege of locating on the SP as being important. Furthermore, six percent of cases (two firms) received business-related support at the building innovation stage. Nine percent of cases (three firms) obtained no inputs from the SP during the building innovation stage.

At the commercialisation stage, NSPs' inputs were to support the firms promoting their businesses and products in competitions and trade exhibitions (55% of all cases, 18 firms). Twenty-one percent of cases (seven firms) claimed that they did not receive any support from the NSP at the commercialisation stage. However, three firms were still satisfied with project outcomes. Six percent of cases (two firms) have learnt through the IVC process, but there was no product commercialisation. There were 15% of firms (five firms) dissatisfied as the expected outcomes were not met. There were 42% of cases (14 firms) which were supported to attend a trade exhibition and satisfied as the outcome at least matched their expectations.

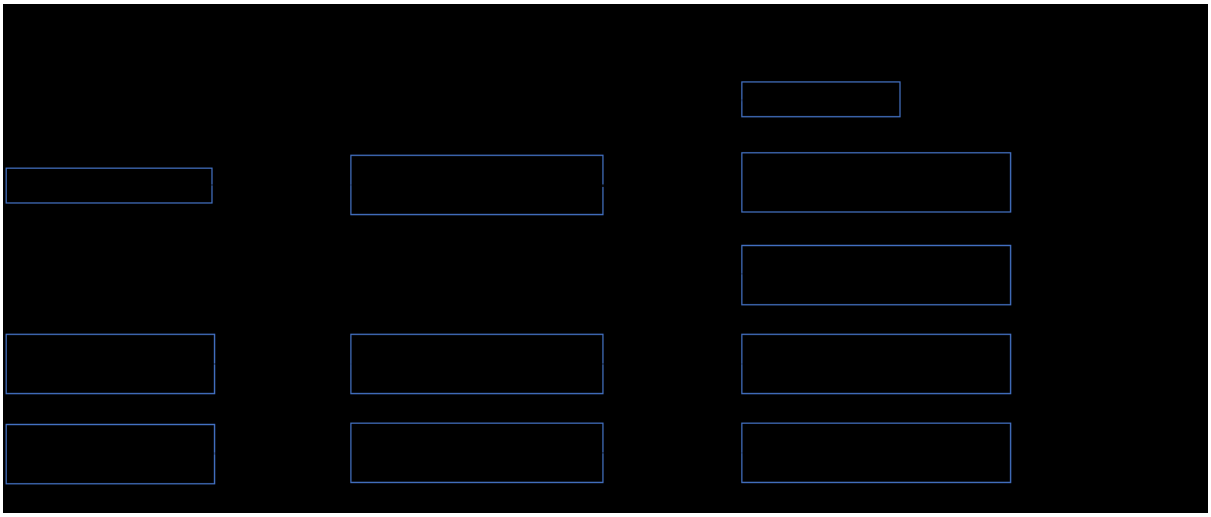


Figure 6.10 Patterns of NSP inputs to the R&D project during the IVC process that leads to a positive outcome.

There are five common pathways based on the provision of NSP can be identified (**Figure 6.10)**. These are

1. Funding support focused pathway
2. Funding support focused–business promotion pathway
3. Funding support focused–standard certified pathway
4. Academic matching focused–funding support–business promotion pathway
5. Business support focused–funding support–business promotion pathway

From these five commonalities, the two most significant pathways can be identified. The first one is academic matching focused–funding support–business promotion pathway, and this accounted for 15% of all cases. NSP matched the business to the researcher, provided funding support, and supported the firm to promote the product in trade exhibitions and competitions. The second significant pathway is the funding support focused–standard certified pathway, involving 12% of cases. NSP did not support the firm during the knowledge acquisition process but provided funding for the firm and supported them to attend the competition and trade exhibition.

All pathways, may include the same main actors: the entrepreneur or firm, the academic and HEI, and the SP. Here it is important to distinguish between actors and their roles compared to contributions. Thus, the contribution made by any one actor in an innovation project varies depending on the project. This implies that it is important to explore differences between actors and the roles they play in each project. This is to argue that the innovation activities that are localised within the NSP are heterogeneous. It is possible to identify common components and buildings blocks and every project will combine these in different ways. This is distinguished between the universal and the particular. Thus, the different roles involved in SP innovation projects can be identified as a set of 'universal' components, but how these relate to any one project will represent the 'particular' or the project context (**Table 6.8**).

Table 6.8 The roles of triple helix in company project pathways

Commonalities of input by triple helix	Key roles (person and activity)
Firm's input pathways	
Inhouse focused - firm-led - online marketing pathway	Firm with enough resources and strong leadership, internal learning sources, online marketing activity
Inhouse focused – firm-led - network marketing pathway	Firm with enough resources and strong leadership, internal learning sources, participates in virtual clustering and this provides opportunities to engage with other firms and actors (networking)
Inhouse focused – academic-led - network marketing pathway	Firm with enough resources but weak leadership, internal learning source, participates in virtual clustering and this provides opportunities to engage with other firms and actors (networking)
Learning focused - firm-invested - business promotion pathway	Firm, partners as sources of learning, invests to the R&D project, participates in temporary clustering that links firm to other actors in another place for a short period of time (competition/trade exhibitions)
Learning focused - academic-led - online marketing pathway	Firm (with weak leadership), partners as sources of learning, online marketing activity
Learning focused - academic-led - factory-upgraded pathway	Firm (with weak leadership), partners as sources of learning, invests in production facility
DUI/STI focused - firm-invested - retail pathway	Firm, partners and academic research material as sources of learning, invests to the R&D project, business negotiation in commercialise of product in retails

Commonalities of input by triple helix	Key roles (person and activity)
DUI/STI focused - firm-invested - business promotion pathway	Firm, partners and academic research material as sources of learning, invests to the R&D project, participates in temporary clustering that links firm to other actors in another place for a short period of time (competition/trade exhibitions)
DUI/STI focused - academic-led - online marketing pathway	Firm (with weak leadership), partners and academic research material as sources of learning, online marketing activity
DUI/STI focused - academic-led - retail pathway	Firm (with weak leadership), partners and academic research material as sources of learning, business negotiation in commercialise of product in retails
HEIs input pathways	
Incremental innovation – expertise-pooled – commercialisation focused pathway	Academic, participates in temporary clustering that actors perform activities with purpose to it (R&D project with other academics), IP granting process, university administration, university support staff
Well-grounded expertise – firm-academic collaborative focused pathway	Academic, creates informal relationship with an actor during R&D process
Well-grounded expertise – knowledge-transferred focused pathway	Academic, knowledge transferring process
Well-grounded expertise – consultation focused pathway	Academic, monitors and aids the entrepreneur in developing the product
Well-grounded expertise – lab-testing focused pathway	Academic, university department
Well-grounded expertise – lab-testing – commercialisation focused pathway	Academic, university department, IP granting process, university administration, university support staff
Well-grounded expertise – lab-testing – research application-focused pathway	Academic, university department, adjusts research result to match commercialisation
SP's input pathways	
Funding support focused pathway	SP administrative, SP facilitator, invests in R&D project
Funding support focused – business promotion pathway	SP administrative, SP facilitator, invests in R&D project, invests for participation in temporary clustering that links actors to actors in another place for a short period of time (conferences/trade exhibitions)
Funding support focused – standard certified pathway	SP administrative, SP facilitator, invests in R&D project, administrative supports on product/factory certification, certification authority
Academic matching focused – funding support – business promotion pathway	SP administrative, SP facilitator, arranges temporary cluster that actors perform activities with some degrees of purpose to it (matching), invests in R&D project, invests for participation in temporary clustering that links actors to actors in another place

Commonalities of input by triple helix	Key roles (person and activity)
	for a short period of time (conferences/trade exhibitions)
Business support focused – funding support – business promotion pathway	SP administrative, SP facilitator, external business trainer, arranges temporary cluster that actors perform activities with some degrees of purpose to it (business coaching), invests in R&D project, invests for participation to temporary clustering that links actors to actors in another place for a short period of time (conferences/trade exhibitions)

There are different innovation intra- and inter-firm pathways. The analysis of innovation projects within the setting of the NSP highlighted that firms play a central role in this process as inputs from HEIs and SP actors were configured to meet the needs of individual firms, and more specifically projects. SP collaborations played an important role in matching expertise and funding to projects and helped to promote the final product through trade exhibitions and competitions. Other support or inputs may be required to enhance a firm's marketing strategy and resources. Academic researchers have an active role to play by reducing or removing knowledge gaps and by working closely with entrepreneurs in building innovation, but they made more limited contributions to the commercialisation stage.

6.5 Conclusion

Innovation is a complex process that may have multiple drivers, motivations, inspirations and pathways. The distinction that has been made between STI and DUI approaches is one way of considering firm-level innovation processes. The triple helix has been developed to focus on SP based innovation processes whilst the IVC approach has been developed to identify different types of intra-firm innovation process.

The IVC approach highlights the complexity of innovation as a non-linear pathway or journey that includes acquiring knowledge, building innovation, and commercialisation. Before

accumulating necessary knowledge, the firm must finalise which idea worth further development considering the company's strategy. The firm is a unique production operation that even in the same industry, different firms have different production (Andres and Bryson, 2018). The study informs that the entrepreneurs' expectations on the inputs from SP and the academics varied depend primarily on the business capacity. The primary concern of the firms in participating with the SP was to have academic support matching with the university researcher. The entrepreneurs may have an idea of what to improve to increase the competitive advantage, but they have to acquire technical knowledge to create innovation. However, some businesses do not need the academic support but expect to increase its reputation and credibility from participating with the SP or locating an office in the SP's area and having the SP as a product's guarantor is a plus.

In Chapter Five, the interviews revealed that funding support provided by SP was necessary, but not the primary motivation for businesses to become involved in the SP program. The entrepreneurs perceived this monetary support as an incentive to encourage participation. Moreover, financial support encouraged firms to make a more rapid decision regarding their involvement in the SP. SP must carefully consider investing in projects which may have positive impacts on the local economy. Without proper selection criteria, the budget will be allocated to low-impacted projects rather than invest in a high potential project (Hansen and Birkinshaw, 2007).

The roles of each actor in the triple helix were different during each stage of the IVC process. The effect of the activities to the project result also different depended on the combination of inputs. The firm was the main actor at all processes since the requests for product development based on their resources. The role of academic depended on the firm's ability to develop the product. In the building innovation process, the researcher’s role can be

more critical than the firm since the development required advanced knowledge. Gathering knowledge from external sources provided an opportunity to bring in expertise from other institutes. However, the researcher's role may be reduced if the firm can develop the product using in-house resources. Moreover, the academic had less engagement at the commercialisation process, and that was when SP increased its support to push the firm to the market.

The inputs from the researcher and the NSP reflected on what the firms needed. The input of NSP limited at the core services, including matching firm to university resources, provide funding support and suggest additional sources of funding, and support on business issues and promote the business. In addition to that, personality and expertise matching of entrepreneur and the researcher is essential to form the positive relationship between them, funding support is also vital to firms that have limited investment in the building innovation stage. Two-third of private SMEs participants benefited from funding support provided by NSP. Moreover, NSP should also extend its funding support to the commercialisation stage for the firms in need or suggest them appropriate sources of funding. Furthermore, the firms appreciated the SP support on promoting businesses in the competition and trade exhibition as well as in the network created with other entrepreneurs in the SP program.

From 57 interviews of 33 projects, each case is distinct in its own right, but some commonalities were identified. Despite this, none of the pathways identified can be adopted as the most important or significant pathway, and this means that there are multiple pathways configures by firms and SPs to support product development and commercialisation. Thus, there is no one route to support R&D activities via a triple helix informed policy, but a diversity of pathways that meet the needs of individual firms and their R&D needs as well as capabilities. Thus, no one-size-fits-all best practice approach emerged from this study.

A firm may acquire external knowledge to support their in-house resources (Isaksen and Karlsen, 2012). External sources of knowledge may be available from other regions, but some firms still benefit from proximity to potential information sources (Isaksen and Karlsen, 2010, 2012) and this is especially the case for the DUI orientated firms. Nonetheless, the firms that gain knowledge from diverse sources are the most innovative (Isaksen and Nilsson, 2013). However, traditional firm such as a food producer may have difficulty in applying the STI approach as a firm must have the capabilities transferring information and knowledge from academics (Jensen *et al.*, 2007; Isaksen and Karlsen, 2012; Isaksen and Nilsson, 2013). Collaborative working between the researcher and the entrepreneur still is the key to the successful development of the product. Nevertheless, the DUI/STI dichotomy appears to be too simple as there are multiple firm-level innovation pathways. Perhaps the DUI/STI needs to be conceptualised as a continuum or as the starting point for the analysis of firm-level innovation processes. In this study, multiple pathways of each helix were identified. The DUI and STI innovation modes, as a result, were applicable for only part of a firm's learning innovation-orientated processes.

Nonetheless, the input of the researcher must be flexible to match with the firm's ability. If the entrepreneur can perform most of the R&D, the researcher may take the role to monitor and suggest advancing the result. SP has a critical role at all stages but as a supporter. At the ideation stage, SP should help the firms developed an understanding of the market to finalise the idea and the problem, and to continue the role as a supporter throughout the IVC process. As such, there is no one policy best for every circumstance, and the policy has to be adjustable base on the situation (Lindblom, 1959). SP policy implementation is no exception. The policy may pave the roadmap for a scope of SP supports. Although funding support is critical, the assistance provided or facilitated by the SP played an essential role for each firm but in different

ways during the IVC process. One firm may need business training at the acquiring knowledge stage while another firm may need business support only to promote the product. Each stage of the IVC process connects and relates directly to the outcome (Ganotakis and Love, 2012). Inappropriate input at one stage can cause the failure or dissatisfaction of the project result. SP should monitor the inputs of the researcher to match with the firm's activities and communicate clearly with its client to offer the right support and at the right time of need.

Furthermore, in triple helix approach relationships between the firm or entrepreneur, the HEI and researchers, and government through the SP management, have a direct effect on the success or failure of the SP policy implementation. An IVC informed analysis of the triple helix provides an approach that enables different R&D or innovation pathways to be identified that reflect different ways in which firms, with or without the support of the SP, bundle or configure the resources or inputs required to support process and product innovation including commercialisation. It appears that the relationships within a SP are the impacts of various combinations of inputs during the IVC process is a much more complicated process compared to the more linear-based relationship that exists within the triple helix approach. Here it is crucial to appreciate that the processes of learning, adoption, and commercialisation can occur back and forth in a non-linear pattern.

Moreover, each project has its own needs and is unique in some way. Each pathway was perhaps driven by different motivations and each stakeholder participates with the SP project on the basis of a different logic. This logic/motivation may derive from personal interest, or their role assigned by their institutes. For example, the researcher conducts the R&D project to enhance their career path without concern about commercialisation while the entrepreneur wants to make a profit. Ideally, the motivation of all actors should be met. There is a tension between a more academic-orientated institutional logic with the more commercially

orientated institutional logic of the firms. According to Thornton and Ocasio (2008), institutional logic provide the connection between individual person and socially construct of the organisation . It is the drive behind a person behaviour to perform based on his role in the organisation. To enhance the benefit of positive connections between each actor, we may have to look more profound to the institutional logic behind the decision making of the triple helix. Knowing the aim of each actor may help to understand their acts in the IVC process.

In the next chapter, we will explore further to the relationship in NSP considering them as non-linear or as a bundle of strings that each string can connect to the others, combine as a cluster, and spread its connection further to other stakeholders outside of the triple helix. The string theory will be introduced its application to this complicated relationship found in the NSP.

CHAPTER 7

UNDERSTANDING SCIENCE PARKS BY THE DEVELOPMENT OF A STRING-BASED ACCOUNT OF THE TRIPLE HELIX

7.1 Introduction

There are many ways of conceptualising innovation processes. Chapters Five and Six explored the relationship between the actors involved in the triple helix - firms or entrepreneurs, higher education institutions (HEIs) and researchers, and government, focusing on research and development (R&D) projects undertaken within the Northern Science Park (NSP), Thailand. The analysis of the NSP has highlighted, in the Thailand context, that initially the application of a triple helix approach was one in which the roles of key actors was framed as a top-down management process. This approach was limited at the macro or institutional level. At the same time, the critical factors influencing the outcome of an innovation project, including relationships created between academic and entrepreneur, and the essential inputs from the key actors, were also identified at the micro or the project level.

Applying an innovation value chain (IVC) approach to SPs adds another layer to the analysis highlighting that the R&D, or innovation processes, involves three interlinked activities: acquiring knowledge, building innovation, and commercialisation. The learning process of firms undertaking R&D projects included applying a '*science, technology, and innovation*' (STI) mode and a '*doing, using, and interacting*' (DUI) mode. The STI innovation mode highlights the absorption by firms of broad codified knowledge that may be external to the firm and requires having employees understand the subject (Jensen *et al.*, 2007; Isaksen and Karlsen, 2012). DUI mode is more localised. Some firms were more orientated towards the STI or DUI approaches. However, the firms that combine STI and DUI approaches were better at creating innovation than firms that applied only one approach (Jensen *et al.*, 2007). The inputs

of researchers and SPs varied depending on each IVC stage and the firm's requirements. Although applying the IVC approach to the SP analysis discovered commonalities regarding each actor's inputs, no significant patterns were identified as each firm was idiosyncratic. Firm-level innovation processes differ from industry to industry and between firm and firm, altering how a firm participates in triple helix style interactions (Asheim, 2007).

The triple helix and the IVC approaches have made valuable contributions to understanding innovation processes, but there is a danger that these are considered to be linear approaches. It is important not to ignore the multiple feedback loops that exist between the stages of the IVC and also between the actors involved in the triple helix. Chapter Six highlighted that dyadic encounters between the helixes' parts may occur back and forth with complex feedback loops during an IVC process and not always following any sequence. Innovation is often the outcome of a non-linear process (Smith, Bagchi-Sen and Edmunds, 2016; Mele and Russo-Spena, 2017) that occurs endlessly as related activities involving the actors participating in an innovation network. The non-linear nature of firm-level innovation processes, combined with the idiosyncratic nature of any firm-level innovation process, suggests that the triple helix approach needs to be extended or further developed (Champenois and Etzkowitz, 2018; McAdam and Debackere, 2018). Thus, a firm's innovation processes consist of a set of interactions that may be planned or improvised, and these interactions connect different actors in different ways and result in different outcomes. An innovation process is the outcome of a process and tasks in which different interactions are bundled together to produce some result.

The triple helix debate has moved on to develop a focus on sustainability management (Anttonen *et al.*, 2018; Scalia *et al.*, 2018) and the identification of additional actors beyond the original triple helix model (McAdam and Debackere, 2018; Galvao *et al.*, 2019; Sá, Casais and

Silva, 2019). A biological metaphor inspired the triple helix, but other metaphors from the natural sciences can be applied to explore innovation processes. This thesis develops a new approach to analysing SPs at the project level that is informed by string theory that has evolved as one metaphor for conceptualising the fundamental constituents of the universe. Point-like particles are conceptualised as one-dimensional 'strings'. A particle is the outcome of loops' vibrations in strings, and each has a characteristic frequency.

In this thesis, each string represents one actor involved in an innovation process. The complete process is a set of strings combined at critical points, looping together, interacting, and producing some outputs. Thus, a triple helix is the outcome of a process involving the bundling of strings, and this process is one in which connections are developed between those involved in an innovation project. It is this coming together that results in a catalytic process that results in some alteration or innovation. String theory provides interesting conceptual approaches that can be applied to exploring firm-level innovation processes as an extension to the triple helix and IVC approaches. Developing a string-based approach to micro-level innovation in place and space provides a different approach for understanding SPs as a bottom-up innovation process contextualized within the triple helix's top-down approach found in Thailand. The string-informed conceptual framework that is developed in this chapter complements the triple helix and IVC approaches.

This chapter focuses on developing a non-linear approach to understanding SPs. The emphasis is on developing a complementary approach to the triple helix model, partly informed by the IVC approach and partly by ongoing developments in the social science of lines (Ingold, 2016). The first section explores research in sociology and anthropology focusing on understanding lines, which complements ongoing research in physics on string theory. Developing a string theory-informed approach to understanding SPs provides a complementary

approach to exploring the complexity and dynamics of R&D innovation pathways. The second section reviews string theory, including an account of string theory. The third section applies a string-based approach to firms and regional economic development, including focusing on institutional logic and different actors' motivations as they engage with an innovation project. The fourth section assesses the contribution that a string-based approach makes to understanding SPs, including its benefits, limitations, and policymakers' recommendations. The last section concludes the chapter.

7.2 String theory in social sciences.

Social science has engaged with line-based metaphors, and this can be found in applying concepts including 'interwoven', 'weaving', 'weft and warp' (Gherardi, 2009; Mele and Russo-Spena, 2017; riiotgrrrl1, 2017; Gherardi, 2019). In this approach, organisations develop texture through an interweaving of inter and intra-firm relationships. The concept of organisational texture was introduced to business and management in 1965 by Emery and Trist (1965) in the *Journal of Human Relations* (Cooper and Fox, 1990), emphasising the connected interaction of organisation parts with the environment. In string theory, loops develop that provide a form of texture. Thus, strings can combine as part of a process of bundling or coupling, and an outcome is a new form of interaction or the emergence of a new type of organisational texture, as such

> A texture is made up of a weft and a warp; the warp concerns the vertical threads run along the yardage's length, and the weft refers to the horizontal threads that run from side to side. In innovating as a texture, the weft represents the practice of co-creating, and the warp represents the practice of weaving. The multiple connections in actions that arise at the cross points of warp and weft allow the big picture to emerge (Mele and Russo-Spena, 2017, p. 113).

An alternative approach developed in anthropology with Ingold's (2016) research on lines. To Ingold,

> The first distinction I would make is between two major classes of line, which I shall call *threads* and *traces*. … A thread is a filament of some kind, which may be entangled with other threads or suspended between points in three-dimensional space. … Here are some common examples: a ball of wool, a skein of yarn, …, the suspension bridge. …The body of animals, too, with their external hairs and feathers, antennae and whisker, and their internal vascular and nervous systems, can be understood as complexly connected bundles of threads (Ingold, 2016, p. 42).

In this account, the body is described as a bundle of strings. The nervous system is composed of threads that stretch out to and from the centre. Every system is interrelated, impacting bodily functions, and multiple activities coincide. The body reacts to internal and external inputs resulting in movement and actions including breathing, eating, running and fighting. The outcome of this process is a set of traces or a trace. A thread connects points, including people and things, and these connections result in traces.

> … the trace is any enduring mark left in or on a solid surface by a continuous movement. Most traces are of one or other of two kinds: additive and reductive. A line drawn with charcoal on paper, or with chalk on a blackboard, is additive since the material of the charcoal or chalk forms an extra layer that is superimposed upon the substrate. Lines that are scratched, scored or etched into a surface are reductive since in this case, they are formed by removal of material from the surface itself (Ingold, 2016, p. 44).

Lines may make connections that facilitate flows, and these flows may produce outcomes or traces. The ongoing research on lines mirrors some of the characteristics of string theory at a very general level.

String theory has informed some research in education management. Erçetin and Bisaso (2016), for example, have explored the possible interrelationships between string theory and the educational system with the intent of applying this approach developed in physics to educational management. This study analysed concepts developed within string theory and applied them to the educational system. The elements of string theory applied in this analysis included strings and membranes, quantum gravity, unification forces, supersymmetry, and extra dimensions (see **Table 7.1**).

Table 7.1 Applying the string theory metaphor to the educational system

Essential elements of string theory	Metaphors in the educational system
Strings and membranes	Values of education
Quantum gravity	Attractiveness of education
Unification of forces: - Electromagnetic force - Strong nuclear force - Weak nuclear force - Gravity force	Forces in the educational system: - Standards - Decision toward practice - Stakeholders and their roles - Professional associations and their expected influence
Supersymmetry: the relationship between bosons and fermions in every particle	Relationships between: - Leadership and resource management - Teaching and learning management - Leadership and research innovation - Leadership and outreach processes
Extra dimensions: not the main focus, but must be in concern	Language, skills, attitudes, values, competencies

Source: Adopted from Erçetin and Bisaso (2016)

In this account, ‘mass’ in the educational system was defined as the needs that must be controlled. The values in learning were identified as ‘key strings’ binding the educational system together. Quantum gravity may unify the two theories: quantum physics and general relativity, reflecting education's attractiveness. Without this gravity pull or attractiveness, children may not be interested in studying. The unification forces were compared with the critical issues in an education system, such as education standards and stakeholders' roles. The supersymmetry informs the coexistence of two elements and that "a fermion [category of elementary particle] must exit for every boson [category of an elementary particle] and vice versa" (Erçetin and Bisaso, 2016, p. 61). It was compared to the relationship between each element of the education system that one cannot exist without another, such as leadership and resource management. The authors claimed that the application of string theory might result in

the development of techniques to overcome the challenges, which could transform the education system.

Another attempt to apply string theory to the social sciences appeared in an article published on the website *The Daily Journalist* by a lawyer from the University of California. Barack Obama Mandela proposed that the unification of socio-cultural theories may be possible by comparing humanity, civilisation and culture to string theory (Mandela, 2016). The author claimed that social scientists might develop a socio-cultural theory of everything that would mirror ongoing attempts in quantum physics to develop a theory of everything. This analysis compared some fundamental elements within string theory to socio-cultural theory components.

Table 7.2 Applying the string theory metaphor to socio-cultural theory

The element of string theory	Metaphor in socio-cultural theory
A string	Each human being
Membrane (or brane)	Human civilization
Collections of strings that vibrate together on a single membrane	Culture
Collision of membranes	War and armed conflicts

Source: Adopted from Mandela (2016)

Mandela (2016) compared the elements of string theory to human beings and the activities resulting from the changes and society's formation, for example, culture, war, and human civilisation. A vibrating string represents an individual's activities. Each individual then socialises and interacts with other people – with other strings – and these connections then form membranes or a form or variety of human civilisation.

These two papers highlight some of the essential elements identified in string theory in physics to explore how they can be applied to understanding socioeconomic or socio-cultural phenomena. Furthermore, they also highlight the possibility to apply string or line metaphors

explanatory tools to explore human-based processes. Before developing this argument, it is vital to begin with an account of string theory and the development of this approach in physics.

7.2.1 What is string theory?

String theory emerged in physics (Kiritsis, 2019) and included M-theory and superstring theory. According to Blumenhagen, Lüst and Theisen (2013), string theory was first introduced in 1960 to explore the study of the masses and the decay of hadrons. Scientists' interest in string theory declined and the concept remerged in 1984 with the work of Mike Green and John Schwarz, Queen Mary College, London. They developed the approach but primarily applied this to exploring the physics of energy. In 1994, five superstring theories were introduced. This development later introduced string theory as one explanation of the anthropic principle.

Hawking (2016) explained string theory as an approach that conceptualises matter consisting of microscopic string-shaped particles that combine in various ways. Each string vibrates and creates a wave that, once combined, then the bundle of strings becomes one type of matter. Different waves and different combinations create different types of matter. Zwiebach (2009) compared string theory to creating music and used the example of playing the violin. In this account of string theory,

> Each particle is identified as a particular vibrational mode of an elementary microscopic string. A musical analogy is very apt. Just as a violin string can vibrate in different modes and each mode corresponds to a different sound, the modes of vibration of a fundamental string can be recognised as the different particles we know (Zwiebach, 2009, p. 7).

String theory is based on a complex mathematical formula (Jones and Robbins, 2010). There have been attempts to broaden the understanding of string theory beyond physicists and mathematicians, including producing videos depicting string theory in a visual format (see

Kurzgesagt – In a Nutshell, 2018) and developing more straightforward descriptions (see Jones and Robbins, 2010). Thus,

> *String theory* is a physics theory that the universe is composed of vibrating filaments of energy, expressed in precise mathematical language. These *strings* of energy represent the most fundamental aspect of nature. … All of the matter in our universe consisted of the vibrations of these strings. One crucial result of string theory is that gravity is a natural consequence of the theory, which is why scientists believe that string theory may hold the answer to possibly uniting gravity with the other forces that affect matter (Jones and Robbins, 2010, p. 9).

String theory emerged in physics to develop a 'theory of everything' that integrated different scales of analysis. These strings are of different lengths, with particular lengths having defined properties and are in the form of open-ended and close-ended strings or loops (Weingard, 1988). String theory has important implications for mathematics and physics, including understanding black holes, wormholes, and the eleven dimensions of the universe, but this theory cannot yet be proved by scientific experiment (Weingard, 1988; Greene, 2005; Jones and Robbins, 2010; Blumenhagen, Lüst and Theisen, 2013; Erçetin and Bisaso, 2016; Kiritsis, 2019). In physics, string theory is still evolving as physicists try to develop approaches for uniting all quantum physics theories (Jones and Robbins, 2010).

Drawing upon string theory to deepen understanding of innovation processes within SPs or the triple helix does not represent an attempt to develop a social science theory of everything. The string metaphor's application highlights some characteristics and features of innovation processes obscured or overlooked in existing approaches. Thus, string theory complements the triple helix and IVC approaches. It is to apply a string-informed view of innovation and SPs that we now turn our attention to.

7.3 Applying string theory to understanding SPs

A SP, acting as a boundary spanner (Champenois and Etzkowitz, 2018), brings together firms, HEIs, and the public sector to enhance firm-based innovation. This boundary spanning function may be formal, for example, reflecting initiatives developed by SP employees, or informal based on serendipitous encounters facilitated by firms being co-located. The network learning literature can be applied here to consider intra- and inter-organisational learning with SPs focused on encouraging inter-organisational learning facilitated by different forms of boundary spanning activities (Westerlund and Rajala, 2010; Lundberg, 2013). Each part of this triple helix plays a role and contribution to make to the SP's operation. The actors and their activities are critical for an individual innovation project's outcome contributing to a SP's success. The combination of individual capabilities and the activities performed according to their roles, and in response to the other actors involved in an innovation project creates different innovation pathways identified in Chapter Six. SP's project components include firms or entrepreneurs, sources of learning, the academic, university staff and administration, SP staff and facilitators, investment in the R&D project, and clustering of the actors in performing specific tasks and networking.

We may consider the similarity between these SP components during the boundary spanning process and the elements explored in string theory. The establishment of a SP and the improvement of an innovative cluster require participation from various stakeholders. Each stakeholder, or organisation, is part of a network of dyadic relationships with its intra-organisational resources and assets and access to other resources owned and controlled by other organisations via inter-organisational encounters. These relationships can be conceptualised as strings. A firm then represents a process that results in a braid in which inter-organisational

relations or strings are combined in different ways, and this combination creates a mass. The formation of these braids is an ongoing process as new relationships are woven into the braid.

A SP is intended to encourage interactions between firms and academics to facilitate innovation to occur. Thus, stakeholders are encouraged to combine to engage in an innovation process, and this reflects a process based on the bundling of stakeholders or actors into structures that underpin innovation. These bundles can be conceptualised as the weaving together of different strings of different lengths and characteristics. This process of bundling or weaving forms a mass that produces some outcome. The activity can be described as a vibration that alters processes and procedures, leading to innovation. In Ingold's terminology, this outcome would reflect some form of a trace.

Collaborations between firms reflect the interweaving of firm-level dyadic relationships, and this process results in innovation or some alteration in existing processes and products. It is similar to string theory that explains the mass as a bundle of small particles shaped like a string. Each string vibrates and pairs up with other strings, resulting in different types of combinations. The vibration of strings reflects input combinations that come together, and this also results in a new form of relationships, activities, and some output or trace. An output might be an innovation or some form of exchange with no defined outputs. As they form around a project. Strings can be of different types – a tight bundle of relationships or something much weaker. The application of string components to SP operations is shown in **Table 7.3**.

Table 7.3 String theory and SP operations

Component	Definition	Characteristic
String	An individual actor or a person containing some qualification can create a relationship with other string/actors, i.e., entrepreneur, researcher, SP support officer, and supplier.	Each string has its roles contributing to an innovation project differently at each IVC stage and responding to a particular logic that reflect the position within the institutional structure to which they belong, and that creates the fundamental attribution to its existence in a place.

Component	Definition	Characteristic
Partial string	An actor who lacks resources to undertake product R&D	A partial-string needs fulfilment to be completed. For example, the entrepreneur with a lack of knowledge needs to learn new technology for product R&D.
Completed string	An actor with enough resources to develop the product to some level	The completed string is ready to pair up with other strings and perform a more advanced output.
Vibration of string	The interaction of actors based on combinations of logics but directed to an outcome that results in a completed project	A blend of strings that facilitates some form of activity. The vibration of strings was influenced by the logic behind each string.
Braid	A form of a relationship created between strings with a mutual goal, i.e., firm, HEI, and SP.	Two or more individual strings combined to perform some activities with one mutual goal. Poorly formed relationships between strings within a braid affect the performance of the braid.
Project braid	A form of a relationship created between strings from different braids and with other strings to conduct a R&D project.	Strings from different braids combine for some time with the purpose to complete an innovation project. For this SP's project braid, the three main strings are from firm braid, HEI braid, and SP braid. Other strings, such as suppliers, may temporarily join the project braid at some point.
Node	A meeting point that interaction between braids/strings occurs.	The point that actors from a firm, HEI, and SP cluster together to perform an activity and has some degree of purpose to it. This is a place-based aspect of the process that leads to the formation of a braid.

A string

In the SP context, a string represents an actor such as the entrepreneur, researcher, university staff and administration, SP staff and facilitator. These strings contribute to the innovation project differently at each IVC stage and respond to other strings such as the academic that may not have any role at the commercialisation stage. A string can be closed or opened, representing different characteristics of each actor. Each string may exist but not activate until it is paired up with other strings. Pairing represents the formation of some form of relationship. For example, the entrepreneur string creating a relationship and starting R&D activities when pairing up with the academic string. During the R&D project, each segment of

a string might do things differently in response to an activity's purpose. This activity reflects the vibrations of strings as they combine and work together to produce outcomes.

There is an institutional logic behind a string's performance. To Reay and Hinings, "logics are an important theoretical construct because they help to explain connections that create a sense of common purpose and unity within an organisational field" (Reay and Hinings, 2009, p. 629). Moreover, the institutional logic shapes the person's behaviour to perform according to his role in the organisation (Thornton and Ocasio, 2008; Reay and Hinings, 2009). In this context, institutional logic creates the fundamental attribute of a string's function and drives the behaviour of the string to perform differently in different braids.

Complete and partial strings

The complete string is an actor with access to the resources required in completing tasks to a certain level and is ready to pair up with another actor to conduct a R&D project. For example, an entrepreneur may code a computer program using his in-house resources. Alternatively, the software may be developed to a higher level with assistance from a computer science academic. In contrast, the entrepreneur who lacks resources represents a partial string, such as the entrepreneur who has the business idea but does not have the know-how. This partial string needs fulfilling by learning or support from another string, such as an academic, to complete a task of developing a product.

A braid

String theory in physics does not account for combinations of strings, but for SPs, combinations occur, producing or facilitating innovation outcomes. For our purposes, these are 'braids'. Braiding is an ongoing process motivated by a need to access different sources of

expertise to achieve the target, such as forming a business that contains various strings from production to commercialisation. There are different degrees of adhesion between strings. A string itself is a micro-braid containing an individual's qualification, and these then combine to form more complex braids that take the form of organisations. A string brings to a braid an existing connection, and these existing connections or weak and strong ties explains why a string is a micro-braid.

A braid consists of two or more strings that may have different logics woven together, creating relationships leading toward the same goal. The braiding process is, thus, the process of blending and balancing two or more logics to achieve the braiding purpose. The strings can combine in many ways and create a different pattern of braid that led to different outcomes or traces. A clear example of this is hair braiding. The hair as strings can be braided into various styles such as box braid, French braid, or fishtail braid. In this context, a braid refers to a firm, HEI, and SP with various individuals responsible for undertaking different tasks. However, the aim must be the same goal, for example, profit maximisation. It is worth noting that a firm consists of strings that form a braid and that interactions between two braids occur between strings (people) within a braid.

A braid may be loosely or tightly woven. A tight braid refers to the strings that are woven together under the same logic forming an organisation. Development and learning occur within the braid, while loose braid has more interactions involving learning outside sources. Thus, a loose braid is akin to Granovetter's weak ties, and a tightly coupled braid might be more akin to a set of strong ties as "weak ties are more likely to link members of different small groups than are strong ones, which tend to be concentrated within particular groups" (Granovetter, 1973, p. 1374).

A project braid

Some of the strings within a braid then may create a relationship with another braid and create an inter-firm braid that forms to undertake some tasks, and this might be short term or long terms, such as the establishment of an innovation project team between a researcher, an entrepreneur, and SP supporting team. This process of bundling strings together to form a project team – a project braid – involves a learning process in which the primary actor driving this process identifies the strings required to deliver some trace. This reflects some form of a more formal partnership.

Braiding is a process within which boundary spanning becomes much more formal as connections are developed that link individuals together that results in more formal relationships. A braid will still benefit from opportunities to learn from other firms and non-firm actors via the activities of individuals acting as intermediaries and this is very much a boundary spanning function. A braid reflects a temporary blurring of the boundaries between distinct organizational entities facilitating more direct and regular boundary spanning learning encounters. In this analysis, a SP represents a network and, in fact, a triple helix is a network development processes with boundary spanning at its center (Champenois and Etzkowitz, 2018).

All project braids are connected through the SP braid. The braid's performance relies on the relationships created and the quality of each string as it contributes to the braiding process. A braid that contains a partial string may dampen the project success, or a braid in which the required bundle of strings has not been assembled to create the desired trace. It is essential to appreciate that this is not a linear process. Thus, a project braid is formed to deliver some innovation, but the final innovation may differ from initially imagined. For example, a firm with insufficient investment (a braid with a partial string), despite being supported by the

SP (a braid with complete strings) and the researcher (a complete string), still unable to commercialise the product. The limited resources of the firm braid compromised the final delivery of the project. The possible solution is to engage another string for funding support, maybe an external investor, to fulfil the partial string in a project braid at the commercialisation stage.

The project braid is a temporary braid that can tighten up, retain the loose form, or come apart once the task is completed. For example, the R&D team may transition as a new firm or project group is formed to commercialise a completed new product, and this would represent a process of tightening relationships between strings. Nevertheless, university researchers may continue with their involvement in the braid in some form of consulting role to the firm, but this might represent a loose relationship, or it may be that the project braid is unravelled, and the academic is no longer involved with the company.

A node

Strings come together in place or space via interactions between people. These places may be termed nodes. Nodes were not part of string theory in physics, but for SPs and regional economies, these represent a point that strings can potentially meet and commence a braiding process. The fusing will occur when there is an exchange within the node. These are inter-organisational relationships, and the vital point is the bundling process that results in some vibration or process that leaves a trace – some outcome.

A node may form from combinations of close and distanced relationships. Some strings can be involved in several nodes at the same time. For example, a SP facilitator may become involved with many entrepreneurs and academics concurrently. A string may play different roles in different nodes, such as the role a SP plays in the building innovation stage compared

to the role played in the commercialisation stage. Moreover, a node may also facilitate informal encounters that may remain informal or be formalised.

Vibration of strings

The vibration of a string represents the interactions between strings as they combine to complete one specific task at one moment. The string vibrates differently depending on the activity and its logic behind each task. A string may perform different roles and respond to different activities concerning other strings within a braid. Moreover, the braid strings' vibration is likely to have the same resonance since the main goal was set for every individual to help achieve some agreed outcome – a completed R&D project or some innovation.

The vibration of the strings creates waves that interfere with other strings' waves. The interference of two or move waves can be constructive, destructive, or mixed (Urone and Hinrichs, 2020; Webb, 2020) (**Figure 7.1**). In acoustics, sound waves combine to form a new wave in a process known as interference. In this process, the sound waves cancel each other out in the process of destructive interference. Alternatively, waves may combine as part of an amplification process or a process of constructive interference in which the amplitude of the combined wave is equal to the sum of the amplitudes of the individual waves. A braid formed to support the delivery of a R&D project may result in constructive or destructive interference.

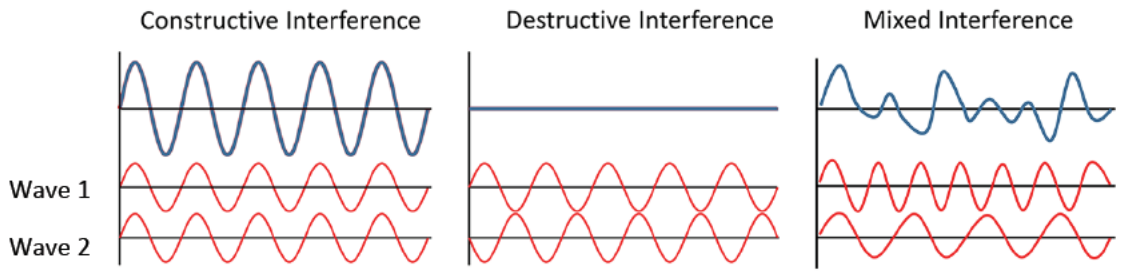


Figure 7.1 Wave interference (Webb, 2020, Fig. 10.2.4)

The interference process may reflect conflicting institutional logic held by strings within a project braid. These conflicting logics may result in destructive interference that dampens project delivery. An academic logic held by the university researcher may focus on academic rigour with a requirement to meet the key performance indicators (KPIs) developed to measure the effectiveness of academic research. An academic institutional logic is very different from a commercial logic that stresses project delivery's commercial dimensions. Tensions between conflicting institutional logics within a braid then may result in destructive interference rather than constructive.

In the SP context, the string-based application of the triple helix is illustrated in **Figure 7.2**, showing how strings combined into braids with each string representing a different institutional logic – public policy orientated institutional logic, science or academic orientated institutional logic and commercially orientated institutional logic.

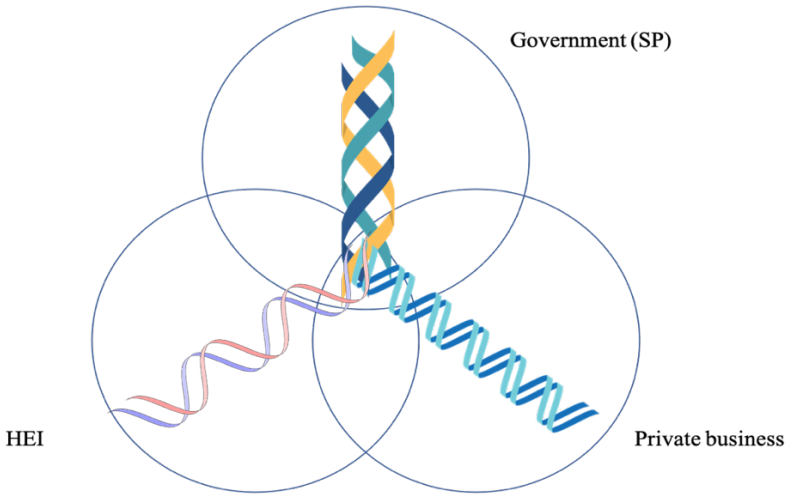


Figure 7.2 String-based concept applies to the triple helix model

7.3.1 Complexity beyond the triple helix driven by actors' logics

A string vibrates according to its role and as it responds to the vibrations of other strings. The activities are performed based on each actor's different logic that can sometimes create a non-supportive relationship and conflict during the R&D process (Edvardsson *et al.*, 2014). Furthermore, not all researchers have the capabilities required to work with a private business. It is essential to match firms with researchers who have developed appropriate attitudes toward working with the private sector to avoid damaging relationships and the university's reputation (Goddard, Kempton and Vallance, 2013).

The link between the university and the private firms should primarily be based on a mutual interest in the technology and understanding of the expected trace or outcome. Proximity is not enough for effective R&D delivery (Goddard *et al.*, 2014) and what is required is an alignment of logic that creates constructive interference (Pietrobelli and Rabellotti, 2011). The application of wave theory to the analysis of SPs is precious as it highlights the need for alignment between strings involved in a project braid, and this alignment is not just a reflection of copresence. The concept of interference highlights that a braid enables forming constructive and destructive interactions, and this reflects a process of interference with each of the strings as they are woven into a braid that will leave a trace.

The motivation of different actors involved in an innovation project is essential, reflecting different institutional logics. Although the professional supporting team, SP and academics, are critical in implementing SP policy, the key persons may have a different motivation for participating in a SP project (Anttonen *et al.*, 2018). A project braid is a collection or bundling together of actors with different institutional logics, and these differences may result in difficulties in project delivery. One of the core tasks for successful project delivery revolves around coordinating tensions between actors informed by different institutional logics

and encouraging the required type of interference. To Thornton and Ocasio (2008); Edvardsson *et al.* (2014), every individual's behaviour in any relationship is shaped by the institutional logic that can be developed and changed over time. One person can have various logics based on their role in the organisation in one particular situation.

Furthermore, institutional logic reflects the connections between a person and an organisation's social construction (Thornton and Ocasio, 2008). Multiple logics from different stakeholders influence the implementation of a SP policy. Thus, variations in the relationships created within the SP occur from the need to coordinate different logics to accomplish project delivery. Part of the vibrations that result in combining strings results from tensions between different and very distinct institutional logics. On the one hand, there is the commercial logic of the firm and, on the other hand, maybe a scientific/research logic adopted by the HEI partner. Mediating between these will be a public sector logic that highlights policy and political outcomes and the delivery of agreed KPIs. A core tension within a SP's R&D project is balancing the entrepreneur's commercial logic with that of the researcher's academic logic. Combining the two logics results in different relationships that directly affect the project's process and the outcome.

The key to a project's success is perhaps the emergence of a more dominant logic as strings combine to deliver a R&D project. An innovation project led by a researcher may be too heavily orientated toward an academic logic that is perhaps more concerned with publishing than commercialisation. Diversly, a project dominated by the firm is perhaps primarily based on a commercial logic targeted at meeting short-term objectives based on market conditions and returns on investment. There are exciting tensions here, with the more academic logic being more concerned with the quality of the solution defined in academic rather than commercial

terms. A commercial solution may meet the needs of the firm and not the academic partner. Thus,

> Entrepreneurs want the development that is most applicable to their businesses. However, to follow them all, it will not be academic research. The difficulty is to tune what the entrepreneur wants to meet what we [academics] need. We must adjust the proposal to him, and he must adjust his needs. For example, an entrepreneur refused my proposal that was written based on academic principles. The research aimed to reduce sugar additive in passion fruit juice. So, we needed to use sweetener, which is non-toxic and very low in calorie. We listed five choices for him, but he already had a sweetener that he wanted to use, which we did not know the chemical structure or anything of it. It would be time and cost-consuming testing that sweetener. We took a long time convincing him to use one from our list. The second problem was that he did not approve any recipes we prepared according to food science principles. He said they were not delicious, or the tastes were different. Finally, we had to send one researcher to adjust the formula and test at his factory instead of finishing it in our lab (R10, 2018).

At the project level, the dominant logic may come from the firm or academic string involved in a project braid, and it is critical to balance the logic from both sides to run the R&D project successfully. From the 33 R&D projects explored in this study, three projects were selected and explored as examples of the logic as they are involved in a string-based approach and focus on project outcomes (**Table 7.4**).

The projects were classified into three levels based on the outcomes: highly successful, moderately successful, and less successful projects. These three levels of outcome were based on product commercialisation, repeated participation in the NSP's R&D project, and the entrepreneur's perception of the project's outcome. Firms that had highly successful outcomes led to product commercialisation, repeatedly engaged in the SP project for further R&D and perceived that SP programs acted as catalysts for the firm's capabilities. Moderately successful firms went through the product commercialisation stage and realised benefits from joining with the SP project. However, there had not yet participated in a further project. A less successful project is defined as a project whose outputs were not commercialised, but learning was still

undertaken during the project. The outcome did not meet the entrepreneur's expectations, and there was no recurring involvement in further projects.

However, there is another way of defining project success based around exploring the relationship between each participant's institutional logic and differences in the ways in which project success was perceived. Success may mean different things within the same project due to differences in the institutional logics held by different stakeholders. Success defined within the context of the logic of a SP officer or policy would highlight that project which completed on time and to budget and with project outcomes that can be developed further or be commercialised. Academic logic and project success include a focus on academic publication and KPIs that are included with assessment measures for academic and HEIs.

Table 7.4 String-informed characteristics in different SP project's outcomes

Project outcome	Description	String-based characteristic
Highly successful	Experienced coffee brewing factory (C05) developed products from coffee waste. The owner realised that IP protection is critical for the business and required scientific proof as a product guarantor. Academics from different universities contacted by the owner, and NSP worked cooperatively with the firm's R&D team. Brainstorm sessions often occurred during informal dinners. The testing was done at a university lab and on the firm's premises. The firm had a separate R&D budget and received partial funding support and channels to promote new products from the NSP. Developed products were successfully commercialised to the domestic and international market through the firm's existing channels. The owner agreed that the academics could publish the paper. The firm continued developing more coffee-based products under the SP program.	The firm braid contained complete strings with different functions, including learning, investment, marketing, and doing R&D. The node combined strings from the firm, academics, university supporting staff, and SP staff. There were strings from other partners, including coffee farmers, packaging services and media. The project balanced competing logic. The firm's motivation was to commercialise the product and rely mainly on having an academic-based guarantee. This was matched with the academics' motivation that expected to publish academic papers for their career path.
Moderately successful	The spin-off firm (C11) joined with the NSP to develop an oven for cooking crocodile meat and received support or partial funding. They were matched with an academic by NSP. The R&D applied to the firm's existing oven. The quality of meat	The firm braid combined complete strings on business function. However, it had one partial-string – the entrepreneur with no technical knowledge on developing the production equipment. This partial

Project outcome	Description	String-based characteristic
	improved significantly with the new oven, and it has been sold nationwide without needing NSP support.	string was fulfilled after combining in a node with academic and SP strings. The firm's motivation dominated the project, and the academic string vibrated, supporting the firm's vibration. The outcome was the developed machine that increased product quality. The project braid was unravelled on project delivery as the firm did not require marketing support—however, the firm strings connected further to its partners, such as souvenir shops and logistic service.
Less successful	An experienced chilli paste factory (C04) wanted to develop a peeling machine to increase process efficiency: less time, less workforce, more production. NSP proceeded with matching an appropriate academic and providing part of the funding to support the R&D project. The machine was created according to the owner's request. However, with the purpose of an academic to let the students practice assembling skill and with limited cost available, the machine was assembled in the university workshop by students instead of a proper welder. The machine was only at the prototype level and not strong enough to be used in the factory. The owner kept the prototype but did not build a new one since it required further investment.	The node for this case contained complete strings from the firm, academic, university, SP supports. However, partial strings existed given inexperienced students and limited project funding. The project was dominated by the academic logic that had a motivation to take this project as part of the teaching, ignoring the firm's expectations. The problem was that the limited funding (from both firm and NSP) and the firm's strings, HEI strings (academic, students, and university workshop), created destructive interference resulting in a project that could not be commercialised.

This example of a highly successful project included completed strings provided by all participants. The partial string was the firm's knowledge. However, it was compensated by a learning process even before the firm became involved with the NSP. Strings in the project braid vibrated and supported each other to create constructive interference at the maximum level resulting in a trace or outcome that exceeded all parties' expectations. The firm led the project and managed to balance the firm's commercialisation logic with academic logic.

The firm's logic dominated the moderately successful project with a focus on increasing product quality. The academic string may vibrate differently but supported the firm's vibration

resulting in constructive or mixed interference or a positive outcome to the project. This project combined complete strings from a firm, HEI, and NSP. A partial string from the firm was supplemented during the project by pairing up with the academic string.

The example of less successful projects was dominated by academic logic, trying to fulfil an academic purpose in having students participate and gain experience from the real entrepreneur's problem. The academic and firm strings vibrated in different phases created destructive interference or a negative outcome for the project. Combining with limited funding, this project failed to meet the firm's expectation of developing a machine that was useable in the factory. Despite having all combinations of complete strings involved in the project, some partial strings (inexperience assemblers) directly affected the outcome leaving a broken trace behind the project's journey. The limited funding prevented further development of the prototype machine, and it could not be incorporated into the firm's operations.

From these three examples, a braid is a bundle of strings that has an institutional logic. Different strings from different braids (organisations) combine into a project braid, and the combination of logics might be supportive or destructive. The project dominated by the firm's logic tends to have a more positive outcome than the project that was dominated by academic logic. Interference can occur when two logics held by different strings are aligned, resulting in a positive outcome. The outcome might even be an innovation or some transformational outcome - it might be seen as a moment of 'explosive' innovation. Strings that try to braid together, which have different institutional logics, might cancel one another or dampen the outcome. However, the logic behind the dominant string is not the only factor driving project success or failure. Having a partial string in a braid can be troublesome if that partial string represents what should be a critical string underpinning project success.

Nonetheless, besides the firm and the researcher's logic, the SP is another primary braid in a bundle of braids that form a R&D project. The logic behind a SP's performance may impact all strings. The management logic of a SP may be too narrow as the focus is on meeting policy delivery KPIs rather than on enhancing innovation activity within firms. These KPIs may highlight financial sustainability, and one implication may be a SP that works with larger firms may not be supportive of smaller firms. Thus, smaller firms requiring more support may be ignored as these are harder to deal with than larger firms. An entrepreneur with experience of dealing with two regional SPs in Thailand noted that:

> My success may come from experience. However, SPs have to teach new entrepreneurs. .... Some SPs selected experienced entrepreneurs first instead of choosing those who are inexperienced, who cannot write a business plan. SPs are responsible for teaching them. Instead, they may select entrepreneurs who are already in the market, just to have high success numbers (C25, 2019).

The string's vibration is influenced by the logic behind it, which affects other attached strings. In some cases, the consequences can be connecting or disconnecting with other strings based on a string's guiding institutional logic. This might highlight the need to develop a sustainable SP, and this logic might exclude firms from the SP policy.

7.4 Assessment of the string-based approach of a SP

There are at least three ways of exploring SPs and their role in innovation: triple helix, IVC and a string-based view. This section explores these three approaches. The triple helix approach was developed to understand SPs' operations and activities, highlighting cooperation between the government, HEIs, and private businesses. In creating a successful SP, each helix must connect and support each other; government-HEIs, HEIs-businesses, and business-government. In the connection of strings, there is an exchange of knowledge and infrastructure sharing as part of a two-way communication process. Hence, the feedback must be considered

to improve operations further. The activity of each member relates to the activities performed by other actors. For example, the project proposed by one company creates tasks for researchers, SP officers, employees, and other suppliers to complete.

The vibration of each string results in the reflexive movement of other strings combined in a braid. Although each vibration creates different waves, they must combine to support the same goal and support one another. Constructive interference can then be created, leading to a successful project outcome. The failure of an innovation project reflects two factors: the absence of strings from a project braid or strings which do not contribute appropriately to the braid and the vibration of strings that create destructive interference.

A SP consists of multiple firm-level projects, and each project concerns the development of a project braid to form an innovative 'mass' that will vibrate to produce some output or trace. Thus, there are multiple pathways towards innovation, and these reflect how different braids form. Moreover, strings from one node can further connect to other nodes, or the same actor is also involved in completing other tasks with other groups or braids that have combined to deliver another project's outcomes. The nodes then combine with other strings into a bundle of strings that include various nodes and braids (**Figure 7.3**).

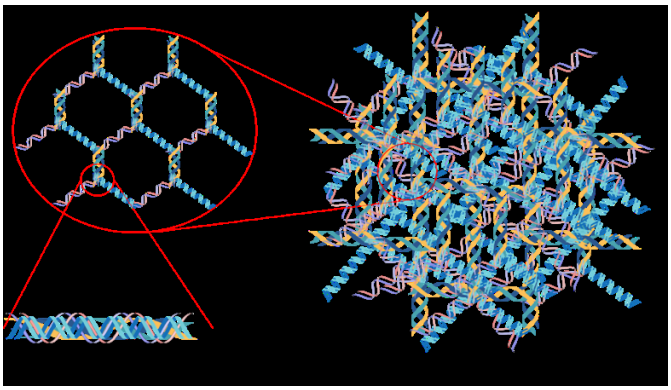


Figure 7.3 Bundles of strings
Note One colour represents one string.

The IVC approach complements the triple helix model by helping to understand differences in the level of engagement of each actor along the stages of acquiring knowledge, building innovation, and commercialisation in the innovation process and allows us to find commonalities that show the patterns of activities leading to satisfactory outcomes (see Chapter Six). Developing a string-based analysis of SPs adds dimension as it highlights that momentum occurs when strings are combined, and this momentum is based around vibrations, the diversity of project forms based on different types of strings and the way these are combined into braids. Innovation is a complex non-linear process that requires different actors working to different institutional logics to work together. Just as a string can fold in any direction, actors involved in a R&D project can shift their attention away from building innovation towards returning to the learning stage.

Nevertheless, a string as an actor has a history before and after the project. They have different motivations and thus perform differently at each stage of the innovation process. Some strings from the braids can connect to other strings outside of a bundle, such as connecting to other firms, local retailers, suppliers, customers, industrial clusters, or SP in another region. The string approach highlights that the strings combine within a braid for a period to achieve some objective that may leave a trace. There are two forms of a trace. For one thing, a trace is a project's outcome, but on the contrary, a trace also includes some alteration in the relationships between strings that might have longer-term benefits.

These three approaches to understanding R&D and SP are complementary. The triple helix highlights that this R&D process is based around interactions between three actors, while the IVC approach highlights that R&D and innovation involve distinct but linked stages. The string-based approach adds to understanding as the emphasis is placed on the different types of strings – from complete to partial – and how these are combined to produce trace outputs. This

combination will be distinct to each project, and this bundling process results in vibrations between actors resulting in outputs (**Table 7.5**).

Table 7.5 Comparison of the triple helix, IVC, and string-based approaches to the SP policy implementation

	Triple helix	IVC	String-based
Key concept	SP was established by cooperating with three main actors: the private businesses, the HEIs, and the government.	The innovation project consists of three stages: acquiring knowledge, building innovation, and commercialisation.	An innovation project contains interaction between different strings; firms, universities, and a SP. The project outcome is based on the logic of the dominant string that emerges and partial strings at a critical point. The vibration of strings reflexes to a positive or negative relationship created between braids.
Contribution of actors to SP policy implementation	Three main actors have equally critical roles throughout the R&D project.	Informing the different inputs from each actor at each IVC stage based on their role and the firm's needs.	Project outcomes rely on the dominant string that can be the entrepreneur or the researcher. Although the SP and researcher strings are always present, they may not be active at some IVC stages.
Individual inputs	Each person performs according to their roles and duties.	Firms have a lead role in the project. HEIs and SPs provide additional inputs.	Each project participant acts based on their role within a project and influenced by their institutional logic and response to other actors.
Perception of the R&D project process	The project starts by matching the firm to an appropriate researcher. Then proceeds to the R&D process and product commercialisation.	The innovation project process starts with the stage of acquiring knowledge, building innovation, and product commercialisation.	The project flows by the IVC process and can be back and forth from different strings taking the lead or playing a more important role at different times of the project, but the coordinating role is critical.
Source of knowledge	Triple helix does not mention the external sources of knowledge.	The learning sources are from inside and outside the SP cluster.	The strings can connect to learning sources from inside and outside the SP cluster.
Firm's learning process	The learning process occurs before start developing the product.	The learning process starts as the first stage, following by building innovation	The learning process can be at any point in innovation development. The firm may return to acquiring knowledge while building innovation or

	Triple helix	IVC	String-based
		and commercialisation.	commercialisation, then reverse back to building the innovation stage.
Benefit	The triple helix model requires the integration of top-down management and bottom-up initiatives. It creates a clear image of the main characters with specific roles to participate in SP operations at an institutional level.	IVC is process-orientated that allow studying the process of innovation at the firm level, including the inputs of key actors that may reveal the pattern that leads to project success.	Reveals that each actor performs differently in different situations. Different combinations of strings within a project braid led to different outcomes or traces. And this bottom-up management complementary to the triple helix model.
Limitation	The implication being that the triple helix in Thailand is a top-down management model that does not consider the different logics that might be involved in influencing project outcome. It also needs to broaden the approach to include other actors and firm level processes. Requires further engagement with the network learning literature including boundary spanning processes.	The IVC process is too linear and does not consider the chance of looping backwards or jumping between stages during an innovation process.	Learning that the string can connect to other strings inside and outside a cluster broadens the scope of the study as the motivation may be driven by external strings. Another set of concepts developed and applied to understand innovation processes.

It is important to appreciate that one contribution made by this thesis is the application of an IVC-informed framework to the triple helix approach and this then results in the development of the string-based approach. Combining the triple helix and the IVC was the pathway that led to the development of the string-based approach. The string approach has many benefits. On the one hand, it highlights the importance of intra- and inter-organizational learning framed within an appreciation of institutional logics. On the other hand, it recognizes that there are different types of boundary spanning structure. Thus, boundary spanning within a braid is an inter-organizational process that has many of the characteristics of intra-organizational learning. Nevertheless, a braid also benefits from additional, sometimes serendipitous, inter-

organizational learning. This is an important distinction that adds considerable clarity to understanding network learning within different inter- and intra-organizational network structures. In this analysis, a braid is thus a temporary network that facilitates an intensive and time-limited process of learning and knowledge exchange, but braids can never be treated in isolation from their organizational or geographical setting. Thus, organizational and geographical context matters.

Comparing each part of the triple helix as a string creates a further question regarding its application to understanding SPs and regional economic development. How can we stimulate strings to connect or bundle together? Does it benefit both sides of the relationship? Is the communication between them two-way, or is it just a one-way, top-down communication process? The question is also about creating the perfect project braid and bundle with open-ended strings left to connect with other bundles, industrial clusters, the local community, and other regions. The government should have a broad vision of how to implement the policy and intervene in SP operation and the development of clusters in helping them connect for the mutual benefit of one and all.

The relationship between the two SPs created two ways of knowledge transfer and exchange of human capital (Saxenian and Hsu, 2001). There are no two SPs alike. There will be significant differences based on location, age, and specialisation (Westhead and Storey, 1994). In successfully developing a sustainable knowledge-based community, the development of a SP should support the economy and society (Etzkowitz and Zhou, 2018; McAdam and Debackere, 2018; Galvao *et al.*, 2019). The strings from the bundle, thus, should attach to other strings in the community and beyond.

However, not all clusters are successful. Some strings were unable or did not adapt to change. To Saxenian (1996), the decline of Route 128 was related to the failure to explore new

markets. The firms did not have flexible structures, sharing knowledge mainly within the company and competed with each other rather than cooperating with other firms. Furthermore, some of the SPs failed due to a lack of cooperation from HEIs and the government (Etzkowitz, 2008). These are examples of weak combinations or braiding that includes partial strings.

The adaptability and the need for linkage creation also apply at the firm level. Frenken and Boschma (2007) suggested that massive changes in a firm can cause employees to resign, move out or spin out. The inability to accept changes leads to the lock-in of both firms and regions. They will experience declining demand due to market saturation. Furthermore, firms to keep their position in the market must keep developing their core competencies, including retaining an ability to learn (Asheim, 2007) and to connect to broader sources of knowledge. The string-informed approach highlights that a firm must have open-ended strings in its braid that can create connections to other strings and braids to support learning and innovation.

Recently, Storper and Scott (2016) have noted that urban development cannot be transferred from one place to another given place-based variations. In 1953, Florence noted that copying a place-based policy would require a ‘swarming’ process in which everything in one place would need to be relocated and "move together like a swarm of bees" (Florence, 2003, p. 88) to another place. Despite using the same approach in establishing the two SPs, the implementation's outcomes that affect the development of clusters and the local economy vary based on the vibration of each string and the background of each region's economic geography. Moreover, to stimulate regional economic growth, it is necessary to interact between at least two regions for trading and sharing of knowledge that will further encourage innovation (Scott and Storper, 2015). From that, the strings located in one SP toned to connect to the strings of other SPs, clusters, and the community, but also need to stretch further to connect with strings in other regions to drive economic growth.

7.5 Conclusion

SP policy implementation in Thailand was based on the triple helix model (Pisalnupong, 2014), highlighting that three actors have roles and responsibilities and are equally critical in SP operation. Although the triple helix approach provides a framework regarding SPs' operation, some limitations include the top-down management approach initially adopted in Thailand that does not consider the performance and interaction of key actors that influence project outcomes. Applying the IVC approach to the SP analysis complements the triple helix, emphasising learning, building, and commercialising innovation. It provides another level of analysis absent from the triple helix approach, including a focus on firms and their roles in innovation processes. The IVC, as a process-orientated approach, helps to understand differences in the pattern of inputs to support R&D projects.

The string-based approach is an application of ideas that have developed in physics to understanding local economic development. This includes the weaving together of strings into braids and the concept of destructive and constructive interference. The combination of different waves and types of string leave different types of mass or trace as the output. This string-based approach enhanced the triple helix and IVC approaches, allowing us to explore firm-level development and innovation projects as non-linear. The learning process and the innovation stages can start at any point of the IVC process, flow back and forth between learning, building innovation and commercialisation.

A SP represents a policy intervention to develop new forms of string combinations that form a SP braid. In this string-based account of the triple helix, a SP results from the braiding of strings that include strings formed around participants involved in developing a SP from government, HEIs, and the business sector. This SP braid is a loose braid that provides opportunities for a more tightly woven braid to form as an innovation project. Moreover, a

string involves in a SP braid, such as a SP coordinator and a SP manager, maybe a key string within a project braid providing support such as funding and matching the entrepreneur to the researcher and may act as a catalyst in the R&D process as it coordinates the processes. Project failure may be the outcome of three factors; academic logic being too dominant over commercial logic resulting in a failure to commercialise, a project braid in which a critical string is absent, or which contains a partial string at a critical point, or the interference between strings' vibration within a project braid creates destructive interference. Identifying and addressing these obstacles is essential in pushing a project towards commercialisation.

The string-based approach highlights that a project's outcome is influenced by which string dominates the project. It is vital that the most appropriate logic drives an R&D project. Given that the goal of a SP innovation project is product commercialisation, then the researcher's academic logic should not be prioritised over the entrepreneur's commercial logic. SP should facilitate this tension, ensuring that the barriers to successful project delivery are identified and removed. Two potentially opposing logics – academic versus commercial – may combine or remain in supportive tension with one another to support project delivery. Policymakers should consider promoting long term relationships between those involved in a SP project. Partial strings should be identified before the commencement of the R&D project as part of the screening process. Evaluation should be undertaken regularly to identify if the partial string(s) still exists or if new partial strings emerge during the project and if there is a requirement to add additional strings to a project braid. The project braid, which has constructive interference and remains tightly bound, develops further to form a spin-off firm and the project braid that remains loosely bound, retaining the academic in a consulting role to the company. These two types of relationships, which may develop from the project braid, may be valuable for the firm's development. The string-based approach includes an appreciation that

strings can join a braid that is either co-located or distanciated. Connections to other economic actors and knowledge sources outside the SP and the firm's immediate environment are essential in ensuring that a firm continues to innovate. This suggests that the triple helix model is perhaps better conceptualised as a quadruple helix with the additional dimension highlighting the importance of connections to other places.

The triple helix, IVC, and string-based approaches complement each other in understanding the roles and responsibilities and the logic that drives the performance of actors involved in a SP. Each adds a new set of concepts to understanding R&D and innovation projects facilitated by SP policy interventions. The IVC approach highlights the essentialness of different inputs at each stage of the innovation process, while the string-based approach focuses on understanding the need to balance each stakeholder's logic to sustain a supportive relationship that enhances the project commercialisation. Combined, these three approaches link the SP analysis at a micro-level to the macro-level, highlighting the importance of developing a more nuanced bottom-up analysis of the triple helix top-down management model found in emerging economies. However, there are limitations to the string-based approach.

On the one hand, one can question applying a new approach to understanding a well-researched process. Nevertheless, the string approach adds new dimensions to understanding the configuration of innovation projects in SPs. It also adds further conceptual complexity. On the other hand, further research is required on failed and semi-successful innovation projects that focus on unravelling destructive and constructive interference. It also suggests that a SP innovation management approach could be developed to identify projects requiring further policy interventions.

CHAPTER 8

CONCLUSION TOWARD THE STRING INFORMED VIEW OF SCIENCE PARKS

8.1 Introduction

This thesis commenced with a vignette of a company established in a regional science park (RSP) in Thailand. The company was established by an entrepreneur identifying a market opportunity and innovating, but with limited capital. The science park (SP) facilitated this firm's establishment by assisting with product development, providing space and business support. The business has continued to grow significantly since its establishment in 2013. This vignette raised essential questions regarding regional innovation policy and economic development in emerging economy settings, but perhaps the most aspect of this vignette is that it highlighted the need to explore intra- and interfirm aspects of innovation projects. The point being that innovation projects are coordinated by firms and for this study these projects are positioned within the context of the establishment of an RSP in Thailand. This vignette was an account of a business formed in response to the uplift in demand for cosmetics in Thailand, but it is also an account of how a SP firm-level innovation processes. Another aspect of this is that most businesses fail within the first three years (Stavreski, 2015), while this firm survived. This then is partly an account of a SP support, an entrepreneur's capability combined with some element of luck.

Completing the research for the thesis has transformed my understanding of this vignette. The university and SP contributed to an entrepreneur's development and encouraged and supported the product development process (Díez-Vial, 2016; Nakwa and Zawdie, 2016). SP support facilitated Miss T's business, including university facilities and access to shared tools and production equipment. Renting office space in the university enabled Miss T to

engage with researchers to support research and development (R&D) and product testing. The company's location in the university SP provided credibility as customers linked the university with the quality of her products. The firm's employees were all graduates of this university. Most importantly, the SP connected her to academics who provided management consultancy and marketing advice. Without a SP, it would have been much harder to establish this firm. The SP reduced the barriers to entry for Miss T.

A SP is a tool for implementing place-based innovation policies intended to develop a regional innovation ecosystem by considering the local context and existing industries in the area and providing support by linking local firms with research institutes and higher education institutes (HEIs) and by facilitating linkage creation with other economic actors. There have been attempts to replicate SP policy from developed market economies to emerging economy settings (Koh, Koh and Tschang, 2005; Zou and Zhao, 2014; Chen, Sun and Batchuluun, 2016; Albahari *et al.*, 2018; Torres de Oliveira, Gentile-Lüdecke and Figueira, 2021). There is an extensive academic and policy literature on SPs in developed market economies (Bakouros, Mardas and Varsakelis, 2002; Koh, Koh and Tschang, 2005; Hasan, Klaiber and Sheldon, 2020), but the SP literature on emerging economies is underdeveloped (Bakouros, Mardas and Varsakelis, 2002; Ratinho and Henriques, 2010; Torres de Oliveira, Gentile-Lüdecke and Figueira, 2021). This is unfortunate. Besides, SP research has been dominated by the triple helix model (Albahari *et al.*, 2017; Etzkowitz and Zhou, 2018; Aportela-Rodríguez and Pacios, 2019). The triple helix model embraces the integration of both top-down and bottom-up initiatives, but previous studies have focused on the macro or institutional levels (Bunders, Broerse and Zweekhorst, 1999; Sá, Casais and Silva, 2019). The success of a SP within an emerging economy setting is perhaps not founded on the macro-level but at the project or micro-level (Bunders, Broerse and Zweekhorst, 1999; Cadorin, Johansson and Klofsten, 2017;

Champenois and Etzkowitz, 2018; Sá, Casais and Silva, 2019). This is to argue that a SP policy is a complex interplay between firms, projects, and institutions. Understanding this interplay is central to this thesis.

This research commenced by applying a triple helix informed analysis to SPs in an emerging economy setting – Thailand. This is the first academic study of Thailand's SP initiative. The study explored the implementation of a place-based innovation policy, focusing on SPs in an emerging economy setting. Moreover, it was essential to identify and explore the roles different actors played in the triple helix, including the relationships created that support research commercialisation and firm innovativeness. An important issue was identifying and defining critical inputs from the key actors that drive the success of individual firm-level innovation projects.

The next section of this chapter re-evaluates the study's aim, objectives, and research questions, highlighting the main contributions to the field of knowledge. The third section presents the research contributions, including the current understanding of SP development and policy interventions and the contributions to theory. The limitations and recommendations for future research are considered in the fourth section and the thesis then concludes in the final section.

8.2 Contributions of this thesis

This thesis aims to understand the relationships between SP innovation projects and the triple helix institutional framework to develop a critical evaluation and appraisal of existing theory applied to understanding SPs at a project level considered in the context of an emerging economy setting. To answer the research question '*How are innovation projects within firms linked to a SP organised, and how are differential outcomes explained in terms of more*

successful projects compared to those projects that fail to meet the objectives set by the firm and/or the SP?', this research is based on a comparative analysis of innovation projects linked to one regional SPs in Thailand, the Northern Science Park (NSP). Data was collected from interviews with 57 participants engaged with the NSP, including all directors involved, representatives from universities in the NSP network, academic researchers and entrepreneurs who had been or were currently involved in an innovation project linked with the NSP. The empirical analysis contributes to the field of study in four ways and relates to each objective (**Table 8.1)**:

- Understanding the adoption and implementation of SP policy in an emerging economy context - Thailand.
- Defining the role key institutional actors play in the triple helix and the relationships that support commercialisation processes within innovation projects and the impacts on firm innovativeness in an emerging economy context.
- Understanding the impacts of the implementation of a SP policy in an emerging economy setting with a focus on exploring the inter- and intra-firm project-level including identifying critical inputs from SPs, academics, and entrepreneurs that underpin an innovation project's outcome.
- Developing a critical evaluation and appraisal of exiting theoretical approach applied to understanding SPs at the firm/project level and making a substantially new and novel theoretical contribution.

Table 8.1 Map of contributions to the research objectives

Objectives	Scale	Contributions	Page
Explore the adoption and implementation of a SP policy in an emerging economy.	National level	- Government is a primary driver in SP establishment	119-126
		- Limited resources available for entrepreneur development	104-109
		- Inconsistency of government rules & regulations	148-152
		- Need to develop HEI structure	154-165
Identify and explore the roles key institutional actors play in the triple helix and define the relationships that support the commercialisation processes within innovation projects and the impacts on firm innovativeness in an emerging economy context	Institutional level (macro)	- Government's roles in matching expertise and funding	148-154, 214-220
		- HEIs' roles in providing expertise and facilities	154-165
		- Informal relationships and their influence on project outcomes	171-173
Develop and inter- and intra-firm project-level understanding of the impact of the implementation of a SP policy in an emerging economy setting including exploring critical inputs from SPs, academics, and entrepreneurs that underpin an innovation project's outcome	Firm-level (meso)	- SP: matching, funding, and promoting - Academic: knowledge - Entrepreneur: ideas and partial investment	205-220
Develop a critical evaluation and appraisal of exiting theory applied to understanding SPs at the firm/project level. This includes applying existing theory but also developing new approaches to theorizing SPs.	Project level (micro)	- The triple helix is compatible with analysing innovation at a macro (institutional) level but neglect the meso (firm) and micro (project) levels	226-229
		- Developed string-based approach to analyse SP at a micro level to complement the triple helix and IVC approaches	250-258

Objective 1 was *to explore the adoption and implementation of a SP policy in an emerging economy setting*. To answer this objective, this thesis explored the development of Thailand national policy from the past to the present, focusing on the policies that aimed to increase country competitiveness, including cluster policy and SP policy. The national strategy and policy documents from different Ministries were reviewed as well as the effect of policy development and implementation, especially SP policy, to regional economic development.

Objective 2 was *to identify and explore the role key institutional actors play in the triple helix and define the relationships that support commercialisation processes within innovation projects and the impacts on firm innovativeness in an emerging economy context*. For this objective, the exploration went further to explore the roles played by the government (through the SPs management), universities, and private businesses in establishing SPs in Thailand. The study also investigated the formal and informal relationships created at an institutional and personal level to identify the influence of relationships on innovation project outcomes.

Objective 3 was *to develop an inter- and intra-firm project-level understanding of the impacts of the implementation of a SP policy in an emerging economy setting including exploring critical inputs from SPs, academics, and entrepreneurs that underpin an innovation project's outcome*. In this account, 33 SP innovation projects were analysed in detail, applying an innovation value chain (IVC) approach to explore the critical contributions of stakeholders linked to the identification by firms of satisfactory outcomes, and outcomes were not always commercialisation but related to firm-level learning. It is important to note that the classification of innovation project outcomes was based on a firm-level assessment of the projects. The critical inputs and relationships created were found to be interconnected.

Objective 4 was *to develop a critical evaluation and appraisal of exiting theory applied to understanding SPs at the firm/project level. This includes applying existing theory but also developing new approaches to theorising SPs.* Identifying the inputs highlights that each actor or stakeholder performs differently in different situations. The triple helix and IVC can be classified as macro- and meso-level approaches, but a more micro-level approach is required to explore the ways in which different stakeholders, with different institutional logics, combine within project terms to support firm-level innovation processes. This thesis develops a new and novel approach informed by drawing upon ideas that have emerged in string theory in physics.

The string-based approach explores the behaviour of actors based on their logics and the blending of logics together as part of a process that involves the braiding of strings (Chapter Seven). Within an emerging economy setting, the string-informed approach highlights intra-project relationships between inter- and intra-firm actors that play an important role in innovation project outcomes. Each objective will now be explored in further detail.

Objective 1: Explore the adoption and implementation of a SP policy in an emerging economy

The implementation of SP policy in emerging markets is different from developed market economies. Perhaps a key issue is that 'hi-tech' has a different meaning in this setting as this term must be applied to existing industries and is context dependent. In Thailand and other emerging economies, hi-tech companies tend to be agriculturally related rather than technology-based businesses. SP policy implementation in Thailand is still at an initial stage. The Thai government was the main driver of SP policy implementation (see Chapter Four, Section 4.3.2 p.117). The development of this SP policy was based on applying a triple helix approach that tries to blend best practices from developed countries within the Thailand context, including applying a SP policy to critical industries predominantly related to food and agricultural products and services. A quadruple helix was introduced in 2006, but this approach has yet to inform SP policy in Thailand. The government expected that the RSPs would encourage regional economic development, including developing industrial clusters. By the time this thesis research was undertaken (during 2018-2020), the influence of RSP policy implementation in Thailand on the development of the regional economy was optimistic but needed improvement (see Chapter Four, Section 4.5 p.140) as there were some critical issues reflected from the analysis.

Limited resources for entrepreneur development (see Chapter Four, sector 4.2 p.104)

The businesses, especially small and medium-sized enterprises (SMEs) and startups lack capacity and access to funding support from government and the private sector (Comins and Rowe, 2008). Sources of funding were available from the government and big corporations, but strict conditions were applied. There were no 'angel investors' in Thailand during the time this research was undertaken. Although the government provided limited funding to complete SP innovation projects, the development of each product had to be completed within the constraints imposed by the budget. Projects were completed, but perhaps no commercialisation occurred as additional investment might be required to support the commercialisation process, but this might be unavailable. Additionally, in an area with limited access to technology, the entrepreneurs did not realise the benefit of applying advanced knowledge for the product's R&D. A lack of resources for development includes the knowledge needed for R&D and this is linked to the underdeveloped nature of the HEI sector; universities still struggled with restructuring and encouraging employees to engage in knowledge transfer to the private sector.

Inconsistency of government rule and regulations (see Chapter Five, Section 5.2.1 p.148).

Different government agencies and bodies were involved in delivering Thailand's SP policy, and each had developed its own rules and regulations that did not always support business innovation processes. A good example is a delay in obtaining a local FDA certificate. This prevented a regional economy from benefiting from the outcome of innovation projects. There were problems with intellectual property (IP) protection in that this did not prevent product imitation by other companies. Imitation is one method in which firms in emerging economies upgrade their competitive advantage (Cuervo-Cazurra and Wang, 2020). Nevertheless, this is a two-way process in which emerging economy firms may experience

imitation that reduces the commercial impacts of their innovation investment. Thus, domestic firms' products may be subjected to reverse engineering resulting in copying. These bottlenecks in the commercialisation process must be eliminated, and the measures supporting the flow of the R&D process must be improved.

The underdeveloped nature of the HEI sector (see Chapter Five, Section 5.3 p.154)

The linkages between the business sector and HEIs in emerging countries are underdeveloped or non-existent (Pietrobelli and Rabellotti, 2011), and this was also the case for Thailand. Academics were preoccupied with teaching and conducting academic-oriented research rather than more commercially aligned research. There was a gap between the need for entrepreneurs to commercialise innovation and academics interested in developing academic solutions to commercial problems. Innovation projects were performed without understanding critical elements that needed to be delivered to add market value to the products. In some cases, these new or improved products were too advanced for the domestic market, and there were trade barriers related to selling products internationally (Comins and Rowe, 2008).

Objective 2: The role key institutional actors play in the triple helix and the relationships supporting commercialisation processes within innovation projects and the impacts on firm innovativeness in an emerging economy context

The analysis has identified some problems with applying a triple helix-informed policy to an emerging economy setting related to weaknesses in the wider framework conditions that exist to support economic activity, including long-time certification processes and IPR protection and inconsistencies in applying government policy. In addition to the institutional level, this thesis analysed Thailand's top-down management approaches framed by the triple

helix and identified the critical roles played by key actors at the institutional level in supporting innovation projects towards commercialisation.

The roles of key institutional actors in supporting SP innovation projects

In emerging economies, the government has a significant active role to play in setting up and implementing innovation policies (Smith, Bagchi-Sen and Edmunds, 2016), including considering altering related procedures to support commercialisation processes (see Chapter Five, Section 5.2 p.148). At the operational level, the government exercises its roles through SP management, and this includes:

- Helping firms identify and define commercial problems and develop solutions.
- Matching of expertise within the setting of a triple helix.
- Providing funding for selected innovation projects.
- Assisting firms to find additional funding.

The primary responsibilities of the RSPs include matching the entrepreneurs to academics and providing funding for R&D projects (see Chapter Six, Section 6.4.3 p.214). Some firms required advice to identify solution pathways to address problems. RSPs helped these firms find and apply solutions within their capacity, assisted by available expertise from HEIs and underpinned by government funding. Additional funding sources were recommended to firms that lacked investment capital for further product development or commercialisation.

A RSP in Thailand includes several university SPs in the network. They are the first point of contact for firms. Both local and non-local firms attracted by the university's expertise. The universities in a RSP network were another critical supporter of a SP innovation project with the essential roles including (see Chapter Five, Section 5.3 p.154):

- Providing university resources, including access to expertise and facilities for firms' R&D.
- Amending university rules and regulations to support the extended role of the academic.
- Providing financial support for SP in its premises.

The government and the university's supporting roles must be co-created, and they are critical in implementing SP policy in Thailand. Private sector innovation requires access to resources, including access to finance, and without appropriate resources, the innovation process may be compromised.

The relationships created within the triple helix

SPs were built upon local geography forming amalgamations of relationships between people employed by the SP, by the university and private businesses (Cadorin, Johansson and Klofsten, 2017). Different types of relationships that influence the project outcome were identified in the analysis. Supportive relationships between key actors enhance project commercialisation, while non-supportive relationships can compromise the success of an innovation project resulting in the entrepreneurs being less interested in government-funded projects. Formal links between business, government (through the SP), and the university were created at an institutional level. However, the relationships critical to project outcomes were informal and reflected person-to-person and entrepreneur-to-researcher relationships (see Chapter Five, Section 5.4.3 p.171). SP's role in personality and expertise matching was essential in encouraging and maintaining supportive relationships.

Applying a triple helix approach to understanding SPs replicates the policy framework applied to initiate a SP regional innovation policy. Thus, the national policy that led to the SPs

explored in this thesis was framed as a political translation of a triple helix approach to a Thai setting (see Chapter Five, Section 5.2 p.148). This implies that a triple helix approach is an excellent starting point for exploring Thailand's SPs, but there are considerable limitations. A key issue is that innovation is a firm-level process that stretches beyond the firm to embrace collaboration with other firms and organisations. Innovation is the outcome of a co-creation process that combines different inputs in complex ways, and this may be a formal and informal process (see Chapter Six, Section 6.2 p.187). To complicate matters, a firm will be involved with many different types of innovation. These include rapid response innovation to immediate problems that may be more about process, logistics and customer problems. It also includes longer-term innovation processes. Innovation processes have different drivers and durations. A SP-related innovation takes the form of a project. The implication is that the SP's primary focus is not on the triple helix or the firm but on defined innovation projects combined with developing a supportive framework with the SP. This raises important questions regarding the conceptualisation of projects. One solution is to apply an IVC approach within the context of a triple helix framework. This approach was adopted and evaluated in this thesis.

Objective 3: Develop an inter- and intra-firm project-level understanding of the impacts of the implementation of a SP policy in an emerging economy setting including exploring critical inputs from SPs, academics, and entrepreneurs that underpin an innovation project's outcome

In Thailand, the triple helix model provided a framework for implementing SP policy at an institutional level. Key actors' roles were identified in terms of that which was critical in supporting the commercialisation of an innovation project. However, each project has its own characteristics; innovation is a complex process that requires various inputs at different points. The roles of key actors then have to be adjusted to meet the needs of a project. An IVC approach was applied to explore SP related innovation projects that were ongoing inside firms. This

approach identifies three linked stages in an innovation process: acquiring knowledge, building innovation, and commercialisation. The IVC process is connected at all stages and relates directly to outcomes (Ganotakis and Love, 2012) and highlights that each project requires different inputs at each stage based on the firm's capacities and capabilities to support innovation (see Chapter Six, Section 6.3 p.191). An innovation project in a SP setting needs to engage with all stages across the IVC, and project outcomes depend on the combination of inputs or 'strings' that are combined into a project braid (see Chapter Six, Section 6.4 p.205).

Critical inputs at acquiring knowledge stage

Firms are the leading players at every stage of the IVC since these are firm centred projects. A firm has to try to develop solutions to its problems, and these are the starting points for a R&D project. The problems may be discussed, and critical inputs identified with the assistance of the SP officers and academics. A firm may acquire external knowledge to support its internal capacity and capabilities (Isaksen and Karlsen, 2012), including inputs from academics. A SP's inputs were limited to providing core services, namely business training, expertise matching, and funding support. At this stage, they include expertise matching and the provision of business training for newly established firms. Matching the entrepreneur to an appropriate researcher is essential since their relationship may enhance or compromise project outcomes.

Critical inputs at building innovation stage

At this stage, the input of advanced knowledge from the researcher is critical. However, the level of expertise input may be reduced if the firms are able to develop the product by themselves to some degree (see Chapter Six, Section 6.3 p.191). The key to successfully

creating some innovation is to agree upon a project's scope that matches a firm's expectations. Funding support generated for each innovation project is an essential input provided by a SP; two-thirds of the firms could not complete the project without financial aid. Partial funding may be required from the firms, and they must commit to a payment schedule. However, as the innovation process is complex and additional knowledge may be required during product development, the academic and entrepreneur may need to take a step back to acquire additional knowledge and continue to focus on the building innovation stage.

Critical inputs at the commercialisation stage

Developed products need to be commercialised to unlock the commercial value of an innovation process. At this stage, the academic had less engagement with the project. Academic input was reduced to helping the firm on installation issues or to make minor adjustments to the final products. The input from the HEIs shifted to the university's role in supporting IP management. The firms that co-invested in innovation projects had priority in the commercialisation of research results at reduced or no fees (see Chapter Six, Section 6.4.2 p.210). SP's support became critical in helping firms promote developed products at domestic and international trade exhibitions and competitions. This is essential for small and start-up firms to access markets and compete with existing businesses (see Chapter Six, Section 6.4.3 p.214).

The empirical analysis highlights that the relationships within a SP resulted from various combinations of inputs during the IVC process. The process is more complicated than a linear-based relationship as there are multiple feedback loops. Although each project is unique, some commonalities of inputs were identified, but the engagement and timing of

support varied. There is no one significant pathway to support R&D activities via a triple helix informed policy, but a diversity of pathways that meet each firm's needs, or more precisely, the needs of each innovation project (see Chapter Six, Section 6.4 p.205). Thus, no one-size-fits-all best practice approach emerged from this study, and the strategies must be flexible and adaptable to each situation (Lindblom, 1959). The critical point is that context matters. For a SP, there are two contexts – the place and the project. A successful outcome reflects a dynamic interrelationship between place and project. In this case, the place is the setting for actors involved in a project, and this can include co-located actors and those located elsewhere but linked in some way to support the project.

Objective 4: Develop a critical evaluation and appraisal of exiting theory applied to understanding SPs at a firm/project level

Developing an IVC informed approach to a SP highlighted the complexity and diversity of inputs required to support firm-level innovation. It also highlighted tensions between the macro or institution-level, meso or firm-level analysis and micro-level accounts of innovation projects. In emerging economies such as Thailand, the triple helix approach is an excellent framework for exploring the macro-level, but there are limitations regarding the meso- and micro-levels (see Chapter Six, Section 6.5 p.220). For the meso-level analysis, the IVC approach adds greater clarity to understanding innovation projects within the firms in the context of SPs. Nevertheless, there is a problem with understanding the multiple complex relationships between these levels and with the project or micro-level. This represents a conceptual challenge centred on understanding the complexity of micro-level processes in the context of meso-level or firm processes and then macro or institutional-level processes linked to regional innovation systems (see Chapter Seven, Section 7.1 p.226). This led to a search for

an alternative conceptual framework that could be applied to understanding SPs, which would supplement existing approaches.

In physics, one of the conceptual challenges is to develop an approach in which quantum mechanics is placed within the context of general relativity. The problem is that subatomic particles in quantum mechanics engage in quantum leaps with probabilistic outcomes whilst general relatively is more deterministic and continuous. String theory has emerged as one attempt to integrate quantum mechanism with relativity. It provides a conceptual toolkit that can be applied to develop a project-based approach to understanding firm-level innovation processes in a triple helix context as part of a non-linear innovation process. The contribution of a string-based approach to the SP analysis includes:

- SP, HEIs, and businesses result from individual strings braiding together to perform activities to achieve the target(s) of that organisation, such as profit maximisation for the businesses.
- An innovation project, or a project braid, combines strings from different [organisational] braids, including strings from the SP, HEI, and a firm. The goal of a project braid should focus on innovation and product commercialisation.
- Each string performs or vibrates differently based on its logic, and the vibration of two or more strings in a project braid may create constructive or destructive interference influencing project outcome.
- The constructive interference reflects the supportive relationships in the project braid and are valuable in enhancing the development of the firm and product commercialisation processes, while the destructive interference or non-supportive relationships can compromise innovation project outcomes. It is critical to balance

the researcher's academic logic with the entrepreneur's commercial logic to create supportive vibrations resulting in constructive interference.

The application of the string-based approach highlighted that each person plays a distinct role in a SP project. The inputs of each actor were driven by different logics derived from personal interest or their role assigned by the institutional setting of which they are part (Thornton and Ocasio, 2008). A project outcome is influenced by three factors: 1) which string dominates the project - firm or academic; 2) the absence of a key string or the presence of a partial string in a braid; and 3) the interferences between strings that are created in a project braid (see Chapter Seven, Section 7.3.1 p.244). The string-based approach emphasizes the need to understand the logics behind each actor and release tensions within a braid linked to competing logics, for example, between the researcher and the entrepreneur.

The triple helix, IVC, and string-based approaches are complementary approaches for understanding the roles, responsibilities and motivations of actors involved in a SP, including firms, HEIs, and the government. Each approach adds a new set of concepts to understanding R&D and innovation projects facilitated by SP policy interventions, and these provide linkages between the macro to micro-level (see Chapter Seven, Section 7.4 p.250).

8.3 Contributions to current understanding in the field of knowledge and theory

This thesis contributes to understanding the implementation of SP policy in an emerging economy. This section explores the contribution to theory.

8.3.1 Contributions to theory

Innovation policy is often informed by exploring best practices developed in other settings. This is then used to develop a context-based solution to a local or regional problem.

This contextualisation process includes resources, existing industries, and culture (Etzkowitz and Zhou, 2018). Thailand's SP policy was informed by exploring practice elsewhere and then applying such practice to Thailand.

This thesis has highlighted that innovation is a firm- and project-level process supported by blending internal and external inputs assembled to support the development of a project-based solution in response to some identified challenge or problem that requires a solution. This process must not be considered too rational as an innovation project is partly planned and partly improvised. Thus, a SP provides a structure that might facilitate or catalyse firm-level innovation that reflects the artful balance of structure with improvisation.

The starting point for this thesis was the triple helix approach. Initially, this was extended by developing an IVC informed analysis. The IVC approach's application was in response to developing a more nuanced understanding of innovation processes within firms. The IVC approach can be applied to a SP as well as to firms and individual projects. The further extension of this new approach based on developing a string-informed approach to innovation within firms, and in the context of regional innovation, was an unexpected development. It is perhaps unusual for a PhD to develop a completely novel conceptual framework. The application and development of a string-informed approach responded to tensions in applying the IVC and triple helix approach to regional innovation systems. A new set of concepts were required. These did not exist in economic geography, economic sociology, or regional science. The problem was one based on the inter-layering of different processes that operate at different scales. This complexity became apparent during the analysis that supports Chapter Seven. The difficulty was in developing an approach that would deepen understanding.

Understanding SP innovation projects through the triple helix lens.

The triple helix model has evolved in response to changes in human behaviour and society (Cai and Etzkowitz, 2020) and has influenced SP policy development and implementation. Currently, the possibility exists to add the fourth and even fifth helix to the model representing those actors which might also play a vital role in innovation development, including financial institutes (Galvao *et al.*, 2019), local community agents (SP2, 2018), and the environment (Sá, Casais and Silva, 2019; Bodolica and Spraggon, 2021). However, adding these actors needs to be undertaken in the context of a need to shift the focus towards understanding innovation projects in the context of SP. Although this thesis does not take the fourth helix into account, it accepts that "the role of the Triple Helix agents evolves over time and therefore, so does an innovative ecosystem" (Pique, Berbegal-Mirabent and Etzkowitz, 2018, p. 1). The current understanding of a SP informed by the triple helix is that:

> A science park is considered a hybrid organisation, which is a result of a systemised form of cooperation between the university, the government, and the private sector organisations. It constitutes an essential regional development tool, capable of transforming the socio-economic profile of a region. It promotes the culture of innovation and the competitive advantage of companies and institutions, by stimulating the creation and the development of technology-based companies (Bencke *et al.*, 2020, p. 22).

There is no doubt that a SP is a hybrid boundary spanning organisation, and that SPs are important policy tools that can be applied to upgrading regional innovation ecosystems. However, the key to establishing a SP is to strengthen existing industries and support new local entrepreneurs by applying advanced knowledge from the HEIs. However, a SP innovation project can come from various industries. In emerging economies, the primary industries are agriculturally related. The mission of a SP, thus, should be extended to include more than just supporting technology-based companies but needs to reflect the local economic context within which a SP becomes embedded.

Moreover, in emerging economies, the triple helix approach highlights the importance of exploring the contributions from HEIs, the public sector, and companies make to place-based innovation processes based on a macro-level management framework or an - institutional level (Sá, Casais and Silva, 2019). There is a danger that this approach overlooks what is going on in a SP at a micro or project level and the contributions micro-level processes play in shaping project outcomes. However, these non-project-based SP activities, in fact, enhance opportunities for new braids to form or for existing braids to include new strings or additional strings.

This research shows that each innovation project is distinct, and that support should be provided based on a firm's needs and this must be project focused. Additionally, the new generation of SPs has evolved to encourage informal relationships amongst triple helix actors instead of formal relationships at the institutional level. Thus,

> In the second-generation science park, instead of a focus on formal relationships, the emphasis is on informal networking, and the park is seen as a hybrid that enables value creation and social prosperity through initiatives located on- and off-site, guided by trust and mutually respected values as well as self-managing initiatives (Steinthorsson, Hilmarsson and Janusson, 2017, p. 392)

In this thesis, a supportive, informal relationship between the helixes was defined as benefiting project outcomes. Formal relationships created at the institutional level are important but informal relationships between individuals are critical elements behind R&D project outcomes and how these relate to a firm's expectations. To identify informal relationships created from person-to-person, this thesis directed the analyses towards understanding SPs by applying IVC approach at a meso or a firm level.

A key question to address here is: *What does the IVC approach add to understanding a SP innovation project*? The IVC approach is an effective tool for analysing innovation activities and reflects processes of value creation that contribute to increasing innovation activities. Thus,

"…In this value chain process, there are not only sequential innovation process links but also interactions and feedbacks between different stages, such as the synergy produced by the interaction between academic activities and industry" (Gong *et al.*, 2020, p. 1).

In this account, the analysis shifted to exploring the implementation of SP policy at the project level. The empirical analysis was informed by the IVC approach, and this highlighted that within a SP project, the innovation process operates back and forth as a firm acquires knowledge and engages in the building innovation stage before commercialising the final product. This is a non-linear process. Moreover, the IVC approach emphasises that each project is unique and has specific needs to be met at each stage of the IVC. Each project needs various inputs from the entrepreneur, academic, and SP those are partly the result of the relationships created during the process. Thus, the role played by each actor defined by the triple helix approach should be customised to match the needs of a specific project in the context of a specific firm. Applying the IVC approach highlighted the complexity of the individual innovation project process and led to an appreciation that the IVC approach needed to be supplemented by a conceptual framework designed to explore project-based on more micro-level processes. This then led to the development of a string-informed approach to understanding project-based innovation.

String-based approach – as a project-based approach to support SP analysis

The string-based approach adds another layer of conceptual complexity to understanding intra and inter-firm project-based innovation in the context of a SP setting. This approach provides another layer of understanding to the triple helix and the IVC approach. This is an important point as this string-based approach emerged from a critical reading of the on-going debate on SPs and regional innovation systems. The literature on innovation processes

within firms and regions is complex with many different and often un-related literatures. Nevertheless, the string-based approach transforms understanding of the need to consider micro-level analysis to establish SPs and the different logics that influence individual behaviour. It highlights the importance of exploring different stakeholder logics and the ways in which they influence each actor's performance or involvement in a project; project outcomes are influenced by the logic which dominates a project. The vibration of each string may create constructive interference based on the actor's logics and the ways these are combined within a braid. Individuals combine into project teams, and in a string-informed analysis this is conceptualised as a process of braiding of individual strings and each string may come with a different form of logic.

Furthermore, strings can join together to form a braid that is either co-located or distanciated during the IVC process. The string approach takes other economic actors and knowledge sources outside the triple helix into account, suggesting that perhaps SP policy implementation requires a quadruple helix model highlighting the importance of connections to other places. The string-based approach highlighted that the triple helix's macro-level management framework in emerging economies requires to be supported by a more micro-level project analysis. The development and application of a string-based approach facilitates deeper understanding by adding a new 'spatial' scale focused on projects and this provides additional forms of understanding linked to how strings are conceptualised within a braiding process that also includes an appreciation of different logics.

However, this approach has some methodological limitations, including measuring and balancing the 'vibration' of the strings. The constructive or destructive interferences can be defined by exploring project outcomes and investigating backwards along the process, but it is critical to detect the occurrence of unsupportive vibrations to prevent destructive interference

that will compromise project outcomes. Another limitation is how to identify the logic followed by each actor. The researcher may follow a strong academic logic that might side-line the commercial aspects of a project. Practically, these limitations still need to be resolved.

This thesis has applied and explored three complementary approaches to understanding SPs in the context of regional innovation systems. It is important to explore the characteristics, strengths, weaknesses of these different approaches (**Table 8.2)**.

Table 8.2 A Comparative analysis of triple helix, IVC, and string-based approaches.

	Triple helix	**IVC**	**String-based**
Characteristic	Highlighting the need for cooperation from three leading institutions (the government, HEIs, and private businesses) and informing their expected roles and responsibilities in implementing place-based innovation policy with SP initiatives.	Defining the innovation process into three sequential stages, including acquiring knowledge, building innovation, and commercialisation.	Defining each actor as a string that contains qualifications and logic. The braid combines strings that vibrate differently, influencing constructive or destructive interference (supportive or non-supportive relationships).
Scale of analysis	Macro or institutional level.	Meso or firm-level.	Micro or project level.
Strengths	Create the ideal approach that will fit the local context based on integrating top-down and bottom-up initiatives during the policy implementation process.	Extracting the innovation process into stages allows the policymaker to define and fulfil different inputs needed.	Highlighting the need to understand the logics behind each actor/string as it affects their inputs and relationships with other actors within a braid.
Weakness	It does not consider other issues or factors that may affect the firms and SPs development, such as environment. The implication being that this might ignore the contribution made by individuals at a firm or project level and the way this influences the success of an innovation project.	Innovation is a non-sequential process. However, the flow of a SP innovation project may be considered as reflecting a linear pattern. Limited time and budget do not allow the process to flow back and forth to improve the product before commercialisation.	Setting up the policy based on understanding each actor/string and the role and contribution that each made to a project braid. This is a time-consuming process and may need to be undertaken project-by-project and also is an on-going process as a project evolves.

	Triple helix	IVC	String-based
	The collaboration between the three institutions involved in the helix often requires intermediaries to facilitate interactions.		Measure to identify non-supportive relationships require development.
Area to develop	Consider an individual's inputs to the R&D project within the context of the existing top-down policy to eliminate gaps in policy implementation.	An evaluation can be completed at each stage to identify and resolve the problems that may compromise project commercialisation.	This new approach requires testing in other settings, including SPs in developed and emerging economies or other sectors.
Contribution to SP analysis	To improve regional innovativeness, it needs collaboration between the government, HEIs, and firms. Each institute has its roles that may be extended to take the role of the others, such as the industry designs the direction of academic research, or HEIs incubate new entrepreneurs.	Innovation must be created from the smallest unit of the system, the firm. The SP policy can be too general as each innovation project requires different inputs (knowledge, fund, time) at a different stage of development, including different strategies for product commercialisation.	Each person plays a distinct role in a SP project. The critical point is to understand their logic(s) A SP may need to regularly monitor and release tensions within a braid linked to competing logics for example between the researcher and the entrepreneur.

The IVC and string-based approaches supplement the triple helix model that has influenced the formulation and implementation of SP policy for decades. Combining these three approaches, triple helix, IVC and strings, adds important extra dimensions to SP analysis by identifying different types of intra- and inter-firm innovation processes, highlighting the complexity of innovation as a non-linear process. Each stage of an innovation project requires different inputs from each element of the triple helix, and the supportive relationships that occurred are critical in successful project delivery. Moreover, this new approach links the micro-level analysis back to the macro–level, indicating that the implementation of a SP policy in emerging economies should be based on integrating bottom-up initiatives with top-down

approaches with an emphasis on project inputs within the context of a supportive SP environment.

There is another theoretical literature on innovation that has been overlooked by this research. This is the debate on sociotechnical change. In 1997, Bijker developed a new theory of sociotechnological development. He set out a framework that identified the requirements of such a theory and this can be usefully applied to the string-based approach. Any innovation theory should explain both change and continuity, be symmetrical, needs to be actor-oriented as well as to take cognizance of structural constraints, and also be a seamless web or, in other words not make a priori assumptions regarding the social, technical, scientific and political. The string approach meets these requirements as it can be used to explore continuity and change, success and failure – symmetry, structure and agency and makes no priori assumptions. In addition, this approach highlights the importance of understanding linkages between micro/project, meso/firm, and macro/institutional levels within particular projects and the ways in which they work across different scales, and this reflects a seamless web approach.

8.3.2 Recent understanding of SP development and policy interventions

The evolution of regional development policy has been based on policy attempt to understand each area's economic geography, but the danger is that SP policy is applied in a new setting based on existing policy (Uyarra *et al.*, 2017). Place-specific policy must be based on an approach that emphasises applying innovation within the context of an entrepreneurial ecosystems with a focus on the development of linkages between firms and sources of knowledge within the context of a specific place (McCann and Ortega-Argilés, 2013; Grillitsch and Asheim, 2018; Bramwell, Hepburn and Wolfe, 2019). One emphasis must be on creating new pathways in local economies based on the development of firm-based innovations that

enhance regional competitiveness. In this account, a SP acts as a bridge to connect private businesses with HEIs and the resulting bridging process is intended to create, stimulate, and support knowledge transfer.

Understanding SP development

The SP concept was developed in the 1950s (Guy, 1996) as a tool for the implementation of place-based innovation policy (Lamperti, Mavilia and Castellini, 2017; Albahari *et al.*, 2018). The triple helix model has been applied as a framework of SP policy implementation (Etzkowitz and Zhou, 2018). The level of cooperation from key actors differs based on the local context, and these differences in local context matter as they influence innovation outcomes. To Saxenian (1994); Garnsey and Heffernan (2005), SPs in developed countries were predominantly established by private businesses working collaboratively with HEIs, and the government's role was as supporter. In contrast, SPs in less developed countries are usually established as a government initiative.

Local SMEs and startup firms were usually the primary target of a SP policy. A SP's support mechanisms include R&D funding support, the use of high-technology tools and equipment available from HEIs, and business incubation programs. Relationship between the HEIs and businesses are encouraged to enhance firm-level innovation. These relationships are primarily based on mutual interest in the technology and the project, rather than the distance between them (Goddard *et al.*, 2014). However, proximity makes it easier to create and maintain a relationship (Andres and Bryson, 2018). Thus, the establishment of a SP involves engagement with local HEIs with related technology to support local businesses and new and emergence firms and industries. Some SPs succeed, and some fail. One issue is that low levels of contribution from government authorities, and HEIs compromise SP operational outcomes

(Etzkowitz and Zhou, 2018). Another issue is that poorly matched entrepreneurs with academics discourage cooperation and knowledge transfer (see Chapter Five, Section 5.4.2 p.167). Also, balancing on-site firms within a SP is critical for ensuring financial sustainability of the SP and to release broader regional impacts. Larger firms can attract smaller firms with related products to the SP or the area (Cadorin, Johansson and Klofsten, 2017). In more successful cases, knowledge transfer occurred from larger to smaller firms, and smaller firms also stimulated regional economic activities in the SP's region. The selection criteria to allocate project funding must be set and carefully followed to ensure that funding was granted to firms with the potential to succeed and not to firms that had relatively low levels of commitment to innovation processes. Furthermore, there is a need to create connections between regions for market expansion and to identify new knowledge to ensure that firms remain innovative (See Chapter Seven, Section 7.4 p.250).

Previous understandings of SP analysis were highlighted in Figure 2.1 (page 52), but this only identified a broad relationship between the government as an actor within a SP, HEIs, and the firms in establishing a SP highlighting the benefits to regional economic growth. Combining the triple helix, IVC, and string-based approaches to the analysis has enabled this thesis to develop an enhanced understanding of SP ecosystems by highlighting the importance of placing projects within the context of firms and the IVC, and then placing firms within the context of the triple helix. Moreover, it shows the contributions of each actor in supporting SP innovation projects by linking the project level to the institutional level that is highlighted in the triple helix framework (**Figure 8.1**).

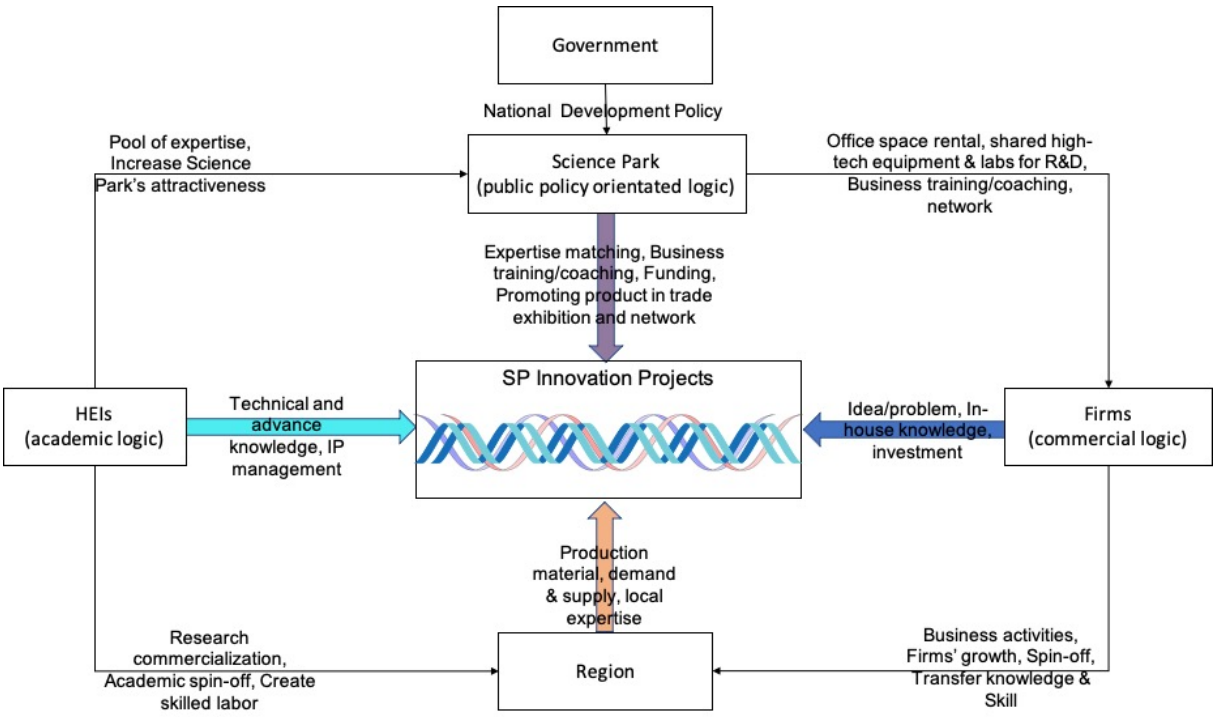


Figure 8.1 Relationship of SP, HEIs, firms, and the region supporting SP policy implementation at a project level.

A SP innovation system requires support from the government, HEIs, the private business sector, and the region. At the institutional level, the government implements the SP policy providing SP services to firms. The HEIs contribute to the SP by offering a pool of expertise and the reputation of the HEIs helps increase SP attractiveness. The region benefits from economic activities and knowledge transfer created by a SP. At the project level, an individual from each institution working collaboratively and provides different inputs that may be conceptualised by applying an IVC framework that highlights that an innovation project requires materials, local knowledge, and demand within the region. Individuals, including an entrepreneur, an academic, and a SP officer may act in relation to the institutional logic that reflects their institutional affiliation. Logics from different institutions are blended or braided together and influencing project outcomes.

Points to consider for policymakers

SP policy is a useful tool for implementing place-based innovation policy. However, some weaknesses must be considered.

1. *Making sure that a project's braid contains the right combination of strings.*

A project braid contains at least three key strings: the SP coordinator, academic, and entrepreneur. They have different logics and interests in participating in a SP innovation project. The vibration of some strings may create destructive interference and may need to be adjusted or a string removed/replaced to enhance successful outcomes. For example, the researcher who has a strong academic logic and directs the project toward academic achievement should be reminded that the goal of the SP project is product commercialisation. This means there should be more monitoring of projects to identify weaknesses early on and remove or replace partial strings or strings that create un-supportive vibrations within the braid. This could, for example, include the application of a 360-degree appraisal process of project partners involved in a braid to identify problems that result from tensions between different institutional logics that have been combined within a project braid.

2. *Managing the critical inputs required to support each project.*

In the context of Thailand, this thesis identified that initially the triple helix model was applied as a top-down management approach which treated every project/firm in the same manner. Thus, initially within emerging economy settings a learning process is required to appreciate that SP policy must be contextualized and this includes understanding the ways in which interventions must be customized to meet the needs of individual firms and their projects. This also suggests that there are capability deficiencies that could be partly overcome with training, for example, by training academics to appreciate the different challenges facing

innovation processes within the context of a private sector firm. Chapter Six highlighted that each project requires different inputs at each IVC stage, and the level of inputs was different from project-to-project. SP policy implication at the level of an individual SP needs to be agile to account for the diversity of projects and business needs. It is not a one-size-fits-all policy but requires considerable adjustment to meet each project's needs. The project may require regular intervention during the process or at the end of each IVC stage to identify and to make sure that the critical inputs that are required are in place.

3. The barriers obstructing the firm's innovativeness need to be identified and removed.

SPs' establishment in advanced and emerging economies was based on the same model, 'the triple helix'. However, the context of these two type of economy is very different (Cuervo-Cazurra and Wang, 2020). The emerging economies tend to be transitioning from agriculturally based economies with low technology levels. There is inconsistency in rules and regulations between different government agencies. The entrepreneurs lack access to funding and other types of business support. The implementation of SP policy in an emerging economy setting occurs at a slow pace as universities and private sectors interests are engaging in a transition process. There are barriers that exists elsewhere within the governance structures that supports, or otherwise, innovation in Thailand. Possible solutions rely mainly upon the ability of national policymakers to amend rules and regulations enhancing consistency of the wider framework conditions that support economic activity, providing clear strategies to practitioners and private businesses, and considering supporting schemes that reflect the needs of firms and by persuading academics to participate in SP projects. For example, the government should offer a fast-track service for issuing FDA certificates for products that emerge as outcomes of a SP innovation projects. Cooperation from related authorities is

required to diminish barriers. Moreover, regional innovation policies must be developed and applied over a long time period and this requires cross-party agreement to ensure policy continuity over the electoral cycle (Albahari *et al.*, 2018).

8.4 Limitations and recommendation for future research

This research was undertaken to understand the implementation of SP policy in emerging economies by undertaking a comparative analysis of innovation projects in the context of one RSP in Thailand. This research needs to be replicated in other emerging and even developed market economy settings. This includes applying a string-informed approach in other settings. In an ideal world, the application of participant observation research techniques should be applied to follow a number of SP innovation projects. This type of method would enable further elucidation of the relationship between logics and project outcomes and the processes by which project-based braids are formed.

The application of the string-based approach in other SPs and other firm-level processes

The string-based approach emerged in this study to complement the triple helix model to explore the implementation of SP policy implementation with a focus on shifting the analysis from a macro to micro-level. A triple helix-IVC-string approach has been developed in this thesis for the very first time. This approach, like all conceptual framing, is intended to enhance understanding, but it will be criticised. One criticism might be the need to develop a new approach to understanding a well-researched innovation process. Nonetheless, the string-based approach adds new dimensions to understanding the form of innovation projects in SPs and introduces further conceptual complexity and illumination including braiding as a process involving a melding together of competing and distinct logics. Further research is required in

terms of empirical analysis, theory testing and development that will apply, test, and refine the novel conceptual framework that has been developed in this thesis. This includes further research on understanding destructive and constructive interference. Furthermore, this string-based approach needs to be applied to other sectors in emerging and advanced economies.

This research was framed within the triple helix approach, and this was then further extended by the application of the IVC approach. Combining these two approaches led to the development of the more project-focussed string-based framework. There are many different and often unrelated debates on innovation and organisational learning. The network learning literature provides an additional approach to the IVC debate and adds a concern with intra- and inter-organisational learning that includes an appreciation of the role of boundary spanning processes. This is an important literature that requires further integration into the three conceptual frameworks explored in this study. Boundary spanning was identified as being important within both braids as a form of intra-project learning and between organisations reflecting inter-organisational learning. A braid provides a temporary organisational structure within which boundary spanning processes can develop and evolve whilst also enabling a braid to be embedded within a network of inter-braid and inter-firm organisational learning exchanges and sometimes more formal transactions.

Comparative analysis of SPs in some different emerging economy settings

This study also required secondary data published by the government of Thailand. Some regional and local level data was unavailable, missing, incomplete or outdated. There were differences and contradictions in the data provided by different authorities and this highlights one of the problems of researching in an emerging economy setting. I often had to contact public sector bodies to request additional information clarifications regarding the data's

credibility and reliability. Furthermore, Thailand is only one example of 38 emerging countries with an economy based on exporting goods and tourism. Thailand had a predominantly agriculturally orientated economy. The government is the primary driver behind setting, implementing, monitoring, and evaluating regional innovation policy. Like all emerging economies, like all economies, Thailand has a very distinct national context that reflects history, culture, economic structure, and governance. Given this, there is a need to replicate this study in other emerging economy settings.

8.5 Conclusion

The establishment of SPs has been a feature of place-based innovation policies across developed economies since the 1950s. The application of SP policy in different regional settings has been inspired by the theory of the triple helix. However, this theory presupposes a framework of well-established institutions - universities, venture capitalists, and high-tech businesses - that may still be in a formative stage in an emerging economy setting. Understanding innovation in emerging economies is utterly critical because one of the most important ways of meeting the sustainable development goals (SDGs) is by providing alternative approaches to wealth creation and this requires contextualized innovation to develop appropriate solutions. These alternative approaches must be contextualized within the context of each emerging economy setting. There have been attempts to transfer SP policy formulated in developed countries to emerging economy settings. However, the context of emerging economies has more barriers than developed market economies creating difficulties in encouraging innovation and one consequence may be limited or perverse outcomes. Thus, innovation approaches that have emerged from developed market economies must only be

applied to emerging economy settings with considerable care and sensitivity. Context matter and this is especially the case for innovation processes.

This thesis suggests that the application of a triple helix informed SP analysis is relevant to developed economies but has less validity within emerging economy settings where the components of the triple helix are not yet fully established. Only applying a triple helix-based approach highlights limitations and restrictions within the institutional environment existing in emerging countries that obstruct the innovation process. These limitations include access to limited resources for entrepreneur development, the inconsistency of supporting policies, and an underdeveloped or weak HEI structure. These challenges are too complex to overcome without having long-term strategies and implementing the reconstruction at a national level. Alternatively, one can develop and apply a small steps approach to enhance innovation by, perhaps, focusing on what and how innovation projects are being developed within an emerging economy setting focusing on the local context to formulate policies to meet local needs. This means that extremely complex or sophisticated policies that attempt to replicate developed market economies initiatives may be less effective compared to more modest policy interventions based around an appreciation of local conditions and needs.

Regional innovation policy development needs a series of tools that are designed to supplement the triple helix approach, and which are based on understanding the conditions that support successful innovation in specific collaborative projects. The IVC approach provides one way to conceptualise firm-level innovation highlighting the critical inputs required for an innovation project and the relationship created between project team members and the ways in which these influence project the outcomes. The triple helix and IVC approaches, then, supplement one another and then this requires an additional or more granular approach. This additional approach is the string-based approach that has been developed in this thesis from an

analysis of innovation projects within an emerging economy setting. The string approach is a project-based approach. This granularity of this approach appreciates differences in the combinations of expertise that are braided together within SP innovation projects. Within this braiding process, there are challenges in balancing institutional logics and releasing tensions between team members. This string-informed approach to exploring firm-level innovation processes highlights the importance of appreciating conflicts between the institutional logics that are combined within a braid. The outcome of this new approach leads to the identification of a new policy pathway that is required in emerging economy settings to overcome some of the barriers to firm-level innovation. Developing local policy solutions to overcome some of the project barriers and difficulties that have been identified in this thesis would go some way towards developing solutions that might contribute to meeting the SDG goals.

Central to this thesis is the alignment of three scales that are involved in regional innovation processes. These scales were introduced in Chapter One as consisting of the micro or project-level, meso or firm-level, and macro or institutional-level. The triple helix approach in emerging economies is focused on the macro or more institutional level while the IVC approach is more of a firm-level or meso scale approach. This thesis has highlighted the importance of developing and applying a project-level, or micro level approach, to understanding firm-level innovation. This approach has led to the development of a new and novel string-informed approach to understanding micro-level inter- and intra-firm innovation processes that support project-based innovation. This approach has emerged from a theoretically-informed analysis of an emerging economy setting – Thailand. This research did not commence with an ambition to develop new theory, but rather the focus was on understanding the implementation and impacts of the development of SP policy in Thailand. Initially, the triple helix approach was applied as a core conceptual framework. Nevertheless,

limitations were identified with the application of this approach to Thailand, and these were initially overcome by adding an IVC layer to the triple helix. Subsequently, the need for a more project-level conceptual framework emerged as the analysis of projects unfolded. This led to the string-informed analysis. This string-informed analysis needs further development and testing in other regional and national contexts. This development also includes the need for methodological innovation to support the measurement and identification of vibrations in strings linked to different forms of institutional logics. The expectation is that this approach would have explanatory power in other settings, including developed market economies. Thus, further research is required that would apply the conceptual approach that has been developed in Thailand to, for example, the Cambridge Science Park phenomenon or even to Silicon Valley.

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APPENDIX

Appendix A: Questions for the directors of science parks

1. How the SP policy supports the national and regional development policy? What is the main R&D strategy for the region in which this SP is located? How much (in %) that the national budget was put into the SP development?
2. What are the changes SP made to the firms? Please describe. (i.e., cost per unit, revenue and profit, growth of a business, business expansion, employee's skill)
3. Are there any key industries that exist in the region? What are those?
4. Is there any industrial agglomeration in the region? If yes, please describe. (before or after the SP establishment, which industry, is it full value chain from production to commercialisation, do they engage with the SP)
5. How the SP strategy supports the performance of existed and newly emerged industries in the region?
6. How has your SP improved the local economy? (i.e., economic growth rate, employment rate, local revenue rate, …)
7. In your opinion, which one of the four SPs is the most success? How?

Appendix B: Questions for the director of NSP

1. How the SP policy supports the national and regional development policy? What is the main R&D strategy for the region in which this SP is located? How much (in %) that the national budget was put to the SP development?
2. What are the sectors of activities of participant companies? (i.e., consultancy, biotechnology, manufacturing, services, ICT and related, others)
3. What are the changes SP made to the firms? Please describe. (i.e., cost per unit, revenue and profit, growth of business, business expansion, employee's skill)
4. Are there any key industries exist in the region? What are those?
5. Is there any industrial agglomeration in the region? If yes, please describe. (before or after the SP establishment, which industry, is it full value chain from production to commercialisation, do they engage with the SP)
6. How the SP strategy supports the performance of existed and newly emerged industries in the region?

Appendix C: Questions for the managers of NSP network universities

1. Please tell me about the university. (i.e., which departments that engage with SP, expertise in any specific technology, number of researchers in total, number of researchers who has been working with the firms in the SP program and privately and how many projects from how many firms)
2. How the SP policy effects to the university's policy?
3. Please describe the work with private business prior to and after the establishment of SP. (comparing the no. of projects, no. of spin-off, no. of licensing agreement, how does the university match with the firms, where do they work, type of business, what technology).
4. What formal agreements exist between SP, university, and business? Please give example. How the benefit (financial) from IP licensing be generated?
5. Does the university strategy support the growth of existing industries and new business in the region? What kind of product categories and technology required by them?
6. Is there any economic activity or key industries particularly important in the area (nearest city or region)? If yes, how has it impacted the university R&D strategy?
7. Is there any industrial agglomeration in the region? Since when? If yes, please describe. (which industry, is it full value chain from production to commercialisation, does it involve with local businesses)

Appendix D: Questions for the owners of the businesses attended the NSP program(s)

1. Please tell me briefly about the company (i.e., years of establishment, number of employees, product category, core technology, R&D expenditure, annual turnover, number of patents, average educational level of the employees and where are they from, level of business: local/ nationwide/ international, who is the main competitor)
2. How do you get involve with the Northern SP? (which program, for how long) What are the important factors that made you decided to attend the SP program(s)?
3. Please tell me more about the project that you have been involved with the SP and the university researcher.
4. How the firm's performance improves after joining the SP? Please explain comparing prior to and after join with SP. (i.e., profit, cost per unit, employee's skill, new technology learning, business expansion) Is this as what you expect?
5. What formal agreements exist between the company, the park, and universities or other research institutes? Please give some examples.
6. Are there any clustering activities in in this area? Are they relate to your industry? When does it start? Please describe. (Which industry? How many companies in the cluster? Is it full value chain from production to commercialisation? Does it involve with local businesses?)
7. Is your business part of the cluster? Where are you in the value chain? Please explain the flow of your key product. Start from where you get the raw material.
8. How the SP strategy supports the performance of the cluster development?
9. How would you describe your contribution to the local community in term of economic development?

Appendix E: Questions for university researchers who work with the private businesses under the NSP projects.

1. Please tell about yourself. (i.e., name, position in the university, how long have you been in the positions, what is your expertise?)
2. Please tell me about the work with private sector prior to the establishment of SP. What are the problem you experienced?
3. Please tell me about the project …… (under SP program) How you get involve? What's it about? What are the problem you experienced? Are they part of the key industries in this area? Where are they in the value chain? How about their improvement?
4. Is there any cooperation or exchange of knowledge among the researchers themselves and between the researchers and the firms' R&D department?
5. Are there any academic spin-off occur? Before or after SP establishment? How many? What are the products/ services? Which technology they use? Do you have any plan to create your own business? (if yes, please explain briefly) (if no, what's the obstacle/ why not)
6. Does that cooperation between university, business, and SP support the growth of new industries/ businesses in the region? What kind of business/ product/ technology?
7. Do you volunteer to do the firm's R&D or assigned by the university? What formal agreements exist between you, the firm, and SP? Please give example. What is the benefit you get from the SP programs (in doing the firm's R&D)? Do you get extra payment? From whom? How they benefit from IP be generated?

Appendix F: Questions for the directors of science parks (TH)

คำถามสำหรับการสัมภาษณ์ - ผู้อำนวยการอุทยานวิทยาศาสตร์

1. ความเป็นมาของการจัดตั้งอุทยานฯ คร่าว ๆ ความสัมพันธ์ระหว่างอุทยานฯ และมหาวิทยาลัยมีบทบาทอย่างไรในการกระตุ้นการพัฒนาอุตสาหกรรมในท้องถิ่น
2. นโยบายของอุทยานวิทยาศาสตร์มีส่วนสนับสนุนนโยบายการพัฒนาระดับชาติและระดับภูมิภาคอย่างไร อะไรคือกลยุทธ์หลักในการวิจัยและพัฒนาสำหรับภูมิภาคที่อุทยานฯ นี้ตั้งอยู่ งบประมาณที่ถูกนำมาพัฒนาอุทยานฯ แห่งนี้คิดเป็นร้อยละเท่าไรของงบประมาณทั้งหมดที่ได้มีการจัดสรรให้อุทยานฯ ทุกแห่ง
3. อุทยานฯ มีส่วนในการพัฒนาของบริษัทที่เข้าร่วมโครงการอย่างไรบ้าง กรุณาอธิบาย (เช่น ต้นทุนต่อหน่วย รายได้และกำไร การเติบโตและการขยายธุรกิจ และการพัฒนาทักษะของพนักงาน)
4. มีอุตสาหกรรมหลัก ๆ อยู่ในภูมิภาคนี้หรือไม่ อุตสาหกรรมใดบ้าง
5. มีการรวมตัวทางอุตสาหกรรมเกิดขึ้นในภูมิภาคหรือไม่ หากมีโปรดอธิบาย (ก่อนหรือหลังการจัดตั้งอุทยานฯ อุตสาหกรรมใด เป็นการรวมตัวเต็มรูปแบบห่วงโซ่คุณค่าตั้งแต่การผลิตไปจนถึงการนำออกจำหน่ายหรือไม่ การรวมกลุ่มอุตสาหกรรมที่เกิดขึ้นมีส่วนจากการดำเนินงานของอุทยานฯ หรือไม่)
6. ยุทธศาสตร์ของอุทยานฯ สนับสนุนการเติบโตของอุตสาหกรรมที่มีอยู่เดิมและที่เกิดขึ้นใหม่ในภูมิภาคอย่างไร
7. อุทยานฯ แห่งนี้มีส่วนร่วมในการกระตุ้นเศรษฐกิจในท้องถิ่นอย่างไร (เช่น การเพิ่มขึ้นของอัตราการเติบโตทางเศรษฐกิจ อัตราการจ้างงาน อัตรารายได้ในท้องถิ่น)
8. การดำเนินงานตามเป้าหมายของอุทยานฯ ประสบความสำเร็จคิดเป็นประมาณร้อยละเท่าไร (เทียบกับเป้าหมายที่ตั้งไว้)
9. ในความเห็นของท่าน อุทยานฯ แห่งใดประสบผลสำเร็จตามเป้าหมายมากที่สุด อย่างไร (เปรียบเทียบทั้งอุทยานวิทยาศาสตร์ภูมิภาคทั้งสามแห่งและอุทยานวิทยาศาสตร์ประเทศไทย)

Appendix G: Questions for the director of NSP (TH)

คำถามสำหรับการสัมภาษณ์ – ผู้อำนวยการอุทยานวิทยาศาสตร์ มหาวิทยาลัยเชียงใหม่

1. นโยบายของอุทยานวิทยาศาสตร์มีส่วนสนับสนุนนโยบายการพัฒนาระดับชาติและระดับภูมิภาคอย่างไร อะไรคือกลยุทธ์หลักในการวิจัยและพัฒนาสำหรับภูมิภาคที่อุทยานฯ นี้ตั้งอยู่ งบประมาณที่ถูกนำมาพัฒนาอุทยานฯ แห่งนี้คิดเป็นร้อยละเท่าไรของงบประมาณทั้งหมดที่ได้มีการจัดสรรให้อุทยานฯ ทุกแห่ง
2. อุทยานฯ มีส่วนในการพัฒนาของบริษัทที่เข้าร่วมโครงการอย่างไรบ้าง กรุณาอธิบาย (เช่น ต้นทุนต่อหน่วย รายได้และกำไร การเติบโตและการขยายธุรกิจ และการพัฒนาทักษะของพนักงาน)
3. มีอุตสาหกรรมหลัก ๆ อยู่ในภูมิภาคนี้หรือไม่ อุตสาหกรรมใดบ้าง
4. มีการรวมตัวทางอุตสาหกรรมเกิดขึ้นในภูมิภาคหรือไม่ หากมีโปรดอธิบาย (ก่อนหรือหลังการจัดตั้งอุทยานฯ อุตสาหกรรมใด เป็นการรวมตัวเต็มรูปแบบห่วงโซ่คุณค่าตั้งแต่การผลิตไปจนถึงการนำออกจำหน่ายหรือไม่ การรวมกลุ่มอุตสาหกรรมที่เกิดขึ้นมีส่วนจากการดำเนินงานของอุทยานฯ หรือไม่)
5. ยุทธศาสตร์ของอุทยานฯ สนับสนุนการเติบโตของอุตสาหกรรมที่มีอยู่เดิมและที่เกิดขึ้นใหม่ในภูมิภาคอย่างไร
6. อุทยานฯ แห่งนี้มีส่วนร่วมในการกระตุ้นเศรษฐกิจในท้องถิ่นอย่างไร (เช่น การเพิ่มขึ้นของอัตราการเติบโตทางเศรษฐกิจ อัตราการจ้างงาน อัตรารายได้ในท้องถิ่น)
7. ในความเห็นของท่าน อุทยานฯ แห่งใดประสบผลสำเร็จตามเป้าหมายมากที่สุด อย่างไร (เปรียบเทียบทั้งอุทยานวิทยาศาสตร์ภูมิภาคทั้งสามแห่งและอุทยานวิทยาศาสตร์ประเทศไทย)

<u>ในมุมของมหาวิทยาลัย</u>

1. กรุณาเล่าสั้น ๆ เกี่ยวกับมหาวิทยาลัยของท่าน (ก่อตั้งเมื่อปี มีกี่คณะ แผนกใดบ้างที่มีส่วนร่วมในการดำเนินงานอุทยานฯ ความเชี่ยวชาญด้านเทคโนโลยีเฉพาะใด ๆ จำนวนนักวิจัยทั้งหมดของมหาวิทยาลัย จำนวนนักวิจัยที่ทำงานร่วมกับบริษัทเอกชนในโครงการของอุทยานฯ กี่โครงการ กี่บริษัท จำนวนนักวิจัยที่ทำงานร่วมกับบริษัทเอกชนนอกโครงการของอุทยานฯ กี่โครงการ กี่บริษัท)
2. นโยบายของอุทยานฯ มีผลกระทบต่อนโยบายของมหาวิทยาลัยอย่างไรบ้าง
3. โปรดเล่าเปรียบเทียบถึงการทำงานกับภาคธุรกิจก่อนและหลังการจัดตั้งอุทยานฯ (จำนวนโครงการ จำนวนบริษัทที่เกิดขึ้นใหม่โดยนักวิจัยไปทำธุรกิจเอง จำนวนบริษัทใหม่ที่แตกออกจากบริษัทเดิม ข้อตกลงทางกฎหมายเรื่องการแบ่งผลประโยชน์และการอนุญาตให้ใช้สิทธิ์ มหาวิทยาลัยทำงานร่วมกับภาคธุรกิจอย่างไร ที่ไหน ประเภทธุรกิจ ประเภทเทคโนโลยี เป็นต้น)
4. ข้อตกลงอย่างเป็นทางการใดที่มีอยู่ระหว่างอุทยานฯ มหาวิทยาลัยและบริษัท มีการจัดสรรผลประโยชน์ (การเงิน) อย่างไร
5. นโยบายการวิจัยและพัฒนาของมหาวิทยาลัยสนับสนุนการเติบโตของอุตสาหกรรมที่มีอยู่เดิมและธุรกิจใหม่ ๆ ในภูมิภาคอย่างไร ประเภทของผลิตภัณฑ์และเทคโนโลยีใดที่เป็นที่ต้องการของภาคเอกชนในภูมิภาคนี้
6. ในการรวมกลุ่มทางธุรกิจในภูมิภาค มหาวิทยาลัยมีส่วนในการรวมกลุ่มอย่างไร และอยู่ส่วนใดของห่วงโซ่มูลค่า

Appendix H: Questions for the managers of NSP network universities (TH)

คำถามสำหรับการสัมภาษณ์ - ผู้แทนจากมหาวิทยาลัยเครือข่าย 6 แห่งของอุทยานวิทยาศาสตร์ภาคเหนือ

1. กรุณาเล่าสั้น ๆ เกี่ยวกับมหาวิทยาลัยของท่าน (ก่อตั้งเมื่อปี มีกี่คณะ แผนกใดบ้างที่มีส่วนร่วมในการดำเนินงานอุทยานฯ ความเชี่ยวชาญด้านเทคโนโลยีเฉพาะใด ๆ จำนวนนักวิจัยทั้งหมดของมหาวิทยาลัย จำนวนนักวิจัยที่ทำงานร่วมกับบริษัทเอกชนในโครงการของอุทยานฯ กี่โครงการ กี่บริษัท จำนวนนักวิจัยที่ทำงานร่วมกับบริษัทเอกชนนอกโครงการของอุทยานฯ กี่โครงการ กี่บริษัท)
2. นโยบายของอุทยานฯ มีผลกระทบต่อนโยบายของมหาวิทยาลัยอย่างไรบ้าง
3. โปรดเล่าเปรียบเทียบถึงการทำงานกับภาคธุรกิจก่อนและหลังการจัดตั้งอุทยานฯ (จำนวนโครงการ จำนวนบริษัทที่เกิดขึ้นใหม่โดยนักวิจัยไปทำธุรกิจเอง จำนวนบริษัทใหม่ที่แตกออกจากบริษัทเดิม ข้อตกลงทางกฎหมายเรื่องการแบ่งผลประโยชน์และการอนุญาตให้ใช้สิทธิ์ มหาวิทยาลัยทำงานร่วมกับภาคธุรกิจอย่างไรที่ไหน ประเภทธุรกิจ ประเภทเทคโนโลยี เป็นต้น)
4. ข้อตกลงอย่างเป็นทางการใดที่มีอยู่ระหว่างอุทยานฯ มหาวิทยาลัยและบริษัท มีการจัดสรรผลประโยชน์ (การเงิน) อย่างไร
5. นโยบายของมหาวิทยาลัยสนับสนุนการเติบโตของอุตสาหกรรมที่มีอยู่เดิมและธุรกิจใหม่ ๆ ในภูมิภาคอย่างไร ประเภทของผลิตภัณฑ์และเทคโนโลยีใดที่เป็นที่ต้องการของภาคเอกชนในภูมิภาคนี้
6. กิจกรรมทางเศรษฐกิจหรืออุตสาหกรรมหลักใดที่มีความสำคัญเป็นพิเศษในพื้นที่นี้ นโยบายการวิจัยและพัฒนาของมหาวิทยาลัยสนับสนุนการเติบโตของอุตสาหกรรมดังกล่าวอย่างไร
7. มีการรวมตัวทางอุตสาหกรรมเกิดขึ้นในภูมิภาคหรือไม่ ตั้งแต่เมื่อไหร่ (ก่อนหรือหลังการตั้งอุทยานฯ) โปรดอธิบาย (การรวมกลุ่มเกิดขึ้นในอุตสาหกรรมใด เป็นห่วงโซ่คุณค่าเต็มรูปแบบจากการผลิตไปสู่เชิงพาณิชย์หรือไม่ มีธุรกิจในท้องถิ่นอยู่ในการรวมกลุ่มด้วยหรือไม่ มหาวิทยาลัยมีส่วนในการรวมกลุ่มอย่างไร และอยู่ส่วนใดของห่วงโซ่มูลค่า)

Appendix I: Questions for the owners of the businesses attended the NSP program(s) (TH)

คำถามสำหรับการสัมภาษณ์ – ผู้ประกอบการ

1. โปรดกล่าวโดยสรุปเกี่ยวกับธุรกิจของท่าน (ได้แก่ ปีที่ก่อตั้ง จำนวนพนักงาน ประเภทผลิตภัณฑ์ เทคโนโลยีหลัก ค่าใช้จ่ายด้านการวิจัยและพัฒนาในแต่ละปี การเปลี่ยนแปลงจำนวนพนักงานในแต่ละปี จำนวนสิทธิบัตร ระดับการศึกษาโดยเฉลี่ยของพนักงาน ระดับของธุรกิจ เช่น ท้องถิ่น/ทั่วประเทศ/ระหว่างประเทศ ใครคือคู่แข่งหลัก)
2. ธุรกิจของท่านได้เข้ามามีส่วนร่วมกับอุทยานฯ อย่างไร (เข้าร่วมโปรแกรมไหน เป็นเวลานานเท่าไร) ปัจจัยสำคัญที่ทำให้คุณตัดสินใจเข้าร่วมโครงการของอุทยานฯ คืออะไร
3. กรุณาบอกรายละเอียดเพิ่มเติมเกี่ยวกับโครงการที่คุณพัฒนาร่วมกับอุทยานฯ รวมถึงนักวิจัยที่ร่วมดำเนินการ (ผู้วิจัยจะติดต่อนักวิจัยท่านนี้ภายหลังเพื่อสัมภาษณ์เพิ่มเติมในมุมมองของนักวิจัย)
4. กรุณาประเมินผลการดำเนินงานของธุรกิจภายหลังการร่วมมือกับอุทยานฯ โปรดอธิบายเปรียบเทียบก่อนและหลังการเข้าร่วมโครงการ (ในแง่ของกำไร ต้นทุนต่อหน่วย ทักษะความสามารถของพนักงาน การเรียนรู้เทคโนโลยีใหม่ การเติบโตของธุรกิจ) การเปลี่ยนแปลงเหล่านี้เป็นไปตามความคาดหวังหรือไม่
5. มีข้อตกลงอย่างเป็นทางการใดบ้างระหว่างธุรกิจ อุทยานฯ และมหาวิทยาลัย/สถาบันวิจัยในเครือข่าย (เช่น การจัดสรรผลประโยชน์ที่เกิดขึ้น)
6. มีการรวมกลุ่มอุตสาหกรรม (industrial cluster) เกิดขึ้นในภูมิภาคหรือไม่ เกี่ยวข้องกับธุรกิจของท่านหรือไม่ การรวมกลุ่มเกิดขึ้นตั้งแต่เมื่อไร กรุณาอธิบาย (การรวมกลุ่มเกิดขึ้นในอุตสาหกรรมใดบ้าง มีกี่บริษัทใน cluster เป็นการรวมกลุ่มเต็มรูปแบบห่วงโซ่มูลค่า (value chain) ตั้งแต่การผลิตไปจนถึงการนำออกจำหน่ายหรือไม่ มีธุรกิจในท้องถิ่นเกี่ยวข้องกับการรวมกลุ่มดังกล่าวด้วยหรือไม่)
7. ธุรกิจของท่านเป็นส่วนหนึ่งของการวมกลุ่มหรือไม่ และอยู่ในตำแหน่งใดของห่วงโซ่มูลค่า (เช่น ในส่วนของการผลิต การขนส่งวัตถุดิบ การแปรรูป การโฆษณา การบรรจุ การจัดจำหน่าย เป็นต้น) โปรดอธิบายขั้นตอนการดำเนินธุรกิจตั้งแต่การผลิต/การจัดหาวัตถุดิบเพื่อการผลิต จนถึงการจัดจำหน่าย (โปรดแจกแจงผู้ขาย ผู้รับซื้อ ผู้ให้บริการในกระบวนการดังกล่าว)
8. การดำเนินงานของอุทยานฯ มีส่วนสนับสนุนการพัฒนาการรวมกลุ่มอุตสาหกรรมดังกล่าวอย่างไรบ้าง
9. ธุรกิจของท่านได้มีส่วนร่วมในการพัฒนาเศรษฐกิจในระดับภูมิภาคอย่างไรบ้าง

Appendix J: Questions for the university researchers who work with the private businesses under the NSP projects (TH)

คำถามสำหรับการสัมภาษณ์ – นักวิจัยที่ร่วมงานกับบริษัทภายใต้โครงการของอุทยานวิทยาศาสตร์ภาคเหนือ

1. โปรดเล่าเกี่ยวกับการทำงานร่วมกับภาคเอกชนก่อนการจัดตั้งอุทยานฯ ในการทำงานร่วมกันมีปัญหาใดบ้าง
2. โปรดพูดถึงการทำงานร่วมกับบริษัท.....ในโครงการ ..... ภายใต้อุทยานฯ ท่านมีส่วนร่วมในโครงการดังกล่าวอย่างไร โปรดอธิบายเกี่ยวกับโครงการอย่างคร่าว ๆ ปัญหาที่พบระหว่างการดำเนินโครงการ ผลิตภัณฑ์ที่พัฒนาและบริษัทเป็นส่วนหนึ่งของอุตสาหกรรมหลักที่สำคัญในภูมิภาคนี้หรือไม่ อยู่จุดไหนในห่วงโซ่คุณค่า (นับตั้งแต่การผลิตวัตถุดิบจนถึงการนำสินค้าออกจำหน่ายสู่ผู้บริโภครายย่อย) บริษัทมีการพัฒนาอย่างไรภายหลังการเข้าร่วมโครงการกับอุทยานฯ
3. มีความร่วมมือหรือการแลกเปลี่ยนความรู้ในกลุ่มนักวิจัยของมหาวิทยาลัยในเครือข่าย และ/หรือระหว่างนักวิจัยของรัฐกับฝ่ายวิจัยและพัฒนาของบริษัทเกิดขึ้นหรือไม่ อย่างไร โปรดยกตัวอย่างโดยอ้างอิงถึงโครงการข้างต้น
4. มีนักวิจัยจากมหาวิทยาลัยออกไปทำธุรกิจเองหรือไม่ ก่อนและหลังการจัดตั้งอุทยานฯ มีมากน้อยต่างกันอย่างไร ผลิตภัณฑ์หรือบริการหลักโดยมากคืออะไร ใช้เทคโนโลยีอะไร และท่านมีแผนจะตั้งธุรกิจของตัวเองด้วยหรือไม่ (ถ้ามีโปรดอธิบายสั้น ๆ) (ถ้าไม่มี อุปสรรคใดที่ยับยั้งท่านจากการตั้งธุรกิจของตนเอง)
5. ความร่วมมือระหว่างมหาวิทยาลัย ภาคธุรกิจและอุทยานฯ มีส่วนสนับสนุนการเติบโตของอุตสาหกรรม/ธุรกิจใหม่ในภูมิภาคอย่างไร เป็นธุรกิจในกลุ่มใด สินค้าอะไร ใช้เทคโนโลยีใดในขั้นตอนการพัฒนา
6. ท่านสมัครใจที่จะร่วมทำการวิจัยและพัฒนากับบริษัทด้วยตนเอง หรือได้รับมอบหมายจากทางมหาวิทยาลัย มีข้อตกลงอย่างเป็นทางการใดระหว่างท่าน บริษัทและอุทยานฯ โปรดอธิบาย (เช่น ประโยชน์ที่ได้รับจากการร่วมโครงการกับอุทยานฯ ในการพัฒนาผลิตภัณฑ์ร่วมกับเอกชนคืออะไร ท่านได้รับผลตอบแทนใดเพิ่มขึ้นหรือไม่ (ทั้งในรูปตัวเงินและในรูปแบบอื่น) ใครเป็นผู้สนับสนุนค่าใช้จ่ายที่เกิดขึ้นจากการวิจัยและพัฒนาร่วมกับเอกชนภายใต้โครงการของอุทยานฯ มีการจัดสรรผลประโยชน์ที่เกิดขึ้นอย่างไร (เช่น ผลกำไรที่เพิ่มขึ้นของบริษัท การจดลิขสิทธิ์ สิทธิบัตร)

Appendix K: Recruitment letter

Participant Recruitment Letter

Dear…

My name is Miss Muttamas Wongwanich (Ning). I am a PhD researcher at the University of Birmingham. I was funded by the Ministry of Science and Technology to conduct the research about the regional Science Park and its impact to the local economic development. Due to the data availability and the readiness of all components, I decided to pinpoint my study to the Northern Science Park and its contribution to the regional economy.

The project requires gathering information from major stakeholders include the Northern Science Park, the network universities, and the business sector. According to your significant engagement with the Science Park and your contribution to the regional economic activities, I would like to ask for your participation in this research.

The topic of the interview is mainly about the role of your organisation and its contribution to the regional economy under the cooperation with the Thailand Northern Science Park. The interview should last no longer than one hour, and it will be done according to your convenience time.

In this email, I also attach the participant information sheet, the consent form, and a list of questions for your consideration. Please find out more detail about the project in the participant information sheet. If you agree to participate in this study, please email me the signed consent form and suggest when would be your convenience time(s) for an interview.

Your cooperation will help us develop the policy of the regional Science Park that will benefit to all relevant stakeholders, and finally benefit to the overall economy of Thailand.

I am looking forward to hear from you.

Muttamas Wongwanich (Ning)

[redacted]

Email: [redacted]

Appendix L: Example of recruitment letter (TH)

ที่ วท ๐๒๑๔ /ว๒๓๘

กระทรวงวิทยาศาสตร์และเทคโนโลยี
ถ.พระรามที่ ๖ เขตราชเทวี กทม. ๑๐๔๐๐

๒๘ กันยายน ๒๕๖๑

เรื่อง ขอความอนุเคราะห์ให้สัมภาษณ์และประสานผู้เกี่ยวข้องเพื่อการรวบรวมข้อมูลทำวิจัยปริญญาเอก

เรียน ผู้อำนวยการอุทยานวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยเชียงใหม่

สิ่งที่ส่งมาด้วย ๑. ข้อมูลสำหรับผู้เข้าร่วมโครงการวิจัยพร้อมแบบแสดงความยินยอม
๒. ชุดตัวอย่างคำถามสำหรับการสัมภาษณ์ผู้อำนวยการอุทยานวิทยาศาสตร์ภาคเหนือ
๓. รายชื่อผู้ประกอบการ

ด้วย นางสาวมุทธมาศ วงค์วานิช นักวิเคราะห์นโยบายและแผนปฏิบัติการ สำนักงานปลัดกระทรวงวิทยาศาสตร์และเทคโนโลยี ได้รับทุนรัฐบาลที่จัดสรรให้กระทรวงวิทยาศาสตร์และเทคโนโลยี เพื่อศึกษาในสาขาวิชานโยบายและการจัดการวิทยาศาสตร์ เทคโนโลยีและนวัตกรรม เน้น Cluster Development ตามความต้องการของสำนักงานเลขานุการคณะกรรมการส่งเสริมกิจการอุทยานวิทยาศาสตร์ และอยู่ระหว่างการทำวิจัยระดับปริญญาเอก ณ University of Birmingham ในหัวข้อการดำเนินงานอุทยานวิทยาศาสตร์ภาคเหนือกับการพัฒนาเศรษฐกิจในระดับภูมิภาค ซึ่งจะศึกษาการเติบโตของเศรษฐกิจภูมิภาคและการรวมกลุ่มอุตสาหกรรมที่เกิดขึ้นเปรียบเทียบก่อนและหลังการจัดตั้งอุทยานวิทยาศาสตร์ภาคเหนือ ในการนี้ นางสาวมุทธมาศ วงค์วานิช จึงประสงค์รวบรวมข้อมูลเชิงลึกโดยการสัมภาษณ์ผู้มีส่วนเกี่ยวข้องกับการดำเนินงานของอุทยานวิทยาศาสตร์ภาคเหนือ ได้แก่ ผู้อำนวยการอุทยานวิทยาศาสตร์ภาคเหนือ ผู้บริหารอุทยานวิทยาศาสตร์มหาวิทยาลัยเครือข่ายอุทยานวิทยาศาสตร์ภาคเหนือ ผู้ประกอบการและนักวิจัยที่เข้าร่วมโครงการ

สำนักงานปลัดกระทรวงวิทยาศาสตร์และเทคโนโลยี จึงขอความอนุเคราะห์ผู้อำนวยการอุทยานวิทยาศาสตร์ภาคเหนือให้สัมภาษณ์และประสานผู้ประกอบการตามรายชื่อ (สิ่งที่ส่งมาด้วย ๓) เพื่อให้สัมภาษณ์ในประเด็นดังกล่าว โดยได้แนบข้อมูลสำหรับผู้ให้สัมภาษณ์พร้อมส่วนแสดงความยินยอมและตัวอย่างคำถามรายละเอียดปรากฏตามสิ่งที่ส่งมาด้วย ๑ และ ๒

จึงเรียนมาเพื่อโปรดพิจารณา และขอได้โปรดประสานผู้ให้สัมภาษณ์ส่งส่วนแสดงความยินยอมที่ลงนามแล้วมาที่ MXW795@student.bham.ac.uk หรือ muttamas@hotmail.com พร้อมแจ้งวันและเวลาในเดือนพฤศจิกายน ๒๕๖๑ ที่สะดวกให้สัมภาษณ์เพื่อทำการนัดหมายในรายละเอียดต่อไป จะขอบคุณยิ่ง

ขอแสดงความนับถือ

[redacted]

(รองศาสตราจารย์สรนิต ศิลธรรม)
ปลัดกระทรวงวิทยาศาสตร์และเทคโนโลยี

สำนักงานปลัดกระทรวง
สำนักงานเลขานุการคณะกรรมการส่งเสริมกิจการอุทยานวิทยาศาสตร์
โทรศัพท์ ๐ ๒๓๓๓ ๓๙๔๒
โทรสาร ๐ ๒๓๓๓ ๓๗๐๐ ต่อ ๔๐๕๖

Appendix M: Consent form

Consent Form

Project: Science Park and Impact to Regional Economic Development in Thailand

By signing this consent form. You acknowledge that you have read and understand the participant information sheet and have been clearly responses to your inquiries about this research study.

You agreed to participate in this study and understand that you may withdraw from this study at any time within three months after the interview without giving any reason. There will have no effect on your future cooperation with any of the Thailand Science Parks, nor with the Thailand Science Park Promotion Agency, Ministry of Science and Technology. Your data will be omitted from the study and will be destroyed.

You understand that your personal data will be processed for the purposes of this research only. You agree for the interview to be recorded and the information recorded will be transcribed, and names of individuals and companies will be removed.

You agree that the researcher may request your further engagement (i.e., request for additional information) in regard to the study after the interview. In that occasion, the contact will be done via electronic mail.

You understand that you will receive a copy of the executive summary of the study once the research has been done completely.

By signing this, you do not waive any legal rights.

Participant signature……..……..

Name of participant…….……

Date…….……

Researcher signature……..……..

Name of researcher…….……

Date…….……

Witness signature……..……..

Name of witness….…….……

Date…….……

Appendix N: Participant information sheet

Participant Information Sheet

Project title: Science Park and Impact to Regional Economic Development in Thailand

Science Park has been developed in Thailand for about 30 years as its important in stimulating the growth of the economy through innovation. The objectives of Science Park establishment are to increase firms' innovativeness, create jobs, and to increase economic growth by promoting the collaboration between the university and the high technology-based firms.
This research will explore the influences of the Thailand Northern Science Park on the industrial cluster development at regional level. The result should show that after the establishment of the Science Park, the regional economy has been actively increasing compare to before the Science Park establishment. The finding will be used as a guide in developing suitable policy for regional Science Parks in Thailand in order to support the country's objective in developing the eco-system for integration of technology and innovation policy, support the technology-based SMEs, create job to the local. Further, to stimulate the regional economic growth and increasing the country's competitiveness.

Aims:
To explore and describe the impact of the Thailand Northern Science Park to industrial cluster development at the regional level.

Research Objectives:
The study includes in-depth interview to the director of the Thailand Northern Science Park, the network universities, the researchers, and the business owners those involve with Science Park's operation. The result of the study will be applied to develop a proper Science Park policy in order to maximise the economic activities and increase the country's competitiveness.

Invitation to participate and explanation of what participation entails:
You are invited to participate in this study due to the significant role involved with the operation of the Thailand Northern Science Park and your contribution to the regional economy. Participation is entirely voluntary, and you are also free to withdraw from the research at any time prior to the end of the data collection process, or within 3 months after completing the interview, without providing any reason.
By participating, you will agree to be interviewed in regard to the position you are enrol and involve with the Thailand Northern Science Park. The interview will last about one hour. The content of the interviews will not be shared with other participants. The verbal interview will be recorded to ensure the accuracy of data and mitigate for any misrepresentation.
A summary of the interview will be provided to you in order to modify any inaccuracy of the interpretation. In case of any modification requires, the researcher will amend the interpreted

record according to your comments. However, full editorial control of the research result remains with the researcher.
The Science Park policy and its operation is a very important area that requires academic research for further understanding of the organisation's contribution to the development of industrial cluster and regional economy. According to this, I would be appreciated for your participation. If you require further clarification, please contact the researcher prior to participating.

Confidentiality/anonymity and data security:
The researcher will keep your information confidential in accordance with international ethical and legal standards. Access to the data will be restricted to the researcher. Both electronic and hard copies will be stored securely, through password protection and encrypted. Data will be stored at the University of Birmingham provided Research Data Store (RDS) and at the Thailand Science Park Promotion Agency (SPA), Ministry of Science and Technology. Access to the RDS is restricted to project members. Access to the SPA's database is restricted to the researcher and the assigned officer under the approval and supervision of SPA director. Your record will not be named. The code is linked to the names and only to be known by research members. Personal information that you do not wish to disclose will be collected and used for research purposes. Backup copies of data are taken on a daily basis, and data is stored in separate buildings from the live data. All data collected in hard copy will be destroyed after five years of research publishing.

Results of the study:
Participants will be sent a copy of the executive summary of the study once completed.
The results of the study will be used to develop a PhD thesis and to use for developing the Thailand regional Science Park policy to encourage the growth of the regional economy through innovation. The report will be published as part of the government report.

Funding of research:
This research is fully funded by the Royal Thai government.
This research project is under the supervision of Professor John Bryson, Dr Catherine Harris, and Mr. Christopher Collinge, University of Birmingham, UK.

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Appendix O: Participant information sheet and consent form (TH)

ข้อมูลสำหรับผู้เข้าร่วมโครงการวิจัย

ชื่อโครงการ: การดำเนินงานอุทยานวิทยาศาสตร์ภาคเหนือกับการพัฒนาเศรษฐกิจในระดับภูมิภาค

ประเทศไทยได้มีการพัฒนาอุทยานวิทยาศาสตร์มาเป็นเวลากว่า 30 ปี เพื่อทำหน้าที่เป็นกลไกกระตุ้นการเติบโตทางเศรษฐกิจด้วยนวัตกรรม การจัดตั้งอุทยานวิทยาศาสตร์ในประเทศไทยมีวัตถุประสงค์เพื่อกระตุ้นการสรรสร้างนวัตกรรม เพิ่มการจ้างงานและขับดันการเติบโตทางเศรษฐกิจผ่านการส่งเสริมความร่วมมือทางการวิจัยระหว่างมหาวิทยาลัยกับผู้ประกอบการธุรกิจที่ใช้เทคโนโลยีชั้นสูง
งานวิจัยนี้จะศึกษาผลกระทบของการดำเนินงานอุทยานวิทยาศาสตร์ภาคเหนือต่อการพัฒนาการรวมกลุ่มอุตสาหกรรมในระดับภูมิภาค ผลการวิจัยควรแสดงการเติบโตของเศรษฐกิจภูมิภาคและการรวมกลุ่มอุตสาหกรรมที่เกิดขึ้นภายหลังการจัดตั้งอุทยานวิทยาศาสตร์ภาคเหนือ งานวิจัยชิ้นนี้จะถูกนำไปประยุกต์ใช้เป็นแนวทางพัฒนานโยบายที่เหมาะสมเพื่อพัฒนาอุทยานวิทยาศาสตร์ภูมิภาค เพื่อสนับสนุนเป้าหมายของประเทศในการพัฒนาระบบนิเวศน์นวัตกรรมตามนโยบายการพัฒนาวิทยาศาสตร์ เทคโนโลยีและนวัตกรรม การส่งเสริมผู้ประกอบการรายย่อยในธุรกิจด้านเทคโนโลยี การสร้างงานในท้องถิ่น และนอกจากนี้ เพื่อกระตุ้นการเติบโตทางเศรษฐกิจของภูมิภาคและเพิ่มขีดความสามารถทางการแข่งขันของประเทศ

เป้าหมายของการวิจัย:
เพื่อศึกษาและอธิบายถึงผลกระทบของอุทยานวิทยาศาสตร์ภาคเหนือต่อการพัฒนาการรวมกลุ่มอุตสาหกรรมในระดับภูมิภาค

วัตถุประสงค์ของการวิจัย:
การศึกษาประกอบด้วยการสัมภาษณ์เชิงลึกกับผู้มีส่วนเกี่ยวข้องหลักในการดำเนินงานอุทยานวิทยาศาสตร์ภาคเหนือ ได้แก่ ผู้อำนวยการอุทยานวิทยาศาสตร์ภาคเหนือ ผู้อำนวยการหรือผู้แทนจากมหาวิทยาลัยเครือข่าย นักวิจัยและผู้แทนจากภาคธุรกิจที่เข้าร่วมโครงการของอุทยานฯ การสัมภาษณ์ยังรวมถึงผู้อำนวยการอุทยานวิทยาศาสตร์ภูมิภาคอื่น ๆ และอุทยานวิทยาศาสตร์ประเทศไทยอีกด้วย ผลการวิจัยจะถูกนำมาประยุกต์ใช้ในการพัฒนานโยบายอุทยานวิทยาศาสตร์ภูมิภาคเพื่อกระตุ้มการเติบโตทางเศรษฐกิจและเพิ่มขีดความสามารถในการแข่งขันของภูมิภาคและของประเทศ

คำเชิญและคำอธิบายการเข้าร่วม:
ท่านได้รับเชิญให้เข้าร่วมในการศึกษานี้โดยพิจารณาจากบทบาทที่เกี่ยวข้องกับการดำเนินงานอุทยานวิทยาศาสตร์ภาคเหนือและการมีส่วนร่วมในการกระตุ้นเศรษฐกิจภูมิภาค การเข้าร่วมเป็นไปโดยสมัครใจ ท่านสามารถถอนตัวจากงานวิจัยได้ทุกเมื่อ ก่อนสิ้นสุดกระบวนการเก็บรวบรวมข้อมูลหรือภายใน 3 (สาม) เดือนหลังจากเสร็จสิ้นการให้สัมภาษณ์ ทั้งนี้ โดยไม่ต้องให้เหตุผลใด ๆ

ในการเข้าร่วม ท่านยอมรับที่จะให้สัมภาษณ์ในเนื้อหาที่เกี่ยวข้องกับบทบาทของท่านต่ออุทยานวิทยาศาสตร์และการพัฒนาเศรษฐกิจภูมิภาค การสัมภาษณ์จะใช้เวลาประมาณหนึ่งชั่วโมง เนื้อหาของบทสัมภาษณ์จะไม่ถูกเผยแพร่กับผู้เข้าร่วมท่านอื่น ๆ การสัมภาษณ์ด้วยวาจาจะถูกบันทึกเพื่อความถูกต้องแม่นยำของข้อมูล ท่านจะได้รับบทสัมภาษณ์โดยสรุปเพื่อพิจารณาแก้ไขความคลาดเคลื่อนของการบันทึก/ตีความ ในกรณีที่จำเป็นต้องมีการแก้ไขผู้วิจัยจะแก้ไขถ้อยคำตามความเห็นของท่าน ทั้งนี้ การปรับปรุงแก้ไขผลการศึกษาขึ้นอยู่กับดุลพินิจของผู้วิจัย

นโยบายและการดำเนินงานอุทยานวิทยาศาสตร์เป็นส่วนสำคัญซึ่งจำเป็นต้องมีการศึกษาทางวิชาการเพื่อทำความเข้าใจเพิ่มเติมเกี่ยวกับการมีส่วนร่วมขององค์กรในการพัฒนาการรวมกลุ่มอุตสาหกรรมและการพัฒนาเศรษฐกิจภูมิภาค ในการนี้ขอขอบพระคุณท่านที่ให้ความร่วมมือ หากท่านต้องการคำชี้แจงเพิ่มเติมโปรดติดต่อผู้วิจัยหรือทีมงานวิจัยตามรายนามท้ายเอกสารก่อนเข้าร่วม

การรักษาความลับ/การเปิดเผยข้อมูลและการรักษาความปลอดภัยข้อมูล:
ผู้วิจัยจะเก็บข้อมูลของท่านไว้เป็นความลับตามมาตรฐานจริยธรรมและกฎหมายระหว่างประเทศ การเข้าถึงข้อมูลจะถูกจำกัดให้ผู้วิจัยแต่เพียงผู้เดียว ข้อมูลการศึกษาจะถูกเก็บไว้ด้วยการเข้ารหัสในระบบฐานข้อมูลของมหาวิทยาลัยแห่งเบอร์มิงแฮม (University of Birmingham) และที่สำนักงานเลขานุการคณะกรรมการส่งเสริมกิจการอุทยานวิทยาศาสตร์ (สอว.) กระทรวงวิทยาศาสตร์และเทคโนโลยี การเข้าถึงฐานข้อมูลจำกัดเฉพาะสมาชิกทีมวิจัยเท่านั้น การเข้าถึงฐานข้อมูล สอว. จะถูกจำกัดไว้สำหรับผู้วิจัยและเจ้าหน้าที่ที่ได้รับมอบหมาย ภายใต้การอนุมัติและการกำกับดูแลของผู้อำนวยการ สอว. ชื่อของท่านและสถานประกอบการจะไม่ถูกเผยแพร่ อย่างไรก็ตาม ชื่ออุทยานวิทยาศาสตร์ ชื่อมหาวิทยาลัย และตำแหน่งงานจะถูกรวบรวมเข้าเป็นส่วนหนึ่งของรายงานผลการศึกษา การเข้ารหัสชื่อของท่านสามารถเข้าถึงได้โดยทีมวิจัยเท่านั้น ข้อมูลจะได้รับการสำรองและสำเนาเป็นประจำเมื่อมีการอัพเดต ข้อมูลทั้งหมดจะถูกเก็บรักษาเป็นเวลา 10 (สิบ) ปีตามนโยบายของ University of Birmingham

ผลการศึกษา:
ผู้เข้าร่วมจะได้รับสำเนาสรุปผลการวิจัยภายหลังเสร็จสิ้นการศึกษาแล้ว ผลการศึกษานี้จะเป็นส่วนหนึ่งของวิทยานิพนธ์ปริญญาเอก และจะถูกนำมาใช้ในการพัฒนานโยบายอุทยานวิทยาศาสตร์ภูมิภาคเพื่อส่งเสริมการเติบโตทางเศรษฐกิจของภูมิภาคผ่านนวัตกรรม และอาจถูกเผยแพร่เป็นส่วนหนึ่งของผลงานวิจัยภาครัฐ

เงินทุนและการสนับสนุนการวิจัย:
โครงการวิจัยนี้ได้รับการสนับสนุนเงินทุนจากกระทรวงวิทยาศาสตร์และเทคโนโลยีเต็มจำนวน และอยู่ภายใต้การกำกับดูแลของ Professor John Bryson, Mr. Christopher Collinge จาก University of Birmingham และ Dr Catherine Harris จาก Coventry University ประเทศอังกฤษ

ทีมงานวิจัย:
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The Department of Management, Birmingham Business School
โทรศัพท์:
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ที่อยู่: สำนักงานเลขานุการคณะกรรมการส่งเสริมกิจการอุทยานวิทยาศาสตร์ (สอว.)
ชั้น 7 อาคารพระจอมเกล้า สำนักงานปลัดกระทรวงวิทยาศาสตร์และเทคโนโลยี
75/47 ถ.พระราม 6 เขตราชเทวี กรุงเทพฯ 10400

ที่ปรึกษาหลัก **Professor John Bryson**, Professor of Enterprise and Economic Geography
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Dr Catherine Harris, Research Fellow
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อีเมล

ส่วนแสดงความยินยอม

โดยการลงนามให้ความยินยอมนี้ ท่านยอมรับว่าได้อ่านและเข้าใจข้อมูลสำหรับผู้เข้าร่วมโครงการและได้รับแจ้งข้อสงสัยเกี่ยวกับการวิจัยนี้อย่างชัดเจนแล้ว ท่านยินยอมเข้าร่วมและเข้าใจว่าท่านสามารถถอนตัวจากการศึกษานี้ได้ทุกเมื่อภายในระยะเวลา 3 (สาม) เดือนหลังจากการให้สัมภาษณ์โดยไม่ต้องให้เหตุผลใด ๆ ซึ่งการถอนตัวจากงานวิจัยจะไม่มีผลต่อการร่วมงานของท่านกับอุทยานวิทยาศาสตร์ภูมิภาคหรือกับ สอว. ในภายภาคหน้า
ข้อมูลของท่านจะถูกละเว้นจากการรวบรวมและจะถูกทำลาย ท่านเข้าใจดีว่าข้อมูลส่วนบุคคลของท่านจะได้รับการประมวลเพื่อจุดประสงค์ของการวิจัยนี้เท่านั้น และท่านยอมรับว่าการให้สัมภาษณ์จะได้รับการบันทึกและตีความ แต่ชื่อของบุคคลและชื่อบริษัทจะถูกเว้นจากการเผยแพร่ ท่านยินยอมให้ผู้วิจัยขอข้อมูลเพิ่มเติมภายหลังการสัมภาษณ์ ซึ่งในกรณีดังกล่าวการติดต่อจะกระทำผ่านทางอีเมล ท่านเข้าใจว่าท่านจะได้รับสำเนาของบทสรุปผู้บริหารเมื่อการวิจัยเสร็จสิ้น และการลงนามนี้ ไม่ส่งผลให้ท่านเสียสิทธิใด ๆ ที่พึงได้รับตามกฎหมาย

ลายมือชื่อผู้เข้าร่วม พยาน

_____ วัน-เดือน-ปี _____ วัน-เดือน-ปี _____

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ลายมือชื่อผู้วิจัย

_____ วัน-เดือน-ปี _____

(นางสาวมุทธมาศ วงศ์วานิช)

Appendix P: Summary of seven universities in the network of NSP

University	Faculty/School
Chiang Mai University (CMU) (host) Year of establishment: 1964 No. of SP employee (2017): 57 No. of all researchers: 2,025 No. of researchers worked with SP**: 220	- Mass Communication - Dentistry - Law - Business Administration - Nursing - Humanities - Political Science and Public Administration - Fine Arts - Science - Engineering - Education - Architecture - Social Sciences - Veterinary Medicine - Public Health - Agro-Industry - Agriculture - Associated Medical Sciences - Pharmacy - Economics - Medicine - Marine Studies and Management - International College and Digital Innovation - Arts, Media and Technology - Research Institute for Health Sciences (RIHES) - Science and Technology Research Institute (STRI) - Social Research Institute (SRI)
Naresuan University (NU) Year of establishment: 1990 No. of SP employee (2017): 21 No. of all researchers: 1,264 No. of researchers worked with SP**: 19	- Allied Health Sciences - Dentistry - Medical Science - Medicine - Nursing - Pharmaceutical Sciences - Public Health - Health Systems Management - Agriculture, Nature Resources and Environment - Architecture - Engineering - Science - Renewable Technology - Logistics and Supply Chain - Business, Economics and Communications - Education

University	Faculty/School
	- Humanities - Social Sciences - Law - ASEAN Community Studies
Mae Joe University (MJU) Year of establishment: 1996 No. of SP employee (2017): 7 No. of all researchers: 45 No. of researchers worked with SP**: 36	- Agricultural Production - Liberal Arts - Animal Science and Technology - Science - Architecture and Environmental Design - Business Administration - Economics - Engineering and Agro-Industry - Fisheries Technology and Aquatic Resources - Information and Communication Technology - Tourism Development - Renewable Energy
Mae Fah Luang University (MFLU) Year of establishment: 1998 No. of SP employee (2017): 17 No. of all researchers: 118 No. of researchers worked with SP**: 32	- Liberal Arts - Science - Management - Information Technology - Agro-Industry - Law - Anti-Aging and Regenerative Medicine - Cosmetic Science - Dentistry - Health Science - Medicine - Nursing - Sinology - Social and Innovation
University of Phayao (UP) Year of establishment: 2010 No. of SP employee (2017): 7 No. of all researchers: 664* No. of researchers worked with SP**: 42	- Agriculture and Natural Resources - Information and Communication Technology - Pharmaceutical Sciences - Medicine - Law - Nursing - Management and Information Sciences - Science - Medical Sciences - Engineering - Liberal Arts - Architecture and Fine Arts - Allied Health Sciences - Energy and Environment

University	Faculty/School
	- College of Continuing Education
Uttaradij Rajabhat University (URU)	- Agriculture
Year of establishment: 2004	- Education
No. of SP employee (2017): 9	- Science and Technology
No. of all researchers: 276*	- Humanities and Social Sciences
No. of researchers worked with SP**: 30	- Industrial Technology
	- Management
Phibulsongkram Rajabhat University (PSRU)	- Education
Year of establishment: 2004	- Agricultural and Food Technology
No. of SP employee (2017): 6	- Industrial Technology
No. of all researchers: 253*	- Management
No. of researchers worked with SP**: 17	- Humanities and Social Sciences
	- Science and Technology

Note: *from the scientist database of the government (www.stdb.go.th)
**(Wongpridi and Sudhipongpracha, 2017, p. 81)

Appendix Q: Input to IVC process from the triple helix

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
C01 Off Park	Firm/ Entrepreneur	Follow the global trend and market demand in developing health products, specifically Thai herbs.	The founder knows herbal substances but needed academic expertise to develop the quality and standard of raw material.	Hire scientists to work with the university researcher and to receive knowledge transfer to the firm. Invest in the R&D	Open four distribution centers across the country. Do marketing research and branding to commercialise developed products. Improve factory standard, getting GMP, Halal, HACCP.	Benefits matched expectations – received knowledge required in developing the products, registered three IPs from research result, completed more than ten research projects in seven years, expanding the new factory.
	University/ Researcher	-	-	Conduct R&D on the control field and tested at the university.	-	
	SP (SP2)	Suggest additional sources of funding. Set up agreed terms on product development.	Match the firm to the university researcher. STeP introduced the firm to other research institutions such as NSTDA, MFI, and Food Institute that the firm could not access by itself.	Partially invest in the R&D project.	SP encouraged business participation in innovation award.	
C02 On Park	Firm/ Entrepreneur	See the potential to develop the protein powder and related products from insect to	Contact the researcher to check the possibility to produce (having imported product as an example)	Invest in R&D for about one million Baht in two years.	Export to the USA. Directly contact the souvenir shops and modern trade.	Benefits more than expected – export the product to an international market, received GMP standard for his insect

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
		supply to the global trend.			Promote the business via Facebook and word-of-mouth.	farm, the government authority is improving the standard of other insect farms in Thailand, planned to set up a factory.
	University/ Researcher	-	Extract the sample product comparing with raw material available in Thailand.	Develop complete product together with the standard of raw material.	-	
	SP (U4)	Support this firm as part of a business incubation training program.	-	SP partially funded the projects.	Support on expenses of joining trade exhibition	
C03 Off Park	Firm/ Entrepreneur	Get the idea of extending the product (drink) 's shelf life from the retailers.	The entrepreneur contacted the researcher to discuss the possibility of developing the product.	Partially invest in the R&D project.	-	Learning occurred, but no research commercialisation – the firm changed its product.
	University/ Researcher	-	Contact a researcher in another institute who had an interest and matched expertise to be part of the team.	The R&D has done cross-institutions and tested at the factory.	Propose the market plan but was not matched with the firm's target market.	
	SP (U4)	-	-	Partially invest in the R&D project.	-	
C04 Off Park	Firm/ Entrepreneur	The entrepreneur had the idea to develop the peeling machine to increase productivity and decrease labour cost.	The entrepreneur consulted with SP for an assistant.	Consult regularly with the researcher on the capacity of the machine to be built, including visiting the factory.	-	The expectation was not met but received other benefits – the machine from this project cannot be used in the real situation.

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	University/ Researcher	The researcher consulted with the entrepreneur of expecting capacity of the machine.	Explore if there is any similar model available for alteration, but there was none.	The researcher sketched it himself. The students in the university workshop did the assemble.	Install the machine to the factory and repaired as needed	However, the firm received other benefits such as consultation and being promoted by the SP.
	SP (SP2)	Persuade the entrepreneur to submit the request for R&D.	Help to match with the researcher.	Partially support in R&D project investment.	-	
C05 Off Park	Firm/ Entrepreneur	The owner wanted to reduce waste from coffee bean production and create a new line of products from coffee.	Explore potential ideas to develop products from the waste of coffee production. Cross-section brainstorming (QA and RD) The owner contacted the STeP to find researchers.	The firm put research team in place to work with academics. Invest in money and equipment for R&D in house.	Promote new products though competitions and target the high-end market nationally and internationally.	Benefits more than expected – many new products were developed and registered for the IPs. The products were backed up with academic research. Professional network stimulates the continuity of products development.
	University/ Researcher	-	Explore new idea from updated journal articles. Discuss with other academics about the potential development of new products.	The R&D projects were conduct collaboratively by a group of academics from three universities.	The university gave priority for the firm to marketise the research results.	
	SP (U5)	Check international IP registration for the proposed projects.	Match the entrepreneur to the academics with the related profession.	Partially support on funding for R&D projects.	Support and train the entrepreneur in pitching in the competitions.	

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
C06 Off Park	Firm/ Entrepreneur	The owner wanted to develop products based on local materials (herbal tea) available on the farm.	Discuss with the personally known researcher.	Supply raw material to use in the R&D project. The firm invested half in the project.	-	Benefits matched expectations – the firm knew that it is possible to produce, but still not launch the products.
	University/ Researcher	With his interest in the herbal product, he studied the needs of the herbal product and convinced the firm to do R&D.	-	Do the research to extract the raw material to edible structure. The results show the feasibility of the products. They are in the prototype stage.	-	
	SP (SP2)	-	-	Partially funding support.	-	
C07 Off Park	Firm/ Entrepreneur	The owner bought the right of research result—some issues needed to be developed based on customer's feedback.	The problems were brought to the creator of the original project. The owner also contacted SP to find paper expertise.	Invest in half of R&D project cost and supply raw material.	Contact potential clients in person. Start online marketing. Try applying the method advice by the researcher to the production and kept adjusting it to match the factory level.	The expectation was not met but received other benefits – the solution proposed by the researcher cannot be applied at the factory level. Further development is still needed in many areas. However, the owner learnt through the R&D process and highly appreciated with being promoted by the RSP.
	University/ Researcher	-	Consult with experts in another university.	R&D was done in the lab-scale without testing it at the factory.	Try correcting the defect reported back from the entrepreneur.	
	SP (SP2)	Support on training through business incubation program.	Search for an additional researcher who has direct expertise in the	Support half of R&D cost.	Help to match with potential customers.	

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
			product to help with the project.		Promote the business through competitions and exhibitions.	
C08 Off Park	Firm/ Entrepreneur	The idea of developing the machine came from the users' problem.	Study similar machines from various brands.	Design the system to some level but still need support on advance knowledge.	The projects are from the end user's feedback. The developed machine can be presented directly to the business's customers.	Benefits more than expected – the firm developed a solution to its clients by working collaboratively with the researcher. New customers were attracted by the reputation of winning the technology competition and backed up by participating with the SP.
	University/ Researcher	Point out what is the cause of the problem and proposed the solution.	Study the papers of related technology.	Apply advanced technology to the machine that was developed first by the entrepreneurs.	The university registered for the IP and prioritized this firm to use the technology.	
	SP (SP2)	-	-	Partially support in funding the project.	Help the firm increased its reputation from participating with SP and winning the competition.	
C09 Off Park	Firm/ Entrepreneur	The owner developed the product recipe by herself but needed help to obtain a standard certificate.	Need a knowledge of cooking the recipe while maintaining cleanliness and food nutrition.	The entrepreneur develops the recipe by herself as concerning trade secret and adjusting based on the test result.	Premium retail shops nationwide.	Benefits matched expectations – the entrepreneur needs support on academic knowledge to apply for product standard that can hardly be obtained if she did it all by herself. The researcher gave support while not touching her trade secret, and she obtained GMP certificate on several products afterwards.
	University/ Researcher	See the potential, the researcher offered to help in R&D.	Check the tests required for applying for standard certification.	Use university facilities for process R&D and product testing.	-	
	SP (U6)	Propose to the entrepreneur about available supports for developing the products.	Check the requirement for the application for standard certification.	Partially support on projects funding.	Push the entrepreneur to attend the competitions for the promotion of the product.	

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
C10 Off Park	Firm/ Entrepreneur	Agree to participate in the SP program allowing the researcher to help to develop the self-check-in system that would reduce labour cost and increase security.	The system required the use of IT, and the program was to be accessed by web and mobile application.	Invest partially in the project.	The staffs learnt how to use the system. The guests were notified about the application of the new check-in system.	Learning occurred, but no research commercialisation – the system does not match with the guest expectation. Also, with the change in management, the system was uninstalled.
	University/ Researcher	Approach the owner offering to solve any problem if there was.	The rough idea of having self-check-in system was exploring for the feasible solution.	Develop the system and installed it to the premise.	The correction and modification were done during the transformation period.	
	SP (U3)	-	-	Invest partially in the project.	-	
C11 Off Park	Firm/ Entrepreneur	The owner wanted to develop the quality of his product (grilled crocodile meat). He was introduced to the SP by a friend.	Learn to grilled crocodile meat. The problem was the capacity of the existing ovens.	Supply meat for testing. Invest 50% of the R&D project.	Sell in souvenir shop around the country, targeting Chinese tourists.	Benefits matched expectations
	University/ Researcher	Inspect the factory and identified the cause of the problem and proposed the solution to develop the oven.	Study the composition of crocodile meat, finding how to cook it thoroughly.	Develop the oven as a prototype in the university.	The university allowed the entrepreneur to use the technology without collecting the fee. Install two ovens at the factory that increased productivity and product quality.	
	SP (U3)	Match the firm to the researcher.	-	Support 50% to the R&D project.	Support on GMP registration.	

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
					Business matching in the trade exhibition	
C12 Off Park	Firm/ Entrepreneur	The idea of product development came from the feedback of end-users collected by the distributors.	The owner wanted to learn the process of developing the product, including lab testing.	Work collaboratively with the researcher during R&D (learning the process to do it by herself later). Partially invest in the R&D project.	Sell the new products on the existing channels (online and product distributors). On the process of registration for Organics Certification	Benefits matched expectations – besides getting a new product as expected, the owner also learnt how to do the R&D to develop another product later.
	University/ Researcher	Discuss the expectation with the owner and decided the project proposal.	-	Develop the product using the equipment as available in the factory.	The university agreed that the entrepreneur owns the IP.	
	SP (SP2)	-	-	Partially support in R&D project funding.	Help with the GMP and other standard certificates. Trade exhibition and business matching	
C13 Off Park	Firm/ Entrepreneur	The idea of developing the product was from the questions of the customer about the quality of the product.	The owner decided that having academic research as a backup can help to solve this problem. He contacted the researcher before got in touch with the SP.	Partially invest in R&D projects. Supply raw material to the R&D projects.	The owner brought the research to international competition and won. He commercialised the products via existing channels referring to the academic research and the award received.	Benefits more than expected – the owner planned to do only one project. However, with the support of SP, he could do more projects paying the same amount of money.

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	University/ Researcher	Discuss with the owner. Then, they decided to do R&D on quality control.	-	The R&D projects were to certify product standard and recipe development.	The university registered for the IP, and they are on the process of licensing it to this firm.	
	SP (U3)	Stimulate the entrepreneur to do more R&D.	Match the entrepreneur with a professional to develop the recipe.	Partially support in project funding.	Promote the product in the trade exhibitions.	
C14 Off Park	Firm/ Entrepreneur	The idea to develop the production process was from facing the problem of the production line at the factory.	He discussed with his academic friend who introduced him to another researcher who can help to solve his problem.	Work together with the researcher (the owner was an engineer). The factory had to adjust its operation at many points to install the system. Partially invest in the R&D project.	- (The project was not completed and on the six months extended period.)	Benefits matched expectations
	University/ Researcher	-	Learn from another expert about the production line to applying his expertise on Big Data to this factory.	Develop the monitoring system for the factory based on previous research on flood prediction.	-	
	SP (SP2)	-	-	Partially invest in the R&D project.	-	
C15 Off Park	Firm/ Entrepreneur	The founder wanted to add value to the wasted of the mushroom farm of his family.	Without prior knowledge of doing business or product development, he contacted the university SP for an assistant.	Work together with the researcher to finalize the recipe.	The owner contacted the shopping mall to put his product on the shelf.	Benefits more than expected

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	University/ Researcher	Discuss with the entrepreneur to finalize the expected product.	-	Develop the product using the university's facilities, including assigned the project as a student's assignment to get many results available for selection.	The university allowed the entrepreneur to commercialise the research result without charges.	
	SP (U5)	Train the entrepreneur about business planning and doing market research that then finalized on which product should be developed.	Match the entrepreneur to the researcher in the Food Science department.	Fully support on the product development funding.	Train in marketing and other business issues Support on trade exhibitions. Assist with GMP and FDA registration.	
C16 Off Park	Firm/ Entrepreneur	See opportunity in commercialising research result.	Commercialise university research.	Develop the recipe.	Online marketing (mainly via Facebook)	Benefits matched expectations
	University/ Researcher	The idea came from the trend of healthy products consumption.	-	Transfer knowledge to the entrepreneur and advised on some minor problems found while creating a recipe.	-	
	SP (U6)	Train the entrepreneur as part of the business incubation program.	-	Support all expenses as part of a business incubation program.	Support on trade exhibition and off-line marketing.	
C17 On Park	Firm/ Entrepreneur	The idea of product development was from two sources; internal creation based on current market cosmetic and	The founders have expertise in pharmaceutical production.	The internal R&D team with pharmaceutical background develop the	Promote the business on Facebook and website.	Benefits more than expected – the business started and joined with SP for the support of necessary tools and

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
		skincare trend and developing the recipe from customer's requests.		cosmetic recipes using natural material.		equipment as a primary concern. They also received supports on marketing and business training by joining SP's business incubation program. A significant additional benefit was reputation and credibility gain from locating on-park.
	University/ Researcher	-	-	-	-	
	SP (U4)	-	-	Support necessary equipment and machines as a privilege of being on-site. Suggest the appropriate funding sources.	Train as part of the Business Incubation Program Partially support on attending domestic and international trade exhibition. The firm gained credibility from locating on-site.	
C18 Off Park	Firm/ Entrepreneur	The owner created the food recipe to feed her child.	To commercialise the product, the cost must be lower with a higher standard and better taste.	The recipe was created and held by the owner. The development process was done in the kitchen. Partially invest in the R&D project.	The entrepreneur did not have much capital. The commercialisation was by matching with the factory.	Benefits more than expected – the entrepreneur did not plan to create a business from her food product. By the encouragement of the researcher and SP support, she partnered with the factory that takes all responsibility in selling it.
	University/ Researcher	The researcher liked the taste of it and suggested her to develop it for sale.	Find the various type of the main ingredient (rice) to develop the recipe.	Suggest which material and ingredient should be best for the owner's recipe. Adjust the recipe for lowering cost, better	-	

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
				quality while keeping the taste.		
	SP (U6)	-	-	Develop the package. Partially invest in the R&D project.	Support in attending the trade exhibition. However, the owner could not produce a large amount of product. SP helped to match with the factory who also take care of all marketing issues.	
C19 On Park	Firm/ Entrepreneur	The idea of R&D was from the founders and the customer's request.	The knowledge is available in-house.	The founder's team did the coding.	Most customers are from the personal connection of the founder and word-of-mouth.	Benefits more than expected - the firm located on-park to be close to all available supports. They also received the benefit of increasing credibility and network creation.
	University/ Researcher	-	Help to research the feasibility of the development.	Give some suggestion, but not the main person doing the code.	-	
	SP (U3)	-	-	-	Train as part of the Business Incubation Program. Create a network and promote the business.	
C20 On Park	Firm/ Entrepreneur	The founder had an idea to form the business selling coffee and tea together with tourism business by being a contact point of all	Visit tea institute to develop the idea. Contact the SP proposing the idea and the needs of supporting knowledge about the	-	Contact existing customers. Souvenir shops. Facebook page.	Benefits more than expected

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
		coffee producers in the north region.	coffee production process and doing business.			
	University/ Researcher	-	Assist in the coffee production process.	Assist in quality control for the coffee product and business issues.	-	
	SP (U2)	-	Support the idea by training in how to do business and setting up the firm as part of a business incubation program.	-	Help to promote the business via the trade exhibitions.	
C21 On Park	Firm/ Entrepreneur	The idea of forming up the business was from the founders (move back from abroad).	Require the knowledge of how to do business in Thailand and suggestion on programming.	The founders can develop most of the product's part by themselves.	The personal connection of founders.	The expectation was not met but received other benefits – this startup business was on the process of building a core framework and internal management rather than creating new products. The business benefits more from the location and reputation from joining SP than the other supports expected.
	University/ Researcher	-	-	Give consultation about programming for the on-site team.	The researcher was in charge of the on-park team delivering the products to the customers.	
	SP (U2)	-	Assist with doing business in Thailand.	-	Train on bidding for the government project	
C22 On Park	Firm/ Entrepreneur	The founders were part of the research team that develops the tribal community. They decided	Require the knowledge of tourism management, business operation, and developing marketing tools.	Apply the research to further development and worked with related stakeholders.	Facebook and contact education institutes.	Benefits matched expectations

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
		to bring the communities to be a tourist attraction.				
	University/ Researcher	Agree with the entrepreneurs to further develop the research.	Need to research more on bring in the tourists to the communities.	Research sustainable development of the tribal communities and how to convert them to the tourism business.	Help to contact the authorities.	
	SP (U2)	-	Assist on setting up the business as part of Business Incubation program.	Support on operation cost except for salary. Encourage network creation to find a partner in forming up the business.	-	
C23 On Park	Firm/ Entrepreneur	The firm relocated to SP for the benefit of network creation and increase credibility.	Contact SP for the support of necessary knowledge.	Design the function and appearance of the program.	-	Benefits matched expectations - the primary purpose of joining the SP was for the network creation. The entrepreneur delighted with the benefit received. However, the R&D projects were still on the matching process.
	University/ Researcher	-	-	-	-	
	SP	-	Connect the firm to researcher and relevant organisation/authorities.	-	-	
C24 On Park	Firm/ Entrepreneur	The owner wanted to develop products using honey from her farm.	Contact the academics who have expertise in food engineer or food science.	Supply the raw material (honey) and partial investment in the R&D project	Invest in a binding machine for the factory. Export, domestic sale, OEM	Benefit more than expected. – the firm succeeds in the projects with SP and on the process

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	University/ Researcher	Discuss the feasibility of the product. Then finalized to develop serial bar.	-	Create a recipe for the product.	Help with the machine installation and modification.	of doing another project. The expectation was only the academic support, but she also benefited from network creation and increased credibility.
	SP (SP2)	-	-	Partially invested in the R&D project.	Promote the product by bought it as New Year gifts.	
C25 On Park	Firm/ Entrepreneur	The products were developed from the owner's study projects.	Contact the academics who used to supervised him for further technical knowledge as well as contact SP for additional expertise.	Work cooperatively with the researchers in the projects.	Produce by OEM through the known factories. Promote the product via the online channel.	Some expectations were met and received additional benefits – having some complexity working with the researchers and lab was not available at all time but received additional benefits on increasing credibility of located on the park.
	University/ Researcher	-	-	Conduct the R&D using the university's facilities.	Offer exclusive right to market the products.	
	SP (SP2)	-	Match the entrepreneur to the researchers with diverse expertise.	Partially support funding to the R&D projects and suggest other sources of funding.	Support on business promotion cost. B2B via trade exhibition.	
C26 On Park	Firm/ Entrepreneur	Teaching statistic in the university, the founder saw that SPSS is licensed and complicated. He designed to write a program to replace SPSS.	The founder can code the program by himself.	Develop the program with some consultant from the expert.	Promote the business through the network created in the RSP.	The expectation was not met but received other benefits – the university did not provide testing service as he expected. Nevertheless, benefited from locating on park (credibility, network).
	University/ Researcher	-	-	Give consultation but not writing the program.	The university cannot certify the standard of the program for the business.	

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	SP (SP2)	-	Support as part of Business Incubation program.	-	Promote the business through network creation, trade exhibition.	
C27 On Park	Firm/ Entrepreneur	The founders have a long-time experience in the technology business. They decided to form up the business and develop the AI technology to support Thai business.	The expertise to develop the product was available internally.	The founder developed AI technology to analyse the data without support from external expertise.	Promote the business through the Bangkok AI cluster, and existing connection with large companies.	Benefits more than expected – the entrepreneur only wants to support on business issues. The benefits he received were also increasing the credibility of the firm.
	University/ Researcher	-	-	Act as a consultant.	-	
	SP (SP2)	-	The founder attended the business training program provided by STeP.	Monetary support as part of Business Incubation program such as rental of a cloud server,	The firm took advantage of the increase in credibility from locating on the park. Support the firm to attend trade exhibitions.	
C28 On Park	Firm/ Entrepreneur	The founder wanted to develop an application to help the operation of his family's apartment.	The project was formed up during his university time includes doing market research and finding an investor. The lack of knowledge was business issues.	Develop the program using an internal R&D team. The prototype was tested with the real user who gave feedback for further development until the product was ready to launch for the public.	Promote the business via Google AdWords, general marketing, and arranging a seminar for apartment owners.	Benefits matched expectations - the firm wanted to benefit from locating on SP such as network creation and the increase in reputation and credibility of the firm.

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	University/ Researcher	-	-	-	-	
	SP (SP2)	-	Support on business training and legal issue.	Help to find funding sources.	Support the entrepreneur to attend the trade exhibitions.	
C29 On Park	Firm/ Entrepreneur	The founder wanted to develop the AI for data analysis for the Thai language.	Besides the IT knowledge of the owner, the firm needed expertise in Thai language and data scientist.	The AI was developed to understand the Thai language by the internal R&D team. The prototype was tested by the real user that sent the feedback for further modification.	Via existing customers and approaching new customers offering data analysis technology at an affordable price and can analyse the Thai language	Benefits matched expectation – the firm found that the researcher at the RSP is active and energetic. Also, the ecosystem of the RSP is suitable for the technology business. The credibility increases from the facility of the RSP.
	University/ Researcher	-	-	Work collaboratively between the language professional and data scientist together with the entrepreneur's team	-	
	SP (SP2)	-	Match the firm to the researchers.	Help to find funding sources and reduce the cost of rental space.	The firm benefited from locating on park (increasing credibility)	
C30 On Park	Firm/ Entrepreneur	To avoid being copied easily, the owner expected to use scientific research as a product guarantor (biotechnology brick).	The R&D required expertise internally (experience of the worker) and externally (academic research). The owner contacted the researchers in Thailand and from abroad.	The R&D team of the firm develop the products together with the experts.	The product will be settled in the country first. Then the firm will export it to China.	Benefits more than expected

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	University/ Researcher	-	Discuss the further improvement of existing research to apply to his products.	Existing academic research was applied and modified in R&D.	-	
	SP (SP2)	-	-	Support in funding and research facilities.	-	
C31 On Park	Firm/ Entrepreneur	The ideas for product development were from the trend and feedback of customers in the owner's restaurant.	The owner has expertise in food science, but still needed expertise about shelf life and ageing.	Conduct the R&D by applying her knowledge to academics.	Use the products in her restaurant and cooking school (Chinese tourists). Promote the business in the cluster.	Benefits more than expected – not only benefiting from the on-park network, but the firm also increased its credibility.
	University/ Researcher	-	-	Collaborative working with the owner.	-	
	SP (SP2)	-	Encourage the knowledge exchange among researchers and entrepreneurs to stimulate creativity.	Partially support on project funding.	Promote the business and matching with potential customers.	
C32 On Park	Firm/ Entrepreneur	The idea for product development was from seeing a variation of pharmaceutical products in Japan. He decided to develop the insect-bite treat in roll-on form.	The founders have basic knowledge about medicine. However, he needed a professional to create the recipe.	Give information on what substances he wanted to be in the recipe.	The founders did the production at the home factory. Contact the pharmacies that have franchises and branches. Online marketing on Facebook and website Trade exhibition.	The expectation was not met but received other benefits.

Firm	Value network's actor	Project Development	Acquiring Knowledge	Building Innovation	Commercialisation	Outcome
	University/ Researcher	-	Construct the idea with the founders.	Formulate the product recipe according to the idea.	-	
	SP (SP2)	-	-	Waive the first-year rental fee.	Assist about a legal issue and other business matters such as packaging and trade exhibition.	
C33 On Park	Firm/ Entrepreneur	Have international experience in public policy consultation. The founder decided to set up the first public policy school in Thailand.	Recruit professional from the related field into the firm. Accumulate knowledge from work experience and training	Decide and managed the implementation of the courses.	Promote the business at an international level by referring to the university.	Benefits matched expectations
	University/ Researcher	-	-	Collaboratively decided and implemented the courses.	Consult the client (student)	
	SP (SP2)	Negotiate the terms and condition on setting up the institute on the RSP's premise.	-	-	Provide facilities services such as meeting rooms for studying.	