LOCAL INNOVATION SYSTEM AND
PUBLIC-PRIVATE RESEARCH PARTNERSHIP:

A case study of national research centres and a science park in Thailand

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LIST OF ABBREVIATIONS

AIT  Asian Institution of Technology
BOI  Board of Investment
CEO  Chief Executive Officer
CPMO  Cluster Programme Management Office
GDP  Gross Domestic Product
GERD  Gross Expenditure on Research and Development
GITS  Government Information Technology Services
HEI  Higher Education Institution
I2P  Idea-to-Product
ITAP  Industrial Technology Assistance Programme
LSI  Local System of Innovation
MDTC  Manufacturing and Design Technology Centre
MOST  Ministry of Science and Technology
MTEC  National Metal and Materials Technology Centre
NECTEC  National Electronics and Computer Technology Centre
NESDB  National Economic and Social Development Board
NIC  NSTDA Investment Centre
NIS  National Innovation System
NRCT  Office of National Research Council of Thailand Na
NSTC  National S&T Policy Committee
NSTDA  National Science and Technology Development Agency
OEM  Original Equipment Manufacturer
PRO  Public Research Organisation
PTEC  Electrical and Electronic Testing Centre
RIS  Regional Innovation System
SPA  Strategic Planning Alliance
SSI  Sectoral System of Innovation
STC  Science and Technology Committee
STDB  Science and Technology Development Board
TLO  Technology Licensing Office
TMC  Technology Management Centre
TNC  Trans-national Company
T-NET  Information Security Company
TRF  Thailand Research Fund
TSP  Thailand Science Park
TU  Thammasart University
U-I IOR  University-Industry Inter-organisation Relationship
ABSTRACT

This thesis investigates the local innovation system of public research organisations in the Thai context, in which research centres and firms are co-located in a planned science park, with particular emphasis on the influence of co-location on interactions between research centres and local firms, and the research collaboration between the research centres and industrial firms. It aims to gain insight into the factors that influence the interaction of research centres and firms located in close proximity and the ways in which research centres and firms interact in relation to their research collaboration. This thesis draws upon three theoretical concepts: the concept of local innovation system, the concept of proximity, and the theories of inter-organisational relationships.

The study suggests that co-location (i.e. physical proximity) to research centres does not normally lead to formal interaction between local firms and research centres in this context. Most of the interactions between them were found to be informal. Thus, the influence of physical proximity on the interactions and linkages of actors in this local innovation system is to some extent over-estimated. There is insufficient synergy to create an innovative surplus from co-location of firms and research centres in this context. The study also suggests that promoting social and technological proximity between research centres and local firms, by introducing institutional or organisational arrangements that would facilitate these two dimensions of proximity, encourages greater extent of formal interaction between them as well as facilitates benefits from spatial relation of these local actors.

Despite the absence of formal interaction with local firms, research centres collaborate with firms located outside the science park. The study introduces a typology to understand how research centres work with firms and shows that most of the collaborative projects involved industrial application and utilisation of technological knowledge accumulated within the research centres, which applied to the firms’ products or development processes. Many of these projects resulted from collective projects or partnering experience between the research centre and firm, and were likely to follow with subsequent collaborations. In addition, the study reveals that technological factors, i.e. technological relatedness between the knowledge base of firms and research centres and firm’s technological capacity, influence the way in which research centres work with firms in collaborative projects. Organisational and institutional settings of research centres, as well as cultural factors are identified as barriers of research collaboration in this study.

The thesis concludes by indicating that physical proximity alone cannot trigger interaction of actors, especially formal interaction such as research collaboration, bounded by spatial relation. Interaction between public research organisations and firms can take place without closeness in distance. Other dimensions of their relationship are important factors influencing their interaction. The research collaboration between research centres and firms is a complex process and requires supportive organisational and institutional arrangements and effective policy intervention.
DECLARATION

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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DEDICATION

To my beloved parents and sister,
and dear husband
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First of all, I am most grateful to the Royal Thai Government, who sponsored my PhD study in the UK. My sincere thanks goes to my employer, the National Science and Technology Development Agency (NSTDA), who granted me leave for study to carry out this research. I would like to express my gratitude to Prof. Dr. Chachanat Thebtarananth, the former Vice President of NSTDA and the Director of NSTDA’s Technology Management Centre, for her great support and inspiration ever since I first started my career and all the way through my PhD study.

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Akeanong Plaeksakul attained a Bachelor’s Degree in Chemistry and Master Degree in Polymer Science from Mahidol University, Bangkok Thailand. She also attained a Master of Business Administration in Technology Management from Asian Institution of Technology in Thailand.

Akeanong had worked at National Science and Technology Development Agency (NSTDA), Thailand for eight years before pursuing a PhD study in the UK, sponsored by a Royal Thai Government scholarship. During her time working at NSTDA, she extensively involved in NSTDA’s Industrial Technology Assistance Programme (ITAP) providing technological consultancy services to Thai SMEs by diagnosing technological problems and coordinating between SMEs and technical experts in technological development projects. She also joined NSTDA’s team to conduct a feasibility study for setting up a business incubator at Thailand Science Park (TSP), NSTDA.

After her PhD, Akeanong will join ITAP and the Technology Management Centre (TMC) of NSTDA to work in the area related to technology, innovation, management and policy that promote innovation and linkages between public and private sectors in Thailand.
1.1 Rationale of the research

The relationships between public and private sectors have long been considered crucial to the development of innovation system of any country (Lundvall, 1988; OECD, 1997; Patel and Pavitt, 1998). Public-private partnerships can be in various forms. Many countries have undertaken policy initiatives in an attempt to stimulate research partnerships between industry and public research organisations (PROs) (Jaumotte and Pain, 2005). In that, public-private research partnerships involved inter-organisational relationships between PROs and industry play an important role for driving innovation processes (Perkmann and Walsh, 2007). This in turn helps to boost knowledge-intensive activities and build up long-term economic development of a nation. Amongst various mechanisms to link public and private research activities, the attempt to concentrate research and development (R&D) activities into a designated geographical space has become a consistent means of policy initiative in many countries. Typically, such a policy initiative entails the establishment of science parks or technology parks, which provide spaces for high-technology research and development activities, as well as other supporting activities, including both technical and non-technical ones.

Implementing science, technology, and innovation policies by means of science parks as a new engine for economic growth appears favourable for policy makers and their advocates. Nevertheless, the success stories of science parks are limited. Many science parks have generally failed to develop innovative networks based on inter-firm cooperation and interactive learning within the science park themselves (Asheim and Cooke, 1998). Sophia-Antipolis in France (Castells and Hall, 1994; Longhi, 1999) and Hsinchu Science-Based Industrial Park in Taiwan (Castells and Hall, 1994; Xue, 1997) are among a few successful science parks. However, whether the science park concept works and in what ways has not been well understood. Additionally, the way in which
Science parks are able to meet the needs of the country are fairly diverse and depend primarily on the particular systems in which they operate.

Science parks generally include a real estate development, technology transfer activities, and partnership between private firms, academic institutions, and government (Link and Scott, 2003b). Central to the concept of science parks is linkages between firms and academic research (Quintas et al., 1992). The development of industry-science links is assumed to encourage innovation and production (Westhead and Storey, 1994), hence enhancing wealth creation and job generation (Malecki, 1991). However, studies indicate that some science parks fail to develop linkages between local firms and spur interactive learning within its local setting (Massey et al., 1992; Quintas et al., 1992; Asheim and Cooke, 1998). It is insufficient for science parks to provide only physical infrastructure and investment benefits to embed R&D activities (Phillips and Yeung, 2003). This is because geographical proximity of firms and academic research is not an important influence on the existence or strength of formal links related to research activities (Vedovello, 1997). It is necessary to go beyond the intuitive feature of science parks to understand what actually underpins its concept. Here the question is: What goes on in a science park and what influences the interactions between firms and academic research? This study attempts to explore interaction within a science park, taking Thailand as a case study.

A developing country like Thailand has ambitions to transform into a knowledge-based society and has paid attention to the importance of building up the competences of the country by creating organisations and institutions responsible for science and technology development of the nation. To this end, the National Science and Technology Development Agency (NSTDA) was established in the early 1990s and has incorporated national research centres under one roof. About a decade later in 2002, Thailand Science Park (TSP) was up and running under the management of NSTDA. The TSP houses the NSTDA headquarters and its national research centres. In addition, it accommodated about fifty technology-based firms in the same locality by the end of 2007. Given this context, the site where NSTDA, national research centres, and TSP are
located is regarded as the national hub undertaking applied and industrial research, as well as various technological development activities of the country.

This research study takes a pragmatic approach to the local context of a Thai public research organisation - NSTDA. The study is conceptualised by way of applying the concept of national systems of innovation (NIS) to a local context. Based on the concept of systems of innovation, it explores the local innovation system of NSTDA. Local innovation system in this particular case study is regarded as a system which firms and local organisations and institutions interact, in which relationship with external world are given much less attention. Hence, this study primarily focuses on the interaction in the innovation process of national research centres and industrial firms located both in the TSP as well as outside the park in order to recognise and account for determinants and dynamics of this specific system of innovation. In particular, the study emphasises (1) the co-location of publicly-funded research laboratories and private firms within Thailand Science Park, (2) relations and interactions between key actors (i.e. research centres and industrial firms) of this local innovation system. It is anticipated that findings from this study can provide empirical–based policy implications for TSP and NSTDA, as well as other countries in catching-up economies.

1.2 Research objectives and research questions

There have been a number of studies concerning innovation system, science, technology and innovation (STI) policies and public-private research partnerships. However, most of them discuss the cases of economies that have rich and resourceful supportive science and technology infrastructures as well as well-structured innovation systems. This study intends to bring to light a local innovation system in an emerging economy taking

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Thailand, a latecomer country in terms of technological catching up, as focus. In particular, the country’s prominent public research organisation, NSTDA, is used as a case study. This organisation has been striving to improve the technological capabilities of the nation by providing various supports to both the public and private sector. Amongst the various supporting mechanisms, science-industry relations have been promoted by means of a science park and public-private research collaboration. This study examines how research centres and industrial firms interrelate in relation to science-industry links.

This research is to study the local innovation system of NSTDA, which incorporates national research centres and Thailand Science Park, with particular emphasis on interactions and relations between research centres and industrial firms, as well as organisational and institutional dimensions of this particular system of innovation. The study also intends to present empirical evidence for academic and policy makers on how the Thai public research organisation, national research centres and science park in particular, are able to better meet the needs of industry and in turn operate in response to the country’s innovation policy. To address the research objective, two main research questions and their subsequent questions are asked as follows:

1. To what extent does co-location (i.e. physical proximity) influence the likelihood of interaction between firms and research centres located in science parks in the case of Thailand?
   (1.1) What is the extent and type of interaction of local actors (i.e. firms and research centres)?
   (1.2) What are the factors influencing interaction of local actor?

2. What is the nature of R&D collaboration between research centres and firms in the case of Thailand?
   (2.1) What are the types of R&D collaboration that exist between research centres and firms?
(2.2) How are R&D collaborative projects between research centres and firms operated?

(2.3) What are the partners’ motivations for participating in R&D collaborations?

(2.4) What are the determinants of and barriers to interactions between R&D collaboration partners?

It is essential to note that the two main research questions of this study are developed in two steps. The first question is formulated to scrutinise whether co-location of firms and research centres in the science park has a positive effect on science-industry interaction, with particularly emphasis on the interaction related to R&D collaboration. The second question emerged from the results of the first question. As stated, this study aims to investigate science-industry links by means of a science park and public-private R&D collaboration. While studying influence of co-location could provide supporting evidence to elucidate the perceived benefits of a science park, it is equally important to explore the way in which R&D collaboration between research centres and their partner firms located elsewhere outside the site of the science park function. This could provide further information to deepening our understanding on how the interaction and relationship between science-industry functions. For this reason, the second research question is derived.

1.3 Scope of the thesis

To explore a particular innovation system in the case of Thailand, this research investigates both organisational and institutional dimensions of the local system. The setting of NSTDA, which aspires to be a local system of innovation, is examined in two aspects: (1) co-location of local actors, and (2) interactions of the actors. The first aspect is focused particularly on geographical proximity of local actors (i.e. local firms and research centres). The second aspect is centred on interactions within the local innovation system and enabling organisational and institutional settings.
The unit of analysis in this research is the local system of innovation of a public research organisation in Thailand. The central research interest of this thesis is in the interactions of actors of this particular system, which are studied in two ways. The first one is by investigating the relations and the way in which local firms and public labs interact in their co-located proximity. The second one is by exploring the relations and interactions of public research laboratories and private firms through their R&D collaborative projects. The empirical findings and analysis of the two studies can then be connected and synthesised to present prevalence and determinants of the interactions in the local of innovation system studied, as well as provide policy implications for Thailand and other developing countries.

1.4 Structure of the thesis

The formulation of the thesis, which consists of eight chapters, is presented in Figure 1.1. The outlines of the rest of the chapters are as follows:

Chapter 2 begins with a discussion of organisations and institutions involved in this study, i.e. NSTDA and national research centres, and Thailand Science Park, in order to provide background for the discussion and analysis concerning the interactions of actors and policy intervention in this local innovation system later on (in Chapter 6 and 7). This chapter also stresses the importance of Thailand’s national system of innovation being in transition, which influences the changes within the local system of innovation being studied.

Chapter 3 begins to build on the conceptual framework of this study by reviewing literature relating to three theoretical concepts adopted in this study, namely the concept of system of innovation, the theory of inter-organisational interactions, and the concept of proximity. The three academic constructs are subsequently brought together to build up a conceptual framework. An analysis frame adapted based on the theory of
inter-organisational interactions is presented to examine the empirical evidence of interactions between the actors in this study.

Chapter 4 continues with a literature review of linkages between science and industry, with particular emphasis on the science park concept and public-private research partnerships, in order to provide direction to explore the relations and interactions of the actors in the local system of innovation being studied in this thesis. The chapter provides a comprehensive review of the science park concept relating to its roles and significance in a system of innovation. The section on science park includes a review of innovation policy relating to public-private research partnership and science parks in some developing economies in Asia, such as Singapore and Taiwan. Following from the review of the science park concept, the chapter moves on to focus on factors underpinning the interaction between public and private partners in research collaboration that can be potentially linked with the extent and success of their partnerships. Other issues related to the determinants of public-private linkages such as absorptive capacity, trust and commitment, and research strategy of the partner are also discussed.

Chapter 5 elucidates and justifies the methodology that is being used in this thesis. The research questions, research design and strategy in conducting the research are outlined in this chapter. The methods used in data collection including interviews and secondary sources are also discussed. In addition, some limitations associated with research operationalisation are highlighted.

Chapter 6 and 7 present the findings and analysis from the fieldwork. While Chapter 6 illustrates the results and discussions based on the interviews with local firms in Thailand Science Park, Chapter 7 portrays how research collaboration projects between the national research centres and firms, both local and external ones, are organised and implemented.
The study is then concluded in Chapter 8, which underlines the main findings from the evidence in Chapters 6 and 7. The research limitations are also discussed and finally the directions for further research are suggested. This chapter also provides some policy implications for Thailand and other developing countries.

![The formulation of the thesis](image)
CHAPTER 2
Systems of innovation in the Thai context:
Experience of NSTDA – a public research organisation in Thailand

The present study primarily explores the interaction of firms and public laboratories within the context of a Thai public research organisation operating a planned science park. This review of the Thai context provides background information of the case studied and forms the foundation of the thesis.

This chapter is divided into four sections. Section 2.1 introduces the overview of Thai economy and the science and technology (S&T) system of the country. Section 2.2 portrays the features of a public research organisation. Section 2.3 highlights a shift in government policy. Finally, the chapter ends with a conclusion in Section 2.4.

2.1 Overview of Thai economy and S&T systems

2.1.1 Economic performance and competitiveness

Thailand is an emerging economy which depends heavily on export-oriented products, which accounts for more than two-thirds of the Gross Domestic Product (GDP). Thailand’s GDP in 2007, 2008 and 2009 was about THB billion 7,830.3 (£ 127.1 billion), THB billion 8485.2 (£ 137.7 billion), and THB billion 9,158.3 (£ 148.7 billion) respectively. The growth rate of the GDP was approximately 5% yearly. The country has gradually been moving from an agricultural to an industrial economy, in which the manufacturing sector has become the major contributor to the GDP. In 2008 and 2009, the manufacturing sector contributed 34.9% and 39% of the GDP respectively, while in 2008 the service sector and agriculture sector accounted for 44.2% and 11.6% of the

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2 NESDB (National Economic and Social Development Board, Thailand)
4 http://www.bot.or.th/English/EconomicConditions/Thai/genecon/Pages/Thailand_Glance.aspx (Thai economy & economic condition, Bank of Thailand)
GDP respectively. In 2009 the figures for these two sectors were 37.2% and 8.9% correspondingly. The main manufacturing sectors in Thailand include automobile and automotive parts, electric appliances and components, textiles and garments, and agricultural processing. Although the country has been diversifying into an industrial economy, in 2007 about 49% of the workforce was in agriculture, 37% in services, and only 14% in industry. In 2009 only 14% of workforce was employed in industry, while agriculture and services accounted for 38% and 31% respectively.

It is therefore interesting to underline how Thailand is performing against the rest of the world, and particularly against other Asian countries. According to the Global Competitiveness Index (GCI) of the World Economic Forum (WEF), Thailand was ranked 31st out of 131 countries in the Global Competitiveness Report 2007-2008. Recently Thailand’s performance has somewhat declined; the country was ranked 34th out of 134 countries in the 2008-2009 Report and 36th out of 133 countries in the 2009-2010 Report. On the other hand, the International Institute for Management Development (IMD), a Swiss-based business school, placed Thailand at 27th out of 55 countries in the World Competitiveness Yearbook in 2008.

In this respect when comparing the WEF listing to the IMD listing, it looks as if Thailand performed relatively well. However, the IMD ranking included mostly developed and emerging countries. According to both the WEF and IMD rankings, when compared to developed and emerging countries, including most major Asian nations, the overall national competitiveness of Thailand stands rather in the middle range5. From an Asian perspective, Singapore, Japan, Hong Kong, Malaysia and China have a greater level of national competitiveness in comparison with Thailand, while India, Indonesia, Vietnam, Cambodia and the Philippines are lower.

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5 Competitiveness of Thailand: Economic Analysis from Competitiveness Reports, paper presented at Thailand Development Research Institute (TDRI) Annual Conference 2008, by Piyachart Phiromswad, Sabin Srivannaboon, Taka Fujioka, and Pongsak Hoontrakul of Chulalongkorn University’s Sasin
According to the GCI, there are twelve factors of competitiveness which affect different countries differently. For this reason, in the Global Competitiveness Report countries are grouped into three stages of development (i.e. factor driven, efficiency driven, and innovation driven) based on their GDP per capita. In this respect, Thailand is said to be in the efficiency-driven stage of development. The countries in this development stage must start to develop more efficient production process and increase product quality. At this point, competitiveness is increasingly driven by the efficiency enhancers (i.e. higher education and training, efficient goods markets, well-functioning labour markets, sophisticated financial markets, a large domestic and/or foreign market, and the ability to harness the benefits of existing technologies).

When considering Thailand’s competitiveness factors, Thailand’s strengths lie in the size of its market, its labour conditions, macroeconomic stability, and reasonable good infrastructure. Its weaknesses lie in its poor health-related factors, higher education and training, institutions, innovation, and technological readiness. In relation to the GCI 2009-2010, amongst the twelve factors of competitiveness, the least two factors which Thailand did somewhat poorly were the innovation factor and technological readiness factor. On the scale of 1 to 7, where 7 is the best score, Thailand scored only 3.3 in innovation and 3.7 in technological readiness – both significantly low in comparison to countries like Malaysia, which scored 4.1 and 4.5, and Singapore 5.1 and 5.9 respectively. In terms of ranking, Thailand was ranked 57th in its innovation and 63rd in its technological readiness, whereas Malaysia was ranked 24th and 37th correspondingly, and Singapore was ranked 8th in both of these two indicators.

Obviously, this means that in order to maintain national competitiveness Thailand needs to keep up its strengths and overcome its weaknesses, specifically the innovation and technological readiness factors.

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6 The twelve pillars of competitiveness are divided into three groups. The first group is basic requirements which include four pillars (i.e. institutions, infrastructure, macroeconomic stability, health and primary education). The second group is efficiency enhancers which include six pillars (i.e. higher education and training, goods market efficiency, labor market efficiency, financial market sophistication, technological readiness, and market size).
2.1.2 S&T institutions and evolution of S&T system

The major development of S&T in Thailand started and developed in the midst of the 20th century, and several key institutions related to S&T were established accordingly. The first one was the National Research Council of Thailand (NRCT) established in 1956, which was responsible for providing advice to the government on S&T priorities, funding university research, and facilitating public and private research programmes. The Ministry of Science and Technology (MOST) was later established in 1979. The most recent one is the National Science and Technology Development Agency (NSTDA) established in 1991 with the objective to boost the development of S&T in the country.

The organisational structure of S&T institutions and S&T policy in Thailand is illustrated in Figure 2.1. In general, there are three different policy-related functions within the overall system of S&T in Thailand. Level 1 is policy formulation at a national level; cutting across the policy responsibilities of different ministries and other government agencies. Level 2 is policy formulation and development at the ministerial level; this is concerned with policy development and articulation to meet ministry missions and mandates. Level 3 is policy implementation, and is concerned with managing and funding of the programmes and activities intended to achieve the policy aims of ministries and departments. It is evident that ministerial bodies typically operate independently, while some cross-cutting policy and planning bodies already exist (e.g. NESDB, NSTC, MOST, NRCT, and NSTDA). Even though a number of the research funding bodies already have cross-cutting roles (e.g. NRCT, TRF, and NSTDA), their influence on the core activities of the major ministries carrying out S&T functions has remained rather limited.
LEVEL 1: Policy formulation at national level
- NSTC
- MOF/Budget Bureau
- NESDB

LEVEL 2: Policy formulation & development
- MOE
- MUA
- MOIST
- MOI
- BOI
- MOAC
- MOI (Revenue Dept.)

LEVEL 3: Policy implementation
Action performing institutes, agencies and enterprises
- School & Colleges
- Universities
- STDA & others R&D Institutes
- Support Institute & Programmes
- Incentive Schemes
- SDF & Training Agencies
- Research & Extension Agencies

Figure 2.1 Organisational structure of S&T in Thailand
S&T policies in Thailand are closely related with the national development plans which began in 1961. However, S&T received moderately less attention than the national development plans. It was not until the Fourth Plan (1977-1981) that the direction of S&T development was recognised and formally drawn. Eventually, a chapter on S&T development was first articulated in the Fifth Plan (1982-1986). The S&T chapter in the Seventh Plan (1992-1997) is somewhat noteworthy for three reasons. Firstly, it was the first time that the government asserted to increase the GERD/GDP (Gross Expenditure on R&D (GERD) as proportion to Gross Domestic Product (GDP)) ratio to 0.75%. Secondly, it was the beginning of a sectoral approach to technology development. And thirdly, a variety of innovation policy mechanisms and incentives were initiated. However, the policies put emphasis only in four main areas: i.e. research and development, human resource development, technology transfer, and S&T infrastructure development. Unlike other developing countries in Asia, S&T elements in Thailand were not seen as being part of broader economic policies. Although innovation policy mechanisms were initiated as early as the 1990s, they did not have any practical or functional relevance to industrial policy, investment policy, and to a lesser extent educational polices.

### 2.1.3 R&D performance

Two indicators for countries’ economic development and S&T competitiveness are GERG/GDP and the contribution of private sector in national R&D expenditure. Although the Thai government states in the S&T Chapter of the Seventh National Development Plan (1992-1997) that the ratio of GERG/GDP is to be increased to 0.75%, this figure in fact remains far from reach. Thus far, Thailand’s GERD/GDP has remained about 0.25% between 2001 and 2006 (see Table 2.1). This figure is to a certain extent low compared to neighbouring dynamic economies in Asia, namely South Korea, Taiwan, Singapore. Specifically, when compare with Malaysia which has a more or less similar

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economic development level to Thailand. In 2007, the figure of GERG/GDP in Thailand is only 0.24%, while that of Malaysia account for 0.63%.

Table 2.1 R&D expenditure trends in Thailand 2001-2006 (unit: THB million (GBP million))

<table>
<thead>
<tr>
<th></th>
<th>2001(a)</th>
<th>2002(a)</th>
<th>2003(b)</th>
<th>2004(b)</th>
<th>2005(b)</th>
<th>2006(c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERD</td>
<td>13,485</td>
<td>13,302</td>
<td>15,499</td>
<td>16,571</td>
<td>16,667</td>
<td>19,549</td>
</tr>
<tr>
<td></td>
<td>(£219)</td>
<td>(£216)</td>
<td>(£252)</td>
<td>(£269)</td>
<td>(£271)</td>
<td>(£318)</td>
</tr>
<tr>
<td>Public sector</td>
<td>8,202</td>
<td>8,138</td>
<td>9,174</td>
<td>10,548</td>
<td>9,829</td>
<td>11,550</td>
</tr>
<tr>
<td></td>
<td>(£133)</td>
<td>(£132)</td>
<td>(£149)</td>
<td>(£171)</td>
<td>(£160)</td>
<td>(£188)</td>
</tr>
<tr>
<td>Private sector</td>
<td>5,283</td>
<td>5,164</td>
<td>6,325</td>
<td>6,023</td>
<td>6,838</td>
<td>7,999</td>
</tr>
<tr>
<td></td>
<td>(£86)</td>
<td>(£84)</td>
<td>(£103)</td>
<td>(£98)</td>
<td>(£111)</td>
<td>(£130)</td>
</tr>
<tr>
<td>GDP (d)</td>
<td>5,133,502</td>
<td>5,450,643</td>
<td>5,917,368</td>
<td>6,489,847</td>
<td>7,087,660</td>
<td>7,850,193</td>
</tr>
<tr>
<td></td>
<td>(£83,336)</td>
<td>(£88,485)</td>
<td>(£96,061)</td>
<td>(£105,355)</td>
<td>(£115,059)</td>
<td>(£127,438)</td>
</tr>
<tr>
<td>GERD/GDP</td>
<td>0.26%</td>
<td>0.24%</td>
<td>0.26%</td>
<td>0.26%</td>
<td>0.24%</td>
<td>0.25%</td>
</tr>
</tbody>
</table>

Source: (a) National Science and Technology Development Agency (NSTDA)
(b) National Research Council (NRC)
(c) UNESCO Institute for Statistics (based on national estimation)
(d) National Economic and Social Development Board (NESDB)

Note: Average annual exchange rate (2008), GBP 1 = THB 61.60
(http://www.hmrc.gov.uk/exrate/yearly_rates.htm)

Moreover, considering the contribution of the private sector in GERD, contribution of GERD in advanced countries (such as Japan and USA) is over 70%. Interestingly, the Malaysian government spends about 34% and the private sector accounts for 66%, while the Thai government spends about 60% and the private sector only accounts for 40%. This figure markedly exemplifies the weaker R&D capability of the private sector in Thailand.

Looking particularly at private firms in Thailand, several studies contend that most Thai firms have developed without deepening their technological capability and their technological learning has been very slow and passive (Bell and Scott-Kemmis, 1985; TDRI, 1989; Dahlman and Brimble, 1990; Lall, 1998). According to Arnold et al. (2002), the majority of SMEs in Thailand are concerned with building up operational capability,

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8 International Institute for Management Development (IMD), 2007
9 International Institute for Management Development (IMD), 2003
acquisition and assimilation of technology, and upgrading of rather standard technology. Only a small minority of SMEs and large subsidiaries of transnational corporations (TNCs) have R&D capability. Unlike companies in other developing countries, such as Korea, very few companies in Thailand carry out innovations. The share of innovating firms in Korea is about 42%, while this figure in Thailand is only about 11%. Among the Korean innovating firms, 21% conduct both product and process innovations, 17% conduct only product innovation, and only 4% conducted process innovation. In contrast, only about 2.9% of Thai innovating firms conduct both product and process innovations, 4.1% conduct only product innovation and 4.3% conduct only process innovation. Thai firms use their resources to improve the production process rather than the product itself, reflecting a rather original equipment manufacturer (OEM)-oriented economy (Intarakumnerd, 2006).

The overview of the Thai industry and its contributions on R&D spending in 2005 and 2006 is presented in Table 2.2. In 2006, the majority of firms in manufacturing sector that conducted R&D were large enterprises; i.e. firms with more than 200 employees and registered capital of more than THB 200 million (£ 3.25 million). They contributed THB 5,165 million (£ 83.85 million) which accounted for 78% of total private R&D spending in manufacturing sector in 2006.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Total number of firms</th>
<th>Number of firms conducting R&amp;D</th>
<th>Proportion of firms conducting R&amp;D (%)</th>
<th>R&amp;D spending (THB million, GBP million)</th>
<th>Average R&amp;D spending per firm (THB million, GBP million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>19,381</td>
<td>19,800</td>
<td>934</td>
<td>1,008</td>
<td>4.8</td>
</tr>
<tr>
<td>Services</td>
<td>6,566</td>
<td>8,050</td>
<td>111</td>
<td>29</td>
<td>1.7</td>
</tr>
<tr>
<td>Total</td>
<td>25,947</td>
<td>27,850</td>
<td>1,045</td>
<td>1,037</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Source: Thailand’s R&D Directory in Private Sector, NSTDA

Obviously, the manufacturing sector has been the major contributor to private R&D spending in Thailand. When considering industry sectors, in 2005 the top three industries which had high value of R&D spending were the machinery industry (THB 1,308 million or £ 21.23 million), the food industry (THB 1,080 million or £ 17.53 million), and the chemical industry (THB 761 million or £ 12.35 million) respectively. According to the Thailand R&D in Private Sector Report 2005, there were 935 firms conducting R&D, in which 245 firms were in the food industry, 133 in the chemical industry, and 100 in the machinery industry. The number of firms in these three industries altogether contributed to 51% of total firms conducting R&D activities. In 2006, the food industry contributed the highest R&D spending against other industries in the country, while the chemical industry came second. This trend explains why a large proportion of firms working with public research centres in this study was from the food industry. However, studies (Intarakumnerd et al., 2002; Brimble and Doner, 2007; Intarakumnerd and Schiller, 2008) show that the Thai firms that conducted R&D activities and had research partnerships with public research organisations were mainly large enterprises.

2.1.4 Inherent features of R&D in Thai firms

As in other developing countries, research partnerships between public laboratories and industrial enterprises in Thailand are small in number and rather weak in their relations. An empirical study by Brimble and Doner (2007) indicates three dimensions of weakness of linkages between industry and public laboratories, universities in particular. Firstly, these linkages are likely to involve somewhat low levels of technology. Secondly, they tend to be weakly institutionalised as reflected in the fact that many are of short duration, operate through individuals rather than through more organised “linkage mechanisms,” and lack significant linkages to local or regional institutional assets. Thirdly, there are only a few instances of linkages with significant benefits to both sides, such as improvements in curriculum, creation of new academic units, or upgrading on the part of firms.

11 Thailand R&D in Private Sector 2007, NSTDA
In addition, a study by Arnold, Bell, Bessant, & Brimble (2000) contends that partnerships between industrial-oriented public research organisations and industrial firms in Thailand are rather limited. The Thailand R&D/Innovation surveys in 2001, 2002, and 2003\textsuperscript{12} indicate that firms acknowledge importance of public research organisation (PROs) as sources of information for innovation activities less than they do so for higher educational institutes (HEIs). Intarakumnerd (2007) presents that the importance of PROs is given about thirty points from a 100-point scale, while HEIs are given thirty-five points in this regard. In comparison, Korean companies acknowledge the importance of universities and public research institutes more than Thai companies do. The extent to which PROs and HEIs in Korea are given importance in terms of source of innovation activities are fifty-two and fifty-three points respectively. The survey report in the Thai case is presumably a reflection of a mismatch between what Thai public research institutes and universities can provide and what firms in Thailand want. Thai PROs in particular have taken a one-way approach to their functions, i.e. define priorities themselves and subsequently develop technologies that they hope will be transferred to private firms. This also indicates that communication channels between the two sides are quite poorly developed. The latent factor for weak linkage is the fact that the Thai industry has a low level of internal R&D activity. Consequently, they are improbable to establish research links with public laboratories. Instead, they are likely to use public laboratories as vicarious research partners by way of contracting out their scientific activity. The public laboratories themselves also have technological constraints working with industry in terms of research relevance to match industrial needs (Intarakumnerd and Schiller, 2008).

2.1.5 Transition of Thai’s national innovation system

2.1.5.1 A major shift in Thai government

S&T development policies from 1990s until early 2000s have covered only four main functions as aforementioned in section 2.1.1 and there were no selective industrial policies to promote specific industries. In this respect, the national innovation system in

Thailand has been viewed as rather narrow in scope and characterised as weak and fragmented (Intarakumnerd et al., 2002). However, Thailand’s national innovation system is in transition; it is the government’s agenda to aspire to gradually evolve from a weak and fragmented national innovation system toward a strong and more synergistic one (Intarakumnerd, 2006).

In the early 2000s, there was a major shift in the Thai government and policy regime. In the domain of S&T policy, the new ten-year National Science and Technology Strategic Plan (2004-2013) was introduced. The plan placed the concept of national innovation systems and industrial clusters at its heart, providing a much broader scope than the aforementioned four conventional functions (Intarakumnerd, 2005). The targeted clusters included in the plan were food, automotive, textile, software and microelectronics, tourism, health, bio industry, environment, and community (grass-root) products. In translating the plan into practice, government authorities acting as cluster development agents were assigned to facilitate cooperation among actors in each cluster. This was considered as a major change in scope of S&T policy in Thailand (Intarakumnerd and Chairatana, 2008).

There are also other favourable signs indicating the changes in the Thai government (Intarakumnerd et al., 2002). Firstly, the National Science and Technology Committee has recently been set up. The committee, chaired by the Prime Minister, oversees the development of S&T and co-ordinates all previously unconnected government agencies, including economic ministries, responsible for increasing the country’s competitiveness in S&T. It also has a sub-committee on strengthening the technological capabilities of the private sector. Key personnel from the private sector (such as CEOs of large Thai conglomerates and TNCs, and executives of industrial associations) are members of the committee and the sub-committee. Secondly, the government budget for public research organisations has been reduced. While public research organisations are under pressure from the Budget Bureau to increase their revenue, reducing their reliance on the national budget compels them to be more relevant to industrial needs to earn extra income and try to promote technological development within firms. Thirdly, the long-
standing investment strategy has recently been rearranged in accordance to a major economic structural adjustment. Priority has been given to increase the support of industries that are knowledge-intensive. The new investment strategy of the country focuses on increasing value-added and indigenous technology capability of the industrial sector.

Furthermore, there are substantial changes in government policy in order to boost the underlying long-term competitiveness of the country. For instance, the Board of Investment (BOI) has initiated a special investment package promoting ‘skill, technology and innovation’ under which firms can enjoy extra tax incentives if they perform the following activities. This includes spending on R&D or designing at least 1-2% of their sales; employing at least undergraduate scientists or engineers at least 5% of their workforce; spending on training of their employees at least 1% of their total payroll, and spending at least 1% of their payroll on training personnel of their local suppliers. Another tax incentive to stimulate R&D activities in private sectors provided by Revenue Department is a 200% tax deduction for R&D expenditure. Concerning policy implementation, S&T policy in particular, has also changed its strategies and initiated new policies in response to the National S&T Strategic Plan (2004-2013). This will be discussed in Section 2.3 of this chapter.

2.1.5.2 Changing behaviour of Thai firms

The behaviour of Thai firms has started to change, to some extent, as a consequence of increasingly strong competition in the global market and the economic crisis in 1997. A recent study by Arnold et al. (2002) highlights some interesting phenomena in the Thai industry. Firstly, several large enterprises recently increased their R&D activities. Secondly, Thai firms started to change their attitude of relying on ready-made foreign technologies towards developing in-house R&D capabilities. Thirdly, a number of SMEs have increasingly been collaborating with university and research organisations to increase their competitive advantage. Lastly, new start-up firms relying on their own development activities are emerging. Another recent study by Intarakumnerd and Virasa (2002) also confirms the positive changes in Thai firms. These authors state that
due to external pressure, especially from foreign customers that adopt global sourcing strategies, several local OEM manufacturer started to develop product through their own design and brand name.

2.1.5.3 Changes in HEIs and PROs

According to the Thailand R&D/Innovation Surveys performed by NSTDA, HEIs and PROs were not regarded as vital sources of external information for Thai firms. This finding was common to all innovation surveys. On the other hand, their parent/associate company, suppliers and competitors are much more important sources of external information. Technological activities of Thai universities and PROs mainly focus on R&D and providing technical services, not on assisting firms to build up their ‘internal’ technological capabilities, especially ‘non R&D’ capabilities such as technology assimilation and adaptation, designing and engineering, which are the technological threshold faced by most Thai firms (Intarakumnerd, 2006). Consequently, this particular circumstance inevitably creates academic-industry gaps which hinder meaningful collaboration. Table 2.3 summarises the gaps in academic-industry collaboration in Thailand and demonstrates the weaknesses for both sides.

<table>
<thead>
<tr>
<th>Table 2.3 Gaps in academic-industry collaboration in Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Academia</strong></td>
</tr>
<tr>
<td>Generally, academic institutes initiate and dominate the relationship, hence, major activities are not two-way cooperation</td>
</tr>
<tr>
<td>Linkages are in terms of asking for help rather than achieving the project together for maximum benefit of the two parties</td>
</tr>
<tr>
<td>No substantial linkages in terms of R&amp;D projects</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Source: College of Management, Mahidol University (2003)
Nevertheless, similar to other developed and developing countries, HEIs and PROs in Thailand are under pressure from decreasing government budgets. The Thai government consented to gradually converting several HEIs as well as PROs to autonomous status. In 2007, several leading public universities attained autonomous status. While most of their budget will be subsidised by the government, they are expected to generate additional income from other sources, particularly from the private sector. In this respect, Thai universities and PROs have been forced to conduct research and other activities that are more relevant to industrial needs to earn extra income. Generally, they have tried to increase industry sponsorships and to create linkages with industry through collaborative R&D and training activities.

2.1.5.4 Recent development of a public research organisation

There are recent indications that NSTDA and its national research centres are beginning to place more attention on the linkages with industry, and even to move further and support industry linkages with academia (Brimble and Doner, 2007). For instance, the National Centre for Genetic Engineering and Biotechnology (BIOTEC) has positively contributed to the shrimp industry by providing support for R&D and cooperation amongst all industry sectors in the value chain, supporting training to scientists, technician and students in shrimp biotechnology, and increasing technology transfer from academia to industry. These efforts have resulted in the creation of new research in new laboratories that have acted as centres of excellence in specialised fields related to shrimp research and extension. Also, Shrimp Culture Research and Development Company - a BIOTEC initiative - has been set up to commercialise R&D results, such as virus test kits and diagnostic training.

In addition, the National Metal and Materials Technology Centre (MTEC) has recently placed more attention on serving automotive industry. In that MTEC is shifting its research focuses to become more relevant to industrial needs (such as finite elements, which can be used for designing many parts of motorcycle and automobile, computer-aided design, engineering and manufacturing, failure analysis and material degradation), and to provide testing and training services to the private sector in the
aforementioned areas. Moreover, the National Electronic and Computer Technology Centre (NECTEC) has played a supportive role in the HDD cluster project. In that NECTEC works with International Disk Drive Equipment and Materials Association (IDMA), Thailand\(^\text{13}\) to set up a cluster management organisation which acts as a coordinator between all main actors, and pushing forward future projects aimed at upgrading the capabilities of the whole industry in Thailand, such as joint training programmes and collaborative R&D projects\(^\text{14}\).

Furthermore, the government attempts to use science park as a policy tool to promote S&T development. The TSP, the country’s first science park, was opened in mid-2002 to be the first fully integrated R&D hub, serving NSTDA’s headquarters and accommodating NSTDA’s research centres as well as technology-based enterprises. Apart from the first science park, TSP, which is located near the Bangkok metropolitan area, the government has planned regional science parks located in the north, the south, the northeast, and the east of the country. These regional science parks will be associated with leading local universities. Furthermore, the Higher Education Commission in the Ministry of Education is in progress of setting up incubators at some twenty universities to encourage spin-off companies and more R&D in the private sector. These initiatives could play important roles as catalysts to the formation of linkages between the public and private sector in the Thai economy, in particular university-industry linkages (Brimble and Doner, 2007).

The attributes of NSTDA and its centres are presented in the next section.

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\(^{13}\) International Disk Drive Equipment and Materials Association (IDMA), Thailand is the Thai branch of IDEMA which promotes the technological, manufacturing, marketing, and business needs of the disk drive industry.

\(^{14}\) IDEMA - Press releases, 3 February 2005 (NECTEC, NSTDA and BOI create HDD Cluster Development project to boost the Hard Disk Drive industry in Thailand)
2.2 Context of public research organisation – the case of NSTDA

2.2.1 Institutional design

The National Science and Technology Development Agency (NSTDA) was established by the Scientific and Technological Development Act of 1991 and officially commenced in 1992 under the Ministry of Science and Technology. This organisation has autonomous status and is committed to applying scientific and technological capabilities to promote and sustain the nation's economic, social development and growth. The establishment of NSTDA brought together four existing national bodies – the Science and Technology Development Board (STDB) set up in 1985; the National Centre for Genetic Engineering and Biotechnology (BIOTEC) set up in 1983; the National Metal and Material Technology Centre (MTEC) set up in 1986; and the National Electronics and Computer Technology Centre (NECTEC) set up in 1986. The three national research centres have dual roles, i.e. providing research funding to universities and conducting in-house research. The STDB was reshuffled to function as NSTDA’s central administrative office. In 2003, the fourth national research centre, National Nanotechnology Centre (NANOTEC) was established under the roof of NSTDA. The latest centre established in 2005 is the Technology Management Centre (TMC).

The main mission of NSTDA includes conducting and supporting research and development in science and technology to strengthen Thailand’s sustainable competitiveness. The mission is complemented with: (1) technology transfer activities; (2) development of human resources in science and technology; and (3) development of science and technology infrastructure. The organisation structure of NSTDA is illustrated in Figure 2.2.
During the first decade of NSTDA’s establishment (1992-2001), administrative offices and laboratories facilities were located in different sites in the Greater Bangkok area. Some of NSTDA’s units and laboratories were within the premises of the Ministry of Science and Technology, while many of them were based within academic and research institutes. It was only in 2002 that NSTDA and the research centres moved into Thailand Science Park (TSP), the first science park of the country.

The following presents features of the four national research centres and the TMC.

**National Centre for Genetic Engineering and Biotechnology (BIOTEC)**

Recognising the potential and importance of biotechnology to national development, the government established the National Centre for Genetic Engineering and Biotechnology (BIOTEC) under the Ministry of Science and Technology in 1983. After the establishment of NSTDA in 1991, BIOTEC became a member of NSTDA, operating outside the normal framework of civil service and state enterprises. This enabled the centre to operate more effectively to support and transfer technology for the development of industry, agriculture, natural resources, environment and consequently the social and economic well-being of Thai people. The main objective of BIOTEC is to induce dynamics in research, development and application of biotechnology in order to support technology development and adoption in both public and private institutions.  

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Amongst the four national research centres, BIOTEC has an extensive network and strong ties with academic and government research institutes, rooted since its early years. In 1985, two years after its establishment, two specialised laboratories (namely Plant Genetic Engineering and Microbial Genetic Engineering Units) were initiated at Kasetsart University and Mahidol University. Later on, a number of different BIOTEC specialised laboratories were set up and based in universities throughout the country. After the construction of Thailand Science Park was completed, most of these specialized laboratories were relocated into the Park, where the core and greatest facility of BIOTEC Central Research Units is now located. However, there are a number of research units which still remain at universities throughout Thailand. This is to maintain the close link with academia.

Research and development at BIOTEC is driven by almost 400 skilled researchers, covering the different areas where biotechnology has appropriate application. Its operating budget in 2005 and 2006 were approximately £13 million and £16.5 million (THB 790 million and THB 990 million respectively), where about 90% of the budget was allocated from the Thai Government and the other 10% was income from other sources. There were 456 and 433 research projects in total in 2005 and 2006 respectively, where the ratio of in-house to external projects was 30:70 in 2005 and 40:60 in 2006. In addition, during 2005 and 2006, one patent application was granted in Thailand, while twenty-seven patents were filed in Thailand and overseas.16 Furthermore, in the past ten years, BIOTEC has licensed twenty-three patents. The Centre equips its capability to handle a wide variety of research in biotechnology-related areas. These range from agriculture, food, medical, biofuels, biodiversity, and the environmental sciences. BIOTEC has also succeeded in transferring several technologies to the private sector.

National Metal and Materials Technology Centre (MTEC)

The National Metal and Materials Technology Centre (MTEC) was established by the Cabinet on 16th September 1986 as a project under the Office of the Permanent-Secretary

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16 BIOTEC Annual Report 2005-2006, National Centre for Genetic Engineering and Biotechnology
of the Ministry of Science and Technology. Its main objective is to support research and development in metals and materials. Similar to BIOTEC, MTEC was merged into NSTDA in 1991.

MTEC aims to develop and strengthen technological capability in materials and related technologies (including design and manufacturing) in both the public and private sectors in order to drive and sustain industrial development, economic growth and environmental well being. MTEC’s main focus is said to be on developing the technological capabilities of supply industries, particularly the small- and medium-sized enterprises that manufacture and supply parts and components to automotive, electronics and electrical appliance industries. Other industries targeted by MTEC include agricultural machinery, industrial machinery, biomedical and devices, and textiles.

MTEC’s annual budget in 2007 is approximately £ 17 million (THB 1,012.40 million) and has 460 personnel. There are 312 research and development projects in total, of which 170 projects are in-house projects accounting for more than half of the total R&D projects. The number of support and funding projects, contract and collaborative research are ninety-four, thirty-four, and fourteen projects respectively.17

MTEC focuses on forging relationships with both the private and public sector for extensive research in the automotive and transportation industry. In 2007, MTEC was granted eight patents, while thirty-three new patent applications have been filed. In addition, five technologies from MTEC have been transferred to 246 firms in MTEC’s related industries. Major achievements to date include the Manufacturing and Design Technology Centre (MDTC), rapid prototyping project, and the transfer of metal and materials technology activities through the Specialty Technology Unit (STC).

As a member of NSTDA, MTEC’s direction of research and development activities has been restructured to align with the fourth NSTDA Strategic Plan (2006-2010). As a

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17 MTEC Annual Report 2007
Consequence, MTEC set its operational plan for the fiscal year 2006-2010 to focus on five key areas: (a) developing technology to produce high value added from natural resources; (b) manufacturing design and product development; (c) renewable energy; (d) medical applications; and (e) agricultural promotion. To implement the plan, MTEC collaborates with partners from universities, research institutes and industry to provide technical and information services through contract research and development and technical consultancies.

**National Electronic and Computer Technology Centre (NECTEC)**

Similar to MTEC, the National Electronics and Computer Technology Centre (NECTEC) was also founded on 16th September 1986 under the Ministry of Science and Technology, and in 1991 it was transformed into a specialised national centre under NSTDA. The vision of NECTEC is being a core organisation forging R&D alliances within electronics and computer technologies for strengthening the sustainability of Thai industries and sufficiency in society. Its main responsibilities are to undertake, support, and promote the development of electronics, computing, telecommunication, and information technologies through research and development activities.

NECTEC has recently adopted its research and development laboratories and cluster programmes in accordance with NSTDA’s R&D cluster-based management concept and national industrial cluster. NECTEC main focus is software, microchip and electronics cluster. The cluster programmes are to enable the centre to enhance linkages between research communities and industries. It is expected that the cluster programmes would allow industrial members to share core technologies and human resource development programmes.

NECTEC supports the units/projects that have potential to grow and generate their own income to be spun off as private companies or autonomous organisations under the supervision of NSTDA. Examples of NECTEC/NSTDA spin-off companies are: Internet Thailand Co., Ltd. and Information Security Company (T-NET). The spin-off autonomous organisations include: Government Information Technology Services
(GIST); Hydro and Agro Informatics Institute (HAI); and Electrical and Electronic Products Testing Centre (PTEC).

Furthermore, the centre stresses the important of strategic research and industry indicator, in which NECTEC contributes to work on the research of technological strategies and industrial indicators for indicating the status and level of relevant industries and technologies in Thailand and neighbouring countries. Market and technology trends are studied and published in the form of white papers.

**National Nanotechnology Centre (NANOTEC)**

Responding to the fast growing development of nanotechnology and its applications to manufacturing technology in the 21st century, the National Nanotechnology Centre (NANOTEC) was officially established on August 13, 2003. It is the latest national research centre under the umbrella of NSTDA.

NANOTEC’s vision is to create micro- and nanotechnologies that able to contribute to Thai industries, protect the environment and give rise to niche innovative products, processes, and increase competitiveness in the global market. Its mission is to support and promote the nanotechnological development of the country through research innovations, technology transfer, human resource development, and infrastructure. During the past three years, NANOTEC has initiated and supported various projects in the fields of semiconductor and optical devices, nanocomposite, nanoscale surface coating, and nanoencapsulation of active ingredients. NANOTEC, however, has currently focused more on R&D by concentrating on three essential platform technologies; nano-coating, nano-encapsulation, and nano-devices. With these three platforms, they will be applied mostly by three major industrial clusters; Textiles, Cosmeceutical, and Food.
Technology Management Centre (TMC)

NSTDA is a multi-functioning S&T organisation: i.e. it conducts and promotes R&D and technology transfer activities, develops S&T infrastructure, and provides support for human resource development. Systematic organisational arrangement is necessary as the organisation progresses and increases in its scope and size. In this regard, NSTDA established the Technology Management Centre (TMC) in order to response for managing of NSTDA’s technologies and technology transfer related activities. As such, TMC is anticipated to accelerate the development of knowledge-based industry in Thailand through a holistic and effective technology management system. While NSTDA’s research centres place emphasis on working with public and private sectors through R&D activities, TMC works primarily with private sectors by providing various mechanisms for industry support and research collaboration between academic and industry as aforementioned.

Three key missions of the TMC include: firstly, to upgrade the technological capability of Thai SMEs through the provision of technical consultation and commercialization of NSTDA’s intellectual property and other selected technologies, as well as financial assistance schemes; secondly, to develop knowledge-based companies and entrepreneurs through the provision of R&D facilities in science parks and incubators; and thirdly, to incubate NSTDA’s technology institutions and programmes under the national agenda to increase the pool of high calibre human resource in science and technology.

2.2.2 The role as an intermediary agent

Unlike other PROs in the country, NSTDA was founded with the explicit aim to be an agency with a high degree of autonomy and mobility unbound by the usual bureaucratic rules and regulation\(^\text{18}\). This enables NSTDA to conduct, support, coordinate, and promote efforts in scientific and technological development between the public and private sectors towards maximal benefit for national development. In

\(^{18}\) NSTDA in brief, www.nstda.or.th
general, the majority of basic and applied research activities are carried out in higher education institutes and public laboratories, while technology development and applications are strongly emphasised in industry. In the case of Thailand, NSTDA serves as an intermediary organisation which connects academia and industry, bringing them to work together through a wide range of coordinated S&T programmes (see Figure 2.3). By acting as a liaison agent, NSTDA aims to reduce uncertainties between academia and industry, coordinates the use of knowledge, mediates conflict and provides incentives.

![Figure 2.3 NSTDA position
Source: NSTDA, 2007](source: NSTDA, 2007)

However, the dual roles of NSTDA in supporting R&D activities, mainly to universities, and implementing R&D activities through its research centres, are sometimes to some extent a contradiction in itself. Conspicuously, there might be the issue of conflict of interest regarding NSTDA’s research grant to universities 19; that is, as NSTDA and universities are trying to link with industry through research collaborative projects, it could be possible that they may have similar research proposals. Acting as a funding organisation for university research, NSTDA may consider providing a smaller research grant to research proposals from universities and allocate more funding to NSTDA’s research centres in similar areas of research work. This is because Thai universities are slowly starting to partner with private sectors in research project cooperation, consulting projects and practical training for students in order to perform applied

19 Interview with Director of Policy and Planning Department, NSTDA 27 March 2008
research to better link with industry (Numprasertchai and Igel, 2005). Most R&D activities of Thai universities comprise applied research (i.e. adapt knowledge from developing countries and attempt to generate results that appropriate in the Thai context), hence making it more likely to meet the private sector’s demands (Schiller and Liefner, 2007). In this regards, research centres of NSTDA and university laboratories might become competitors to some degree in receiving research funding and creating R&D collaborative projects with industry.

### 2.2.3 Resource and performance

Since its inception, NSTDA has grown rapidly. It has served as a key institution where leading scientists and experts can meet and work to carry out scientific and technological activities. The number of NSTDA personnel has increased from about 1,500 in 2002 to about 2,400 in 2008, in which about 65% of the total staff are researchers and technicians involving in R&D related activities\(^{20}\). The annual government budget has been doubled from about THB 1,700 million (about £ 28 million) in 2003 to THB 3,414 million (about £ 57 million) in 2009\(^{21}\).

Figure 2.4 presents NSTDA resources in terms of personnel and government budget. Each year, about 35% of the budget is for conducting and supporting R&D, 20% for development of S&T infrastructure, 15% for implementation of technology transfer activities, 10% for development of human resources in science and technology, and 20% for general administration and management respectively\(^{22}\).

\(^{20}\) NSTDA Report 2002-2008

\(^{21}\) NSTDA Internal Document 2009

\(^{22}\) NSTDA Annual Report 2006, National Science and Technology Development Agency
In terms of NSTDA’s R&D performance, the accumulated figure of publications by NSTDA researchers in international journals has also increased from fifty-six articles in 2002 to 426 articles in 2008. In addition, from 1991 (when the organisation was established) to 2007, NSTDA has filed 347 patent applications both locally and internationally. The number of patent applications increased since the early 2000s. The establishment of NSTDA’s Technology Licensing Office (TLO) in 2005 also boosted the figure of patent applications in recent years. By 2008, NSTDA had been granted sixty-five patents. Figure 2.5 illustrates the accumulated number of patents filed and the breakdown of the number of patents filed from 1991 to 2007.
Additionally, NSTDA conducts and supports a number of research and development projects each year. The types of projects include in-house research, funding to universities, contract research, and collaborative research. Figure 2.6 illustrates the number of each project by type between 2002 and 2008. Interestingly, the number of in-house projects has increased since 2002, while that of the support and funding projects has decreased. As a consequence, the ratios of in-house projects against R&D funding to universities were about 1:3 in 2002 and 1:1 in 2006. In 2008, the number of in-house research is almost doubled that of the R&D funding to universities.
This phenomenon is explained by the fact that the number of NSTDA staff, especially researchers and technicians, has increased every year, resulting in the increasing number of in-house project proportionally. In addition, due to the changing strategic management of NSTDA, the organisation tried to gradually balance the number of in-house research and funding research projects and eventually decreased its role as a funding agency to university research. This is evidenced in 2008 where the number of in-house research is almost twice that of funding research to universities. Increasing in-house research projects has also boosted the number of NSTDA research publications in international journals as mentioned. An important reason underpinning this increase is that it is in NSTDA’s interest to better manage research directions carried out in-house and to improve utilisation of the research results for economic and social benefits.

While in-house projects and funding to universities involve research in public sector, contract and collaborative research projects are related to public-private research partnerships. Interestingly between 2002 and 2008, the number of contract research had increased every year, whereas there has been only marginal increase in the number of collaborative research with industry. Although NSTDA has put forward policies to
enhance research partnerships with industry, the policy initiatives and their implementation are still ambiguous. Interestingly, it is questionable what triggers the collaboration of NSTDA and the research centres with industry.

2.2.4 Policies and mechanisms to promote S&T development

It has been perceived that NSTDA has played a significant role in supporting Thai industry, by providing both technical and financial support to promote the upgrading of technology, to promote the R&D for new products and processes, and to raise production standards for competitiveness and sustainable development23. By means of the Technology Management Centre (TMC), NSTDA has devised private sector support programmes, including technical support and technology transfer, financial support, and S&T infrastructure and facilities.

Technical support and technology transfer

A leading technical support programme is the industrial consultancy services which has been provided by Industrial Technology Assistance Programme (ITAP). ITAP has a network of eleven satellite units throughout the country to increase innovative and technological capability of SMEs. ITAP has been claimed to help Thai SMEs to gradually move up the technological ladder, i.e. from labour intensive and skill intensive to technology intensive, and finally R&D intensive activities. ITAP’s methods are illustrated in Box 2.1.

23 http://www3.easywebtime.com/itap_eng/about.html
Box 2.1  ITAP: NSTDA’s model to promote technological advancement in Thai Industry

ITAP assists firms to upgrade technology by diagnosing technical problems, sourcing experts to solve the problems, and subsidising expenses up to 50% of the project cost but not exceeding approximately €8,300 (THB 500,000). ITAP uses ITAs (Industrial Technology Advisors), who are science and engineering graduates with some degree of industrial experience, as liaison persons to assist firms in searching for and acquiring appropriate technology. In terms of experts sourcing, ITAP explores possibilities from both local and overseas experts. In cases where overseas experts are employed, ITAP attaches local university people to overseas experts on a regular basis to facilitate technology transfer to firms and universities.

It is worthwhile to note that sixty per cent of ITAP experts are sourced from local universities, while only 3% are from BIOTEC, MTEC, NECTEC, and NANOTEC. The number of researchers from the research centres participating in ITAP programme is possibly because the majority of ITAP projects are viewed more or less as technical problem-solving and technology upgrading, not R&D intensive projects. However, a number of NSTDA researchers have play their role in ITAP projects as technical evaluators when the project is completed. This provides an opportunity for the researchers to network with firms and university experts. In some cases, contract and/or collaborative research projects between firm and research centres are derived as a result of their relationships in ITAP projects.

ITAP’s mechanisms have proved to be successful in promoting university researchers as experts, creating industry-university linkage, and encouraging contract and collaborative R&D project between public and private sectors. The figure of ITAP projects has dramatically increased in the past few years. The number of projects increased from 400 in 2006 to about 800 in 2009. Among these, new projects initiated in 2009 were about 450 projects, while in 2006 that figure was only about 170 projects. ITAP performance is built up from ITAP headquarters located at NSTDA and the network of eleven satellite ITAP units in locations associated with leading universities in the north, north-eastern, east, west and south of Thailand.

Additionally, ITAP endeavours to encourage firms to conduct not only upgrading technology but also R&D projects. It is evidenced that some of ITAP’s clients, who have worked with ITAP for quite some time and have more than one or two technology upgrading projects, have begun to create in-house R&D related activities. These firms have gradually developed their technological capability from skilled-intensive firms to technology-intensive and to some degree R&D intensive ones.

24 ITAP Performance Report, 2009
25 Ibid.
26 ITAP internal document, ITAP’s success stories, 2006 (in Thai)
Equally important, the private support programme regarding technology transfer is provided by the Technology Licensing Office (TLO). The support programmes provided by TLP include providing advice regarding intellectual property protection to firms, and managing and marketing NSTDA’s intellectual properties. TLO functions as NSTDA’s unit responsible for commercialisation of NSTDA technology, matching the needs of technology users (firms) and suppliers (NSTDA’s research centres). Recently, TLO launched the NSTDA Idea-to-Product (I2P) Competition, an early-stage technology commercialisation plan competition, which is opened to NSTDA-funded researchers who are interested in technology-focused entrepreneurship27. The competition provides a good start for the researchers to speed up the commercialisation process of their research results.

Financial Support:

Apart from technical support, TMC/NSTDA also provides financial support to encourage R&D in the private sector by way of soft loans (up to about £ 333,300 per project (THB 20 million)) and R&D grants. Moreover, joint investment on projects that have considerable impact on the country’s S&T development is provided by mean of NSTDA Investment Centre (NIC). Since 1998, NIC/NSTDA has supported the establishment of twelve technology-based companies with an investment amount of about £ 1.4 million (THB 84.04 million)28. The Shrimp Culture Research and Development Company, initially Shrimp Biotechnology Business Units within BIOTEC, is among one of the success companies in NIC’s investment portfolio. More recently, NSTDA has also introduced NSTDA spin-off policy to encourage entrepreneurship among the community of NSTDA researchers, to assist them in their business endeavour, and facilitate industrial exploitation of NSTDA research projects. 29

27 http://www.ideatoproduct-asia.org/
28 http://www.stks.or.th/nic/ (in Thai)
29 http://www.stks.or.th/nic/index.php/spin-off-policy (in Thai)
One of NSTDA’s mandates is to provide infrastructure and facilities which are critical to the development of science and technology in the country. Thailand Science Park (TSP), the first science park of the country, was thus created to serve this purpose. TSP is under the management of TMC.

The development of TSP was initiated during Thailand’s Sixth National Economic and Social Development Plan (1987-1991). In 1989, the government of Thailand entrusted NSTDA to establish and manage the TSP. A few years later, a feasibility study was completed and the construction plan began. However, it took more than ten years for Thailand to materialise the country’s first science park. The project should have been launched by the end of 1990s, however Thailand were affected by economic crisis of 1997. Due to the crisis, the construction budget was delayed about three years. Eventually, in 2002 TSP began its operation as a fully integrated hub for R&D in science and technology in Thailand. Its mission is to create a dynamic S&T community comprising of successful companies, promising enterprises, innovative entrepreneurs and public institutions. It was expected to strongly support the S&T community in its R&D and business endeavours, and encourage cooperation amongst universities, public agencies and industries.30

TSP is located in Pathumtani Province, in the northern outer skirt of Bangkok, on eighty acres of land adjacent to two academic institutes: Asian Institute of Technology (AIT) and Thammasat University (TU). The park is intended to comprise of three zones: i.e. NSTDA and its research centres as well as the TMC; an incubation space; and renting space for technology-based firms. TSP has strived to create an environment that is conducive for R&D cooperation and commercialization, and encourage joint research projects in which private sector can share and exchange knowledge with national-level specialists, as well as share the use of laboratories and high-tech equipments.

30 http://www.sciencepark.or.th, 2009
TSP was planned to consist of two development phases. The first phase was to build up R&D critical mass and was completed, in which national research centres re-located to the park (in 2002) and over fifty tenants moved in (by the end of 2007). The aim of the second development phase is to encourage more companies from the private sector to establish themselves in the park, and is currently ongoing. The park is expected to attract a further 150 tenants.

The profile of the tenants of TSP is diverse. The ratio of local to international firms is 70:30. In terms of key activities, about 65% of the tenants are doing R&D, about 20% are in R&D support business, and 15% provide services. In terms of industrial sector, the tenants are in three industrial sectors: metal and advanced material (40%); biotechnology (30%), and electronic and computer technology (30%). These firms have contributed to the creation of 374 jobs, in which 223 personnel are researchers and engineers, and have contributed to the country’s economic value of about £40 million (THB 2,365 million) a year. 31

The park has a dual purpose to assist technology-based start-up companies as well as to encourage large local and international companies to invest in research and development in Thailand; therefore it caters for all sizes of technology-based firms. It has small and medium rental space available for start-ups and established firms. Long-term lease land is also available for large companies to invest their R&D unit. Small scale pilot production or high value-added production in support of product and market development and innovation may be permitted in the park. However, mass production is not allowed.

Tenants at TSP benefit from R&D incentives provided by the government can enjoy Board of Investment (BOI) privilege equivalent to ‘BOI Zone Three’ investment promotion schemes in Zone 1 area32. These privileges include: (1) exemption of import duty on machinery; (2) corporate income tax exemption for a period of eight years; and

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31 Internal document, Thailand Science Park 2006
32 BOI Zone 1 includes Bangkok and 5 provinces (i.e. Samut Prakan, Samut Sakhon, Nakhon Pathom, Nonhhaburi and Pathumthan). Zone 2 includes twelve provinces in central and eastern parts of the country. Zone 3 encompasses the remaining fifty-eight provinces.
(3) 50% reduction of corporate income tax for a period of five years from the expiry of the eight-year corporate income tax exemption. In addition, tenants can apply for tax deduction for research expenditures at 200% from Revenue Department if they choose to do so. This government incentive is not only limited to firms located in the TSP; it is also available to off-park firms that have R&D activities.

2.3 Institutional shift: NSTDA’s innovation model

As aforementioned in section 2.1.3.1, the Thai government has recently emphasised the nation’s competitiveness by using a cluster-based approach as the main strategy for improving the country’s weak and fragmented national innovation system. In the shift towards a knowledge-based economy, NSTDA has endorsed the National Science and Technology Strategic Plan (2004-2013) focused on technology development in specific areas including biotechnology, materials technology, nanotechnology, and information and communication technology (ICT). The main objectives of this Plan are to enhance Thailand’s capability to be able to effectively respond to rapid changes in the age of globalisation and to strengthen the country’s long-term competitiveness under the vision: Thailand is economically competent, being a knowledge-based society, globally competitive, socially secured and with all its citizens having a good quality of life. In driving toward the goals of the vision, four fundamental development factors are emphasised: (1) the strength of the national innovation system (2) the strength of human resources (3) the enabling environment for development, and (4) the capability of the four core future technologies, i.e. ICT, biotechnology, material technology and nanotechnology.

As shown in Figure 2.7, the Plan contains five strategies to enhance the long-term competitiveness and sustainable development of the Thai economy, in anticipation to leapfrog from a labour-intensive and skilled intensive positioning to an R&D intensive one.
2.3.1 Organising the industrial cluster at NSTDA

Prior to the endorsement of the National Science and Technology Strategic Plan (2004-2013), R&D activities had been carried out with limited synergies between public and private sectors, as well as within the government and industry themselves. The changing climate of S&T in the country started with the emergence of the national industrial cluster initiative directed the relevant parties to set strategic goals in moving towards a knowledge economy. The cluster approach initiative was recommended to the Thai government by Professor Michael Porter, according to his 2003 and 2005 study on what Thailand should focus on in order to promote the country’s competitiveness. Consequently, national industrial clusters were identified.

In response to the national cluster-oriented policy, during 2004-2005 NSTDA deliberately devised a new management tool, the Strategic Planning Alliance (SPA), which embraces the concept of clusters as a source of national competitiveness, to reorganise and restructure the organisation. The model of NSTDA’s SPA which has been implemented since 2006 is presented in Figure 2.8.
The SPA initiative has brought the clusters concept to the level of practice by initiating NSTDA R&D cluster programmes to reinforce national clusters and restructuring its R&D strategic management. The main idea of NSTDA’s SPA initiative is programme-based research, rather than technology-based, to cut across the research disciplinary focus of each of the centres. This aims to enable researchers in different centres to work together under a research programme relevant to their expertise, as well as to facilitate multidisciplinary research in response to Thailand’s strategic industrial clusters. The Cluster Programme Management Office (CPMO) is responsible for the management of NSTDA’s research clusters and programmes.

Through the SPA implementation, NSTDA has initiated four cluster programmes: NSTDA strategic clusters, NSTDA industrial clusters, platform technologies and essential programmes for technological and industrial applications, and internal management programmes to reinforce its national clusters. The strategic clusters are major innovative programmes that have significant potential for innovation and commercialisation. They are designed to be programmes which respond to industrial needs and are expected to achieve short-term result (within 1-2 years). The NSTDA industrial clusters are intended to create potential for new commercial product
development. They are medium-term programmes (2-3 years) which are expected to support the development of national clusters. The platform technologies and essential programmes for basic knowledge are long-term programmes (3-5 years) to support the advancement of the strategic sub-cluster and the national clusters programmes and to promote their technological and industrial application. The internal management programmes intend to improve internal capabilities to support transition of the organisation to a knowledge-based community. The details of these cluster programmes underlying NSTDA management policy are illustrated in Box 2.2.

Box 2.2 Cluster programmes at NSTDA under National S&T Policy (2004-2013)

**Group A: NSTDA strategic clusters**
- Shrimp
- Emergency Diseases
- Hard Disk Drive
- Radio Frequency Identification (RFID) and Smart cards
- Solar Cell
- Bioenergy
- Fabric

**Group B: Industrial clusters**
- Food and Agriculture
- Medical and Healthcare
- Automotive and Transportation
- Software, Microchips, and Electronics
- Environment
- Renewal Energy
- Textile
- Rural Community and the underprivileged

**Group C: Platform/core technologies and Essential programmes for technological and industrial applications**
- Biotechnology: BIOTEC (i.e. Genomic medicine, Cell technology, and System biotechnology)
- Material technology: MTEC (i.e. Simulation for design and manufacturing, Surface sciences and engineering, and Materials compounding and forming)
- Information, Computer and Telecommunication (ICT): NECTEC (i.e. Sensor technology, Security technology, Intelligent knowledge management)
- Nanotechnology (NANOTEC) (i.e. Nanocoating, Nanoencapsulation, Nanodevices)
- Technology transfer
- Human resource development in S&T
- S&T infrastructure
- S&T policy study
- National policy framework
- Public awareness in S&T
- International cooperation

**Group D: Internal Management**
2.3.2 Changing practices of NSTDA R&D management

Prior to the SPA initiative, the NSTDA budget had been allocated directly to each research centre. In this regard, each research centre operated independently in terms of conducting R&D activities. The SPA initiative has changed how the NSTDA budget is allocated and the way in which research centres plan and implement their research. SPA splits the R&D budget into two main parts. The first portion (25% of NSTDA R&D budget) goes to research centres in relation to their platform/core technologies. The second portion (75% of NSTDA R&D budget) goes to NSTDA industrial and strategic clusters for implementing R&D programmes and projects. The budget for capacity building is managed by each research centre, while the budget for R&D cluster programmes is managed by CPMO. In this way, the research centres are brought to work together within NSTDA cluster programmes. Figure 2.9 depicts the budget allocation for NSTDA industrial cluster.

![Budget Allocation Chart](image)

*Figure 2.9* NSTDA budget by cluster (fiscal year 2008)

*Source: Policy and Planning Department, NSTDA*

During 2004-2008, NSTDA and its research centres as well as the TMC gradually underwent organisation re-structuring to support the implementation of SPA initiative. The particular emphasis of the re-structuring during 2007-2008 focused on how research activities were funded. From 1 October 2008, research funding activities and research programme management were coordinated under the Cluster and Programme Management Office (CPMO) of NSTDA. As a result, NSTDA’s research centres now function as research institutes, no longer as funding agencies.
The Cluster Programme Management Office (CMPO) manages all aspect of NSTDA’s R&D programmes from identifying research topics and finding the appropriate research teams, to monitoring research processes and facilitating the exploitation of research results. The research topics are identified by the management board of each NSTDA industrial cluster, comprising of stakeholders from public and private sector. For example, the management board of the NSTDA medical cluster includes gatekeepers and experts from the Ministry of Public Health, professors from medical schools, NSTDA senior researchers, and professionals from medical industry. This group of people identify research issues and trends based on the needs of industry, the internal research capabilities of NSTDA, and the technological competency of the country. Once research issues have been identified, the NSTDA cluster programme manager and his team conceptualise the research topics to related research programmes. In most cases, a research programme consists of several research projects to answer specific research problems and respond to the needs of industry. After that, typical research administration processes are followed. Finally, research progress and output are monitored and assessed by CMPO.

Previously NSTDA researchers worked mainly within their respective research centres with less prevalence of cross centre collaboration; consequently industrial exploitation of research results has been relatively limited. CPMO encourages cross-centre collaboration among NSTDA researchers. By means of programme-based R&D management, researchers from different research centres are able to cooperate with each other in research projects. An exemplar from the medical cluster is the research programme to develop medical diagnostic kits. Obviously, this research programme involves BIOTEC researchers who are experienced in the biotechnology field. However, there are others technologies required to develop diagnostic kits, such as bio-sensor and advanced material technology, as well as electronics and electrical technology. Thus, MTEC and NECTEC researchers have been drawn together to participate in this research programme.
Another significant function of CPMO is connecting the research competence of NSTDA with industry and facilitating collaboration between research centres and academic institutes. For example, the medical cluster recognises that there has been increasing importance of nanotechnology in medical application such as nano-medicine. However, development of nano-medicine involves not only nanotechnology but other biomedical science. While both NANOTEC and BIOTEC have limited research activities relating to this field of application comparing university research, especially in pharmaceutical and medical science, mechanisms of CPMO can bring NANOTEC, BIOTEC and universities to collaborate under the nano-medicine research programme.

2.4 Conclusion

This chapter presented the overview of the S&T system in the Thai context. It has clearly shown that R&D performance in Thailand, in terms of R&D expenditure in private sector, is relatively low. Also, the Thai private sector is less competent on all counts compared to neighbouring countries, such as Malaysia, Taiwan, and Singapore. Although the government has strived to promote S&T development by having a number of academic institutes and public organisations to support S&T related activities in public and private sectors, its attempt has not been much successful. The linkages between firms and HEIs as well as PROs were limited and remained relatively weak. This is because the policy mechanisms to promote their linkages were not tied with broader economic policies, thus hindering effectiveness of the S&T policy. For this reason, Thai’s national innovation system can be described as weak and fragmented. However, recently there was a shift in the Thai policy regime. The government places emphasis on the concept of national innovation system and industrial clusters in order to progress towards a knowledge-based economy. Consequently, there have been positive signs of change in government, firms, as well as HEIs and PROs. The significant changes have been evidenced in NSTDA - the major S&T agency in Thailand.
The four national research centres (i.e. BIOTEC, MTEC, NECTEC, and NANOTEC) and one technology management centre (i.e. TMC) of NSTDA have played significant roles in supporting S&T development of the country. These research centres focus their activities on applied and industrial research. Also, they conduct contract and collaborative research with industry. However, the extent and intensity of their linkages with industry remain relatively limited. In this respect, effectiveness of the research centres on economic development the country is somewhat doubtful. On the other hand, the TMC has been successful in providing technological consultancy services to promote S&T development in Thai firms, especially SMEs. Financial support is available through soft loans, research grants, and joint investment in technology-related business. Besides these supports, TSP is one of NSTDA’s policy tools providing S&T facilities and infrastructure to Thai industry. The proximity of TSP is expected to provide opportunity for firms and public laboratories to interact in R&D related activities. Furthermore, NSTDA has recently changed its R&D management strategies from technology-based research projects to cluster-based research programmes in response to government’s industrial cluster development strategies with anticipation to better link public and private sectors research activities.

The model of NSTDA in promoting S&T and innovation looks appealing. The existence of national research centres laboratories and S&T supporting institutions (including TMC, ITAP, TSP, and SPA initiative) seems to provide a conducive environment for innovation to prosper. Specifically, the premise of TSP is intended to stimulate interaction between research centres and proximate firms. In this respect, TSP is considered as a seedbed of innovation helping to build closer links and collaborations between R&D oriented businesses, the government leading research centres, and academic institutions. However, there are those who are skeptical that the image and prestige of TSP may outweigh its reality and value added.

The elements constituting the model of NSTDA, using the TSP as a policy tool to link public and private sector R&D activities, could presumably resemble a small version of Thai’s national system of innovation or sub-national territorial system of innovation,
whereby the government, firms, research institutes are present and to some extent interact in a planned territory. Nevertheless, it is recognised that a system of innovation comprises of two key elements and the interplay between them. One element is organisations, such as universities, firms, and public agencies, acting as actors in the system. The other element is institutions, i.e. set of common practices that regulate the relations and interaction between organisations. On the one hand, whether this specific setting in the case of Thailand is justified as a sub-national territorial system of innovation is doubtful. On the other hand, studying this particular space and focusing on its sophisticated proximity of firms and public laboratories and their relationships could provide insight into how public-private research partnership, in the Thai context, really works. Ultimately, it is anticipated that the fundamental factors underpinning the linkages of firms and public research organisations could be identified and attentive policy implication could be proposed. Furthermore, this would provide evidence to support the argument about the nature of this system of innovation per se.

The next chapter reviews the concepts relevant to our assumptions: i.e. the concept of systems of innovation, the theoretical frameworks of inter-organisational interaction, and the concept of proximity.
Chapter 2 described the evolution of S&T policy and the national system of innovation in Thailand, and highlighted the context of public research organisations in the Thai context by focusing on the settings of national research centres and the relevant policies in supporting public-private research cooperation. Following from the local context presented in the previous chapter, this chapter attempts to link related theoretical concepts and frameworks to explore the interplay between public research organisations and industry in Thailand. In this aspect, the concept of systems of innovation, the theoretical framework of university-industry inter-organisational relationships, and theories of proximity are drawn upon to build a conceptual framework for this thesis. This chapter reviews these concepts and theories in three sections. Thereafter, the fourth section brings together the three theoretical constructs and discusses them with emphasis on applying the aforementioned concepts and theories to frame the conceptual framework and analytical framework of the thesis. The chapter ends with some concluding remarks.

3.1 Systems of innovation (SI)

The origin of the systems of innovation approach has developed and evolved from studies which recognise that differences in economic performances of territories (countries and regions) are the consequence of specific national/regional factors (Lundvall, 1992; Nelson and Rosenberg, 1993a; Carlsson and Stankiewicz, 1995; Freeman, 1995; Edquist, 1997). These studies seek to identify the underpinning factors that make some nations (or regions) more successful than others in certain innovation processes and consider the ideal institutional set-up to promote innovation and learning. This approach is increasingly appreciated both among academia and policy-makers for understanding differences between economies and various ways to support
technological change and innovation (Edquist, 1997). This section will now review the key components of the concept of SI.

3.1.1 Concept and components

A system of innovation can be thought of as a set of actors such as firms, other organisations, and institutions that interact in the generation, diffusion, and use of new – and economically useful – knowledge (Fischer, 2001). Generally, systems are made up of three elements: components, relationships, and attributes (Carlsson et al., 2002). The main components of the SI are organisations and institutions (Edquist, 1997). Organisations are formal structures with an explicit purpose and they are consciously created; they are actors of the SI. Some important organisations in the SI are firms, universities, venture capital and public policy agencies (ibid.). Institutions are sets of common routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups and organisations. Examples of important institutions are patent laws and norms influencing the relations between universities and firm (ibid.). Components are the operating parts of a system, such as individuals, firms, universities, government institutes, and rules and regulations. Relationships are the links between the components. Attributes are the properties of the components and the relationships between them; they characterise the system.

The SI concept has been used in different contexts. Freeman (1987) was the first to emphasise the concept as the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies. Lundvall (1992: 12) describes a system of innovation with two distinctions – i.e. narrow and broad senses. In a narrow sense, a system of innovation consists of ‘organisations and institutions involved in searching and exploring – such as R&D departments, technological institutes and universities’. In contrast, a system of innovation in the broad sense includes ‘all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as subsystems in which learning takes place’. Nelson and Rosenberg (1993) put
emphasis on the set of institutional actors that play a major role in influencing innovative performance. A narrower definition of a system of innovation has been adopted by Carlsson and Stankiewicz (1995), who stress the importance of the difference between industries within the same national innovation system and centre their focus mainly on technological innovations.

It is apparent that the SI concept has been referred to in slightly different ways. For instance, Lundvall (1992) emphasises interacting relationships of the components in the system and states the importance of interactive learning and knowledge, but has not specified the application of such knowledge. Nelson and Rosenberg (1993) place their emphasis on institutional actors and indicate the influence of innovation performance, but have not mentioned the process by which innovation can be influenced. Carlsson and Stankiewicz (1995) incorporate knowledge and competence of the interacting agent and networks in the systems and consider the systems of innovation from a specific technology area.

The SI concept is not a theory per se; however, it provides a practical framework to explicitly recognise complex interdependencies and the potential for interaction between various elements in the innovation process. The breadth of the SI concept hence inevitability reflects in different definitions and applications of the concept with respect to specific factors involved in a system.

3.1.2 Interrelations between the components

Fundamentally, innovation does not take place in isolation; it is regarded as an interactive process. The process of innovation involves interaction between organisations (or actors) such as firms, universities, government agencies etc. The relations between the components of systems of innovation, i.e. organisations and institutions, are important for innovation and for the operation of systems of innovation (Edquist, 2005). The innovative performances of a nation/region depend on the combination of organisations and institutions involved and their interactions. Due to
the fact that organisations and institutions are embedded in each other, the relation between the two phenomena can be adequately analysed only if they are conceptually distinguished from each other (ibid.). Hence, a clear distinction between organisations and institutions is essential when specifying the concepts.

Interaction between organisations in the systems can take place in either market or non-market relationships. The latter is said to be highly relevant for learning (Lundvall and Maskell, 2000; Edquist, 2001). Interactions do not only take the form of flows of knowledge and information as well as flows of investment and funding, but also informal agreements such as networks (Cooke et al., 1997; Niosi, 2000). According to Carlsson et al. (2002), the core activities in a system of innovation are those interactions that involve technology transfer, either intentionally or unintentionally (i.e. technological spillover). Basically, these knowledge flows incorporate interaction among firms, universities and public research laboratories, the diffusion of knowledge and technology to firms and the movement of personnel (OECD, 1997).

Figure 3.1 presents a basic model of a system of innovation with some of the main factors. It also illustrates the fundamental relationship of different types of spatial systems of innovation, specifically global, national, and regional.
Although the literature stresses the importance of interaction of elements in the systems and justifies the importance of the interactive nature of innovation processes (Lundvall, 1992), the nature of interactions is inadequately explained in the concept of systems of innovation. In this regard, Coombs et al. (2001) contend that little research has been conducted into how the components of these systems interact and inter-depend.

### 3.1.3 Activities in the systems

According to Edquist (2001), it is not sufficient to specify the concept of systems of innovation from what constitute the systems – i.e. only identifying the main components and the relations between them. The ‘activities’ or what actually happens in the system is a crucial issue contributing to the development and performance of the
system. However, Edquist (2001) points out that early debates contributing to the development of the system of innovation approach (Lundvall, 1992; Nelson and Rosenberg, 1993a; Edquist and Johnson, 1997) have neglected the dynamics of the systems of innovation.

At one level, the activities of the SI focuses to produce, diffuse, and use of innovation, while at a more specific level, it stresses importance on influences of the development, diffusion and use of innovations. To specify the ‘activities’ in the systems, Edquist (2001) suggests to move beyond the explanation of components of the systems and the relations between them to explicitly address what really take place in the systems. That is: what organisations (or the actors) of the system of innovation do in relation to the innovation process; how institutions constrain, prevent or stimulate the organisations to do certain things related to the innovation process; what roles the relation between the components in the systems play for the innovation process; and what the overall function of the system as a whole is – constituted by the components and the relations between them.

The literature shows that recent studies have increasingly placed emphasis on studying the activities in the system and on how they shape the system performance. For instance, Johnson and Jacobson (2000) study factors that affect the knowledge production process by focusing on how knowledge is created, transferred, and exploited. Borrás (2004) focuses on activities of the different organisations in the system of innovation affecting innovation performance. Edquist (2005) looks at activities needed to turn an idea into new product and process.

3.1.4 Boundaries of the systems

To specify a system of innovation, it is crucial to distinguish between what is inside and outside the system. The fact that systems of innovation have been defined from different perspectives means that the variety of definitions is problematic in identifying relevant components or actors of a system of innovation. This is because it is not clear which
elements should be included in the system, their relative relevance and their relation, and what the boundaries of the system should be analysed (Edquist, 1997).

As mentioned in section 3.1.1 that the concept of systems of innovation approach has been emphasised differently based on spatial dimension of the systems. This can be differentiated into localised system (national and regional) and sectoral or technological systems (Fischer, 2001). Among these systems, the national perspective of system of innovation has been predominantly adopted on the basis that institutions influencing innovation normally present a national dimension (Lundvall, 1992). The following reviews the systems of innovation perspective from national, regional/local, and sectoral and technological perspectives.

3.1.4.1 National systems of innovation (NSI)

The national system of innovation (NSI) approach emerged in the study by Freeman (1987) as a conceptual framework for analysing the consequences of institutional factors on patterns of technological development and innovation of a country. NSI is generally recognised as comprising the complex functions and interactions between market and non-market organisations via various institutions (OECD, 1999).

According to Lundvall and Maskell (2000) the national system of innovation is based on three understandings. First, close interaction and long-term relationships influence successful innovation. Second, the relationship and interaction between the agents is connected to non-market relationships, which involve trusts and loyalty. Finally, different country specific conditions place a strong influence on how the relationships and interaction between the organisations develop. The performance of NSI largely depends on how organisations, which include government, enterprises, universities, public and private research institutes, bridging institutes and other contribution institutions, function and interact with each other to develop and apply innovative knowledge.
The study by OECD (1997) acknowledges that the four basic knowledge flows among actors in the national system of innovation include: interaction among enterprise; interactions among enterprises, universities, and public research laboratories; diffusion of knowledge and technology to firms; and movement of personnel. In addition to the flow of knowledge in the national innovation system, Lundvall (1992) presents the core elements playing an important role in the innovation process, which include the internal organisation of firms, the inter-firm relationship, the roles of the public sector, the institutional set-up of the financial sector, and R&D intensity and R&D organisations. In this regard, the national systems of innovation approach reflects the increasing attention given to the economic role of knowledge that involves tracing the link and relationships among industry, government, and academia in the development of S&T. It also reflects the rise of systematic approaches, in which innovation can come from many sources and at any stage of R&D, marketing and diffusion.

The basic argument of the innovative performance of a nation depends on the combination of institutions involved and their interactions (Edquist, 2005). However, institutional settings are country specific and historically determined (Uyarra, 2004). Descriptive studies of different NSI show a large variety of institutional landscape such that it is very complicated to decide which institutional difference are relevant (Radosevic, 1998). Therefore, to understand the role of institutional set-up the whole context of path dependency, functions, and built-in incentives must be taken into account (ibid.).

While stressing the importance of institutional factors influencing the innovative performance, Nelson and Rosenberg (1993) argue that the NSI approach may be too broad to consider systems of innovation in particular regions or industries. This is because the institutions involved in technological innovation in one industry (e.g. pharmaceutical) may have very little common characteristics with the ones involved in innovation in another industry (e.g. automotive). On the other hand, in many industries a number of the institutions are transnational (ibid.). In this regard, rather than
considering the system of innovation from a national perspective, a regional context may serve as a more meaningful unit of economic interest.

3.1.4.2 Regional and local system of innovation (RSI and LSI)

What does it mean by ‘region’? Cooke and Morgan (1998, p.64) view regions as “territory smaller than their state possessing significant supra-local governance capacity and cohesiveness differentiating them from their state and other regions”. Following from the idea of NSI, the concept of regional system of innovation (RSI) is that regions offer particular environment conditions and opportunity for interactions that can either foster or hinder the co-operation between innovative actors in a region, and the amount and quality of regional actors influences the opportunities for learning by interacting (Cooke and Morgan, 1998). A necessary condition for a regional innovation system is a region’s governance power, including capacities to develop innovative support policies and organisations (Cooke et al., 1997).

According to Cooke and Morgan (1998), RSI is defined as a system in which firms and other organisations are systematically engaged in interactive learning through an institutional milieu characterized by embeddedness. The “interactive learning” means the interactive processes which knowledge is combined and made a collective asset of different actors within the productive system, while “milieu” is regarded as open-territorialized complex, which involves rules, standards, values, human, and material resources, whereas “embeddedness” includes all of the economic and knowledge processes created and reproduced inside and outside the firms (Maskell and Malmberg, 1999). In addition, a regional innovation system can be conceptualized as regional industrial clusters surrounded by supporting knowledge organisations (Asheim and Isaksen, 2002).

With respect to Doloreux (2002), four basic elements of RSI are: firms which generate and diffuse knowledge; institutions that act as intermediary agents; knowledge infrastructure including innovative support structure (such as Science Parks), focusing diffusion of knowledge, and providing technical support and information to NTBFs;
and innovation policy that respond to the needs for innovation. Doloreux also underlines the principle internal mechanisms involved in the RSI approach. Firstly, interactive learning enables firms to increase know-how information, reduce fixed-cost in procurement and distribution, and influence management of speed and reduce uncertainties in technological innovation. Secondly, knowledge production in which knowledge is developed and shared. Thirdly, proximity that generates benefits of spatial agglomeration, increases the speed of communication between firms while reduces related costs. Lastly, social embeddedness that considers the role of personal relations and networks.

These elements and mechanisms reveal that the concept of regional systems of innovation brings together the notion of interactive learning, networking, and proximity of actors. Maskell and Malmberg (1999) argue that proximity plays an important role in interactive learning processes. The role of proximity, in particular geographical proximity, is amplified because it provides necessary conditions for transferring of tacit knowledge (The different dimensions of proximity are discussed in Section 3.3). Tacit knowledge is embedded in individuals and geographically localised phenomena which can be shared only through interpersonal, face-to-face contact and the development of personal relations based on trust (Cooke and Morgan, 1998; Howells, 2002). The distinct features of tacit knowledge make the proximity of actors more important.

While literature on RSI (Braczyk et al., 1998; Cooke et al., 1998; Cooke and Wills, 1999) emphasise the concept of system of innovation with respect to regions and view it from the national/sub-national level consisting of a set of firms, research organisations, and institution that linked together, Saxenian (1989) on the contrary starts from the local level, specifically technological districts, comprising a set of firms and research organisations with a partly free exchange of information between organisations. In this respect, specific region or area characterised by well-defined historical, social, cultural, or productive features is referred to as local system of innovation (LSI) (Breschi and Malerba, 1997).
In brief, a local innovation system is a geographically concentrated network of different actors who are interacting frequently, and this interaction is essential for their innovation efforts. Similar to NSI and RSI, LSI does not focus on a specific industry or technology, but on a set of industries active in a specific country or region and on the institutions supporting them. Matin and Simmie (2008) point out that the main function of a local innovation system is to generate new (practical) knowledge and to commercialise it. They also specify that the combination of growing knowledge-based entrepreneurial capacity and supporting institutions, such as local science parks and venture capital, are fundamental to strengthen and develop the local system of innovation. Examples of settings viewed as a local innovation system are Sophia-Antipolis in France, Cambridge in and Oxfordshire the UK, and Hsinchu in Taiwan, in which interactive learning takes place to trigger technological learning and innovation network in a specific area/region of a nation. In this respect, local innovation system has a national/sub-national dimension contributing to the performance of regional and national system of innovation. One special example of a localised/regionalised national innovation system is the planned science parks in which R&D laboratories of large firms and/or government research institutes are clustered (Asheim and Gertler, 2005).

It can thus be seen that LSI, RSI, and NSI are not alternatives, but complementary features of the systems of innovation. While the NSI focuses on the overall incentive structures which create the necessity to innovate, the RSI and LSI place emphasis on the co-operation and interaction between firms and different organisations for knowledge development and diffusion. As innovation is based on interaction, and a lot of this interaction is highly localized, the notion of RSI and LSI thus simply provide additional layers to the NSI approach and reflect localised learning and knowledge sharing processes. The nature of actors, their habits and practice with regard to linkages that lead to learning and innovation, are common in developed countries, whereas many of these assumptions are called into action in developing countries (Mytelka, 2000). For this reason, analysis of NSI in developing countries should take into consideration LSI (Cassiolato and Lastres, 1999), given that the institutions and technologies of these countries are more diverse than what should be expected in advanced economies which
are characterised by a relatively more homogeneous and stable patterns. Many studies (e.g. Schmitz, 1999, Cassiolato et al. 2002, and Cassiolato and Lastres, 2000) have also applied the LSI approach to analyse local industrial development in developing countries. Their application has been characterised by the concentration on the interaction between local firms and with local institutions. Focusing analysis on sub-national level of innovation system in developing countries, such as agglomeration of firms in local production arrangements, high-tech industrial districts, clusters of specific industries, as well as science parks and innovation centres, may help provide better understanding of innovation systems and provide practical information to structure institution support for better interactive learning in these countries.

3.1.4.3 Sectoral system of innovation (SSI) and technological system (TS)

While national innovation systems take innovation system as delimited more or less clearly by national boundaries and focused on the roles of non-firms organisations and institutions, and the regional/local innovation systems is restricted to the system to regions or individual localities, sectoral innovation system emphasises that the knowledge links between firms and organisations result mainly from technological interdependence. Breschi and Malerba (1997) define sectoral innovation systems as ‘the specific clusters of the firms, technologies, and industries involved in the generation and diffusion of new technologies and in the knowledge flows that take place amongst them’ (page number).

A sectoral system approach claims that a sectoral system may have local, national, and/or global dimensions (Malerba, 2005). Some sectors compete at the local level, while the others compete globally. The sectoral system approach emphasises the differences between industries or technologies and considers spatial aspects in a subsequent step. This approach views that difference between sectors as more important than differences between countries. It focuses strongly on private firms as central actors and looks at the competitive relationships among firms of the same industry, and then takes into account the geographical boundaries of innovative activities by considering the meaning of different spatial levels for particular sectors. (Breschi and Malerba, 1997). It
is argued that the specific features of technology shape the dynamics of sectoral systems and their spatial boundaries (ibid.).

Technological systems are in some ways similar to the national innovation system. According to Carlsson and Stankieicz (1991), technological systems is defined as networks of agents interacting in a specific technology area under a particular institutional infrastructure for the purpose of creating, diffusing and utilizing technology focus on knowledge, information and competence flow. However, technological systems differ from national innovation systems in a number of ways. Firstly, they are defined by technology rather than national boundaries; although they are influenced by national culture and institutions, they can be international in nature. Secondly, they vary in character and extent within the nations. Lastly, they are emphasised primarily on technological diffusion and exploitation rather than creation.

3.1.5 Discussion

Despite the fact that the notion of systems of innovation carries the idea of interaction and mutual dependency among the different elements of the system, the three approaches of the concept of systems of innovation have its own definition of innovation and claim their boundaries, facilitating factors, and major knowledge links differently. In addition, these approaches consider the determinants of innovations by focusing primarily on the institutional and infrastructure side of innovation, while organisational and technological dimensions of the interacting agents of the systems are seen as peripheral. After all, as a system consists of components and interrelations among them, analyzing individual component and interrelation of the components alone cannot construct the whole picture of a system. In order to understand a system of innovation, it is therefore necessary to consider not only the major constitution of the system and their influencing factors, but also further investigate the underlying factors of the interaction among the components of the system and between each component.
On the one hand, the system of innovation approach can help to identify which elements of this specific locality are to be included in the analysis (i.e. organisational elements comprise research centres and firms and institutional elements involve public-private partnership policies), and to specify the importance of their interrelation and significance of relationship between the organisational and institutional influencing factors. On the other hand, it appears inadequate to apply the SI approach to examine the interaction between firms and research centres in order to identify determinants of their interaction for further policy implication to promote public-private research partnership. The insufficiency of the SI approach for this study lies in that its concept does not clearly explain how the relations among various organisations and institutions function and what determines the nature of their interaction. In other words, the SI approach is useful for macro level analysis; it helps recognise the relations between firms and research centres as well as the related policies.

These limitations being considered, there is a need to call upon more appropriate concepts/theories to allow study and analysis of interaction between firms and research centres at a micro level - why firms and research centres act in specific ways, how they interact, and what influences their interactions. At this point, the theoretical frameworks of inter-organisational interaction that focus on the fundamental linkages between R&D institutions and industry are employed to complement the SI approach, especially in reflecting the behaviour of individuals and the organisational variables underlying their interaction and relationship.
3.2 Theoretical frameworks of inter-organisational interaction

In the previous section, the use of SI concept has been reviewed. It indicated that the concept of an innovation system has been widely used to explore the innovation process at national, regional and sectoral levels (Lundvall, 1992; Freeman, 1995; Malerba, 2005). The SI approach recognises the importance of certain types of relationships and linkages between actors in a system of innovation. To this end the significant of SI approach, which centres on interaction of actors, provides the basis for construction of a conceptual model of this thesis. To explain how interaction of actors function, the SI approach is here complemented by additional frameworks such as inter-organisational relationship (IOR) framework to improve its explanatory capacity. Therefore, this section briefly reviews two theoretical frameworks of university-industry inter-organisational relationships (U-I IOR), which are adopted to construct an analytical framework and reinforce the conceptual framework of this study. The two theoretical frameworks are the theoretical frameworks of U-I IOR proposed by Geisler (1995) and Bonaccorsi and Piccaluga (1994) respectively.

Note that this thesis is focused on research partnerships between publicly-funded research centres and industrial firms. Most studies on university-industry interaction have been based on detailed analysis of science-industry links, and research partnerships is a channel of university-industry links which are referred to as an inter-organisational arrangement for pursuing collaborative R&D (Perkmann and Walsh, 2007). In this respect, it is therefore relevant to apply the theoretical frameworks of university-industry inter-organisational interaction to this study.

3.2.1 Interdependency, interaction, and their influencing factors

Geisler (1995) proposed a theoretical framework of R&D technology cooperation based on theories of inter-organisational relationships. The notion of the framework is borrowed from theories of interdependency and theories of interaction to explain the rationale for starting cooperative R&D and to justify what makes it survive. With reference to the theories of interdependency, the role of interdependency in the origin
and continuation of inter-organisational cooperative relationships has been emphasised in inter-organisational relationships. The theories of interdependency propose that academia and industry will engage in R&D collaboration when they recognise interdependency in terms of resources needed and perceived benefits. In accordance with interaction theories, a dynamic of inter-organisational relationship is focused with respect to the evolution of the growth in influence of commitment, trust and communication patterns. The evolving interactions in the inter-organisational relationship help to make the relationship more formal and institutionalised (Oliver, 1990). Interaction theories therefore argue that the emergence of inter-organisational relationship is a consequence of prior relationships between parties, prior beliefs, mutual trust and commitment. The theories of interdependency and interactions are complementary in that the former takes the resource-oriented perspective stressing the impacts of the external environments on inter-organisational relationship, while the latter takes the process-oriented viewed in exploring the internal development of the relationship itself.

Bonaccorsi and Piccaluga (1994) construct a theoretical framework to understand and assess the various factors that influence the performance of U-I IOR by proposing two building blocks of interdependent variable of the U-I relationship: the economic background and the organisational dimensions. The first building block involves the motivation of firms to enter into U-I IOR and the characteristics of knowledge transfer. The second building block concerns the organisational structure and the coordinating procedure of the interaction. These authors also argue that the performance of the relationship depends on the match between the characteristics of the knowledge transfer process and the structural and process dimensions of the relationship itself. It is also proposed that the firms’ motivations to enter into U-I IOR have a direct impact on their expectation regarding performance of the relationship. The actual performance of the relationship relies on the complement between the characteristics of the knowledge transfer process and the structural and process dimension of the relationship itself. Furthermore, the outcome of the relationship is defined based on the comparison between the expected and the actual performance. In addition, an
independent effect on relationship outcome resulting from the generation of new goals is also considered in the framework. Figure 3.2 present the theoretical framework proposed by Bonaccorsi and Piccaluda (1994).

![Diagram](image_url)

**Figure 3.2** Bonaccorsi and Piccaluga’ (1994) theoretical framework to study U-I IOR

Banaccorsi and Piccaluga (1994) suggest several factors relating to each of the elements of the building block. The influencing motives of firms to interact with academia are driven by the firms’ need in getting access to scientific frontiers, a lack of resources, reducing development time, cost, and efforts. These factors are related to Geisler’s (1995) notion of theories of independency. The factors involving knowledge transfer process are related to firms’ absorptive capacity (Cohen and Levinthal, 1990), i.e. the ability of firms to appropriate relevant knowledge from interactions with external resources. This ability is determined by their past experience and investment in R&D. The structure and process of the U-I IOR depend on how the relationships are formulated and organised. The performance and expectation hinge on how the knowledge is generated, assimilated and disseminated.
Fundamentally, Geisler’s (1995) theory of inter-organisational relationships provides a wider perspective to understand the rationale behind why industry and academia engage in collaborative R&D and to identify factors during the interaction process that affect their relationships. The notion of interdependency explicitly associates with the motives of the collaborating partners underlying their relationships. The concept of interaction directs attention to the internal process of the development of the collaboration itself. The main concerns in the interaction process include how the collaboration is started, formulated, and carried out. The motivation to enter into inter-organisational relations, the knowledge transfer process, and the organisational dimensions of the relationships, drawing from the theoretical framework of Bonaccorsi and Piccaluga, are emphasised to understand the factors associated with the interaction processes of R&D collaboration.

3.2.2 Interpretation of the concept of inter-organisational interaction

Drawing upon the two theoretical concepts described above, the relationships between actors in a system of innovation can be intricately studied. In that respect, the interdependency perspective helps to investigate beyond the outset of the relationships into underlying reasons why the actors, i.e. research centres/researchers and industrial firms, in the local system of innovation in this study work together. Since the actors are diverse in nature and have different motives for interacting with each others, their motivations have a direct impact on how they behave in relation to their interaction. In addition, the interaction perspective help to delineate how relationships between research centres/researchers and industrial firms develop over a period of time. In this aspect, their relationships can be studied in a dynamic fashion, thereby helping us to recognise the development of the local innovation system in this study.

Moreover, as interaction between the actors in a system of innovation involves a transfer of knowledge. The theoretical framework purposed by Bonaccorsi and Piccaluga (1994) is supportive to systematically study the structure and process of knowledge transfer process between research centres/researchers and firms by
examining inherent factors of their interactions in particular; go beyond the structural arrangement to consider the coordinating arrangement of knowledge transfer process. These factors include the characteristics of actors, their motivations to cooperate with each others, and the nature of knowledge transfer process. Hence, bringing to light the structure and processes of the relationships between the actors as well as the factors associated with their interactions help deepen our understanding about the local innovation system in this study.

3.2.3 Discussion

The inter-organisational relationship based on the theories of interdependency and the theories of interactions attempts to explain the origin and the development of cooperation in R&D by stressing the importance of factors related to the interdependency of actors and the dynamics of their interaction. Nonetheless, the effects of others factors are less emphasised. The limitation of this framework is counterbalanced by integrating the theoretical framework of U-I IOR relationships which considers the influences of factors involved in R&D cooperation, i.e. knowledge transfer dimensions and organisational dimensions. These two concepts are correlated and supportive to augment the use of the concept of systems of innovation to study interaction between components in the system.

With regard to the fact that interactive learning process between science and industry has become the key mechanism for economic and technological development, geographical proximity has also been considered as one of the best contexts for facilitating tacit-knowledge transfer. Literature on university-industry interactions (e.g. Kaufmann and Tödtling, 2001, Lindelöf and Löfsten, 2004, Vedovello, 1997) point out that geographical proximity between academic and industry is a crucial factor to promote the exchange of ideas through both formal and informal interactions. While Vedovello (1997) indicates in her empirical study that geographical proximity between partners is not an important influence on the existence of their links, it promotes the necessary synergy between them. On the other hand, Kaufmann and Tödtling (2001) state that providing sufficiently close proximity between science and industry facilitates
their innovative partnership. In addition, Lindelöf and Löfsten (2004) assert that proximity between academia and industry helps industrial firms to achieve certain advantages. Moreover, some literature underline that the geographical location of academic institutions is a major factor influencing the behaviour of interactions between academic and industrial partners (Jaffe and Trajtenberg, 1993; Mansfield and Lee, 1996).

Considering the importance of geographical proximity in science-industry interaction and innovation process, the next section therefore reviews the concept of proximity in terms of how it is relevant to the innovation process and interactions between academic and industrial partners.

### 3.3 Proximity and innovation processes

The functioning of innovation systems is based on knowledge exchange between actors. While codified knowledge can be easily shared, tacit knowledge requires interaction between actors, which in most cases takes place locally. This highlights the importance of proximity between actors involved in knowledge transfer processes. The notion of proximity implies relations between actors within the firm, and between firms and other organisations such as universities and public research institutes. However, proximity covers not just geographical closeness but a number of other dimensions (Torre and Gilly, 2000). It is a multi-dimensional concept, including different dimensions of relatedness and distance which are not exclusively related to territory (Kirat and Lung, 1999; Freel, 2003; Boschma, 2005b; Knoben and Oerlemans, 2006). To understand relationships between actors in innovation systems, it is necessary to be aware of the concepts of proximity and their effects. This section discerns the different dimensions of proximity and addresses its impacts on interaction between actors, and then relates the different dimensions of proximity with the concepts of innovation system and inter-organisational interactions.
3.3.1 Dimensions of proximity

In the literature, several alternative constructs of proximity have been suggested. These constructs are similar in their focus in that proximity is referred to as a mechanism that reduces uncertainty and solves the problem of coordination, and thus facilitates learning and interaction (Boschma, 2005b). Among the variety of the constructs, proximity can be defined as being close to something measured on a certain dimension (Knoben and Oerlemans, 2006). Taxonomies of proximity are specified in slightly different ways with respect to the number of dimensions of proximity. Boschma (2005) distinguish between five dimensions, Knoben and Oerlemans (2006) separate it into seven dimensions, and Kirat and Lung (1999) present three dimensions. Nevertheless, the content that is covered is fundamentally similar.

Geographical proximity describes the spatial distance between actors (Boschma, 2005b; Knoben and Oerlemans, 2006). It leads to interaction between actors, in the form of informal social interaction, network, and mobility, which enable knowledge transfer over organisational boundaries. The frequent face-to-face contact that occurs unintentionally between people living and working in the same area is referred to as “local buzz” (Malmberg and Maskell, 2006). It is considered to be an essential social capital comprising of strong and weak ties between agents in an area.

There have been several studies that highlight the benefits of co-location, while others have presented findings that contradict the localisation thesis. On one hand, evidence from case studies of particular innovative regions highlights the benefits of local learning processes of innovation (Saxenian, 1994; Gertler, 1995; Blind and Grupp, 1999). Studies show that innovative firms tend to cluster in specific geographical regions (Baptista, 2001; Audretsch et al., 2004) and that firms tend to source external knowledge from firms located in geographical proximity (Jaffe and Trajtenberg, 1993). On the other hand, empirical data shows that there is relatively little interaction between firms located in the same place (Doloreux, 2004) and that firms in highly innovative regions primarily source external knowledge from non-local sources (McKelvey et al., 2003;
Audretsch and Lehmann, 2006). Data also points out that there is an increasing internationalisation of R&D, use of international technology alliance, and use of distributed innovation projects (Bonaccorsi and Rossi, 2003; Hildrum, 2007). Several studies also indicate that co-location is neither a necessary nor a sufficient condition for innovation (Boschma, 2005b; Gallaud and Torre, 2005; Torre and Rallet, 2005).

In addition, technological proximity and cognitive proximity are similar to some extent. The former refers to interdependency woven between the various activities within the scope of production relationship (Kirat and Lung, 1999). The latter concerns similarities in knowledge base and expertise as well as sharing a common language used to describe particular phenomena (Boschma, 2005b). The important difference between the two constructs is that technological proximity refers to the extent to which actors can actually learn from each other, i.e. ‘what’ they can exchange and the potential value of these exchanges, whereas cognitive proximity refers to the extent to which actors can communicate efficiently, i.e. ‘how’ they interact (Knoben and Oerlemans, 2006).

Moreover, organisational proximity refers to the closeness of actors in organisational terms (Boschma, 2005b). Institutional proximity is defined as the degree of similarity between, and acceptance of the legitimacy of, the institutional infrastructure in which agents operate (Freel, 2003). Social proximity is defined in terms of socially embedded relations between actors at the micro-level manifesting organisational and institutional proximity (Boschma, 2005b). Institutional proximity is closely related to organisational and cognitive proximity (Thune, 2009), in that institutions are an inherent part of organisations and the environment in which inter-organisational relationships are carried out, and institutional frameworks influence the cognitive model and language that agents use to make sense of the world. Social proximity might serve to coordinate efforts in situations where formal institutional is absence, because relational embeddedness limits opportunistic behaviour of the actors and increase their willingness to cooperate.
3.3.2  Effects of proximity on interactive learning

Although it is often believed that proximity favours innovation, knowledge creation, and knowledge transfer, the different dimensions of proximity can also complement one another to foster an innovation system. However, it is noteworthy to recognise that too much or too little proximity may also be unfavourable to innovation systems.

According to Boschma (2005), locations where there is too narrow a focus on certain types of activities might come across a spatial lock-in, hindering them to benefit from external knowledge. To reduce the risk of spatial lock-in, individual localities need to diversify their focused activities and establish non-local linkages to access spatial externalities. In addition, it is argued that knowledge from external sources can only be absorbed if the cognitive distance between the actors is not too large or too small (ibid.). In other words, dissimilar but complementary bodies of knowledge are necessary to trigger creativity and new ideas for knowledge generation. Moreover, social relations of actors are believed to influence the degree of knowledge exchange and interactive learning (ibid.).

Boschma (2005) also contends that although institutional proximity provides the basis for co-ordination and interactive learning based on common institutions of actors, on the one hand, too much institutional proximity can lead to inertia where awareness of new opportunities is reduced, and consequently provides deficient opportunities for change. On the other hand, too little institutional proximity can impede innovation. Therefore, institutional check and balance are required. Moreover, organisational proximity reduces uncertainty and opportunistic behaviour between actors; high organisational proximity implies bureaucracy, which is often not sufficiently flexible to allow for innovation. In this regard, a loosely coupled system between hierarchical and trust-based relationships is a possible solution.
3.3.3 Proximity and concepts of systems of innovation

Different dimensions of proximity are emphasized regarding the definition of an innovation system. Aspects of geographical proximity are highlighted within the concepts of systems of innovation where the system boundaries are spatial, in terms of national, regional or local innovation systems. This is because geographical proximity allows frequent face-to-face contact to exchange information and to build a stock of common knowledge. Institutional proximity is prominent for the concept of national system of innovation, which focuses on institutional frameworks. In addition, the social, organisational and institutional forms of proximity may be overlapped and interconnected (Knoben and Oerlemans, 2006). They may also influence the interactive learning of the actors (Boschma, 2005b). This is because institutional settings involve intra- and inter-organisational relations as well as social relations between the actors. Moreover, the cognitive proximity is emphasised in the concept of sectoral systems of innovation and technological system, in which compatibility of cognitive distance of actors foster the success of knowledge exchange and spatial agglomeration of innovative activities is not always necessary.

3.3.4 Influence of proximity in inter-organisational relation (IOR)

In general, proximity is often regarded as an important pre-condition for knowledge sharing, knowledge transfer and technology acquisition (Gertler, 1995). These knowledge exchange processes are often seen as the primary goals of inter-organisational interaction (Hagedoorn and Schakenraad, 1994). Therefore, in a complex process of knowledge exchange, different types of proximity facilitate the interrelation of actors and their performance. This section considers the different dimensions of proximity and their specific importance in inter-organisational relation (IOR).

The importance of geographical proximity in IOR is that spatial distance facilitates frequent face-to-face interactions and fosters knowledge transfer and innovation. Short geographical distances concentrate organisations in proximate space, favour interaction with a high level of information richness and facilitate the exchange of tacit knowledge.
between actors (Torre and Gilly, 2000). It is more difficult to transfer knowledge as the spatial distance between actors becomes greater. This is true not only for tacit forms of knowledge but also codified knowledge, since interpretation of codified knowledge still involves tacit knowledge and thus spatial proximity (Howells, 2002).

The significance of technological proximity is based on the concept of absorptive capacity, as absorptive capacity is defined as the ability of firms to recognise the value of new, external knowledge, assimilate it and apply it to commercial ends (Cohen and Levinthal, 1990). In order to collaborate successfully, the prior knowledge of a firm must be similar to the new knowledge on the basic level, but fairly diverse on the specialised level (ibid). In other words, firms need to be similar enough in knowledge bases to be able to recognise the opportunities that the other actor’s knowledge gives, but different enough to contribute new knowledge to the IOR.

The main reason underlying the importance of social proximity for IOR is that social relations not only co-ordinate transactions but are also vehicles that enable the exchange of knowledge because of mutual trust, relationship, and experience as well as external resources to be mobilised (Boschma, 2005b; Oerlemans and Meeus, 2005). For organisational proximity, it is considered as a precondition for collective learning and co-operation between organisations (Kirat and Lung, 1999). That is, when the organisational context of interacting partners is similar, IOR are more efficient and lead to better performance, because this similarity facilitates mutual understanding. For institutional proximity, it helps facilitating collective learning by allowing free knowledge transfer among agents based on common rules, procedures, norms being applied to thought and action (Kirat and Lung, 1999). However, literature does not clearly state the importance of cognitive proximity in IOR, but suggests that cognitive proximity should be as part of organisational proximity, since it is also based on the notion that sharing routines, cultures, values and norms facilitates the interaction of actors over geographical distances (Knoben and Oerlemans, 2006).
3.3.5 Discussion

The importance of proximity is recognised in that dimensions of proximity can influence the relationships between actors in an innovation system in different ways. Proximity could be considered as one of the factors involved in explaining the ways that the local innovation system in this study performs. It is therefore necessary to take into consideration the importance of proximity of the actors (i.e. research centres/researchers and industrial firms) in order to study and analysed interaction of the actors in the system.

However, as this study centres on a local innovation system of a public research organisation with particular emphasis on relations between research centres/researchers and industrial firms, the study therefore consider primarily the notion of geographical proximity when examining their relationships and interactions. Nevertheless, the other dimensions of proximity are regarded as complementary views to specify the interactions of these actors in our local innovation system.

3.4 Constructing conceptual framework

In this study, the focus is laid on a systematic analysis of interaction between publicly funded research centres and industrial firms in relation to their research partnership within a local innovation system. The study takes the National Science and Technology Development Agency (NSTDA) – a major public research organisation in Thailand that comprises of research centres physically embedded in an adjacent science park – as the empirical case. The study places emphasis on spatial co-location of actors and the interplay between the research centres and industry, specifically in their research collaborations.
3.4.1 Building blocks of the conceptual framework

The conceptual framework of this study is constructed from the combination of three theoretical concepts: the concept of systems of innovation, the frameworks of university-industry inter-organisational relationships, and the concept of proximity.

Firstly, drawing on the basic point that a system comprises of a number of distinctive components and relationships between them, and an innovation system consists of components of consequences to innovation and relationship amongst them. This thesis uses the narrow definition of the system of innovation defined by Lundvall (Lundvall, 1992), which includes organisations (or actors) and institutions involved in research activities, to specify the local system of innovation of NSTDA. The boundary of the system is a specific locality where public research organisations co-locate with technology-based firms, i.e. the science park. The organisations in this study include firms and research centres, and the institutions include TSP and NSTDA support policies. The study investigates and analyses what really happens in relation to public-private research partnerships in the context of NSTDA from a local innovation system perspective.

Secondly, the theoretical frameworks of inter-organisational interaction are adopted to deepen our knowledge of how actors in the system interact and inter-depend. Interrelations between research centres and firms as well as influences of institutional factors that shape the way in which these actors interact in this particular local innovation system are emphasised. In addition, interactions between actors, which are considered as one of determinants of the performance of the system, are examined and analysed. Furthermore, characteristics and factors influencing public-private research collaboration are also investigated to provide a better understanding of the dynamics and performance of this local system of innovation.

Thirdly, as this specific case study consists of spatial proximity of research centres and firms in a highly concentrated S&T infrastructure and conducive research environment,
the concept of proximity is applied to examine factors associated with proximity of actors that affect their interactions and interactive learning.

In sum, the concept of the system of innovation is used as the point of departure for modelling contentions of the study as discussed in Chapter 2. The latter two concepts, the theories of inter-organisational relationships and the concept of proximity are combined to heighten our analytical lenses of this local innovation system. The concept of proximity is underlined in Chapter 6 to study the benefits of co-location of research centres and firms in a science park as well as to justify the roles and influences of dimensions of proximity on the interaction of the actors. The theories of inter-organisational interaction are adopted and adapted to give reasons for empirical evidence gathered in Chapter 7 to identify how research centres and firms work in this local innovation system using R&D collaborative projects as a means of study. The analysis frame that will be used in Chapter 7 is discussed in detail in the following section.

3.4.2 Formation of an analytical framework

Following from the insights into Geisler (1995) and Bonaccorsi and Piccaluga (1994) and a review of the literature relating to public-private research partnership, this section presents an analytical framework to be used to understand the various factors which influence the interaction of firms and research centres in their R&D collaboration. It considers the way in which firms and research centres interact in relation to R&D collaboration in a three-step process; first is the genesis of collaboration, second is the formulation of the collaborative projects, and third is the project implementation. This model also takes into account contextual and organisational factors which are related to their antecedent and present association. Figure 3.3 presents this analytical framework. The model is further described as following.
It is apparent that the characteristics of firms and research centres are quite different. Firms vary in size, sector, and origin. Research centres, and researchers in particular, have different research interests. These differences are the underlying basis of their motivations to enter into R&D collaboration (Montoro-Sanchez, 2006) and influence the nature of R&D collaboration (Meyer-Karahmers and Schmoch, 1998; Lee, 2000). In addition, previous association between the research partners and degree of firm’s dependency influence the likelihood of R&D collaboration (Mora-Valentin et al., 2004, Barnes et al. 2002, Fontana et al. 2006, Geisler et al., 1990). For that reason, it is proposed that two aspects beyond R&D collaboration are partners’ characteristics and previous links.

**Genesis of R&D Collaboration**

Figure 3.3 An analytical framework to explore interaction between firms and research centres during R&D collaboration
**Formulation of R&D Collaboration**

Firms and research centres have different motives to enter into R&D collaboration (Autio et al., 1996; Bayona et al., 2001). The basic reasons underlying their research motivation are financial, technological, strategic, academic, and political (Montoro-Sanchez et al., 2006, Lee, 2000, Autio et al., 1996). These motivations have been found to vary according to the characteristics of the cooperating partner (Montoro-Sanchez et al., 2006) and correlate with the nature of transfer knowledge (Bonaccorsi and Piccaluga, 1994). Interactions between firms and research centres in relation to R&D collaboration involve knowledge transfer activities which are complex processes and differ depending on the nature of knowledge involved, in that the knowledge transfer process determines the way in which the collaboration is constructed and materialised (Bonaccorsi and Piccaluga, 1994). The nature of the knowledge transfer process is considered with respect to three aspects. First is the development stage of the project in the research life cycle (Bonaccorsi and Piccaluga, 1994). Second is the technological capability and technological relatedness (Santoro and Bierly, 2006). Technological capability reflects the extent of a firm’s internal expertise that enables it to understand and use the knowledge transferred from an external source, and technological relatedness is referred to a certain level of technological overlap between partners (Bierly et al., 2009). Third is the knowledge gap of the partners, which is defined as the degree of institutional proximity as well as the level of mutual understandings across organisational boundaries between the partners (Wang and Lu, 2007). Therefore, motivation of research partners and nature of knowledge transfer are considered the factors underlying the way in which firms and research centre interact when organising their R&D collaboration.

**Operating R&D Collaboration**

The structure and process of the collaborative project determine in what way the R&D collaboration functions (Bonaccorsi and Piccaluga, 1994). The collaboration structure involves the nature of the research project, the length of the project, and the resource input from the partners. The collaboration process focusing on what really happens in
the interaction examines the involvement and interactions of the research partner. In addition, organisational factors have an impact on the activities of partners in R&D collaboration process (Mora-Valentin et al., 2004). These factors include commitment, communication, trust, and level of conflict, and researchers’ perceived important of the collaboration. Explicitly, the greater the perceived importance of the collaboration, the better the relationship will be dealt with (Bonaccorsi and Piccaluga, 1994).

3.5 Conclusion

The starting point of the conceptual framework of this study is built upon the core insights from three theoretical concepts, i.e. system of innovation, inter-organisational relationships, and proximity. These concepts share common concerns regarding interactions between actors.

The concept of system of innovation is applied as the basis for analysis of the interaction between actors in this study. It stresses that technological innovation involves complex interaction between actors (e.g. firms and universities/research institutes) in the innovation system and their environment (e.g. institutional setting in which firms operate) (Edquist, 1997). This complex interaction is considered as crucial issue for the evolution of innovation systems (Edquist, 2001). Taking into consideration the interaction between actors thus helps to understand intrinsic factors shaping the development and performance of an innovation system (Johnson and Jacobson, 2000; Edquist, 2001; Edquist, 2005).

Although the concept of system of innovation recognises the importance of interaction between actors as vital activities contributing to dynamics of innovation systems, to some extent it provides a fuzzy idea about what actually takes place in the process of interaction. In other word, the concept of system of innovation does not give clear explanation on dynamics of cooperative network between actors which is in fact the driving force of innovation systems. Therefore, the theoretical frameworks of inter-
organisational relationships (Bonaccorsi and Piccaluga, 1994; Geisler, 1995) are brought in to support the understanding on the interaction process of actors in an innovation system. The key notion of the theoretical frameworks of inter-organisational relationships highlights interaction and the inter-dependency of actors. It underlines the structure and process involved in interactions between actors, focusing on actual activities occurring within the process of interaction (i.e. formation and functioning of interactions between actors).

Interactions between actors imply proximity of actors. Proximity is a prerequisite of interaction of actors and affects their relationships (Gertler, 1995). There are different dimensions of proximity (e.g. geographical proximity, technological proximity, and social proximity), which have impacts on the interaction process and the interactive learning of actors in a different way (Boschma, 1999; Maskell and Malmberg, 1999; Boschma, 2005b). Hence, relationships between actors in an innovation system can be better comprehended by considering influences of proximity on interaction between actors.

Figure 3.4 illustrates the pertinence of these three theoretical concepts applied in this study.
Accordingly, this thesis applies the perspectives of innovation and learning process to explore the interaction between firms and research centres and the role of proximity in relation to their interaction in a local system of innovation in the Thai context. With reference to the SI approach, the study uses a sub-national or local level boundary to investigate the interaction between firms and research centres in the local innovation system of NSTDA. A local innovation system in this study is regarded as a system in which firms and local organisations (i.e. research centres and NSTDA) and institutions (i.e. TSP and R&D policies) are linked together in close proximity. Research centres and firms are defined as the key actors, and TSP and NSTDA R&D policies are important institution supports in this local innovation system. The roles of these key actors and institution supports have been outlined in Chapter 2.

As stated, interaction implies interactive learning and proximity of actors. Concerning the important role of proximity in the interactive learning process, this study explores the extent to which the geographical proximity of local firms and research centres influence their interaction in TSP. The concept of proximity presented in section 3.3 is
used to provide an explanation of the factors influencing the interaction of these local actors. In relation to the significance of relationship between actors in the interactive learning process, this study investigates the way in which firms and research centres interact by means of R&D collaboration projects in order to identify the determinants of their interactions. At this point, the SI approach is inadequate to provide the basis to study and analyse the complex interactions between firms and research centres. Therefore, the analytical framework based on inter-organisational relationships, proposed in section 3.4.2, is used to examine the nature of R&D collaboration between research centres and firms in order to deepen our understanding of the factors influencing their interaction.

In summary, this conclusion has explained how these three theoretical concepts support the conceptual framework to investigate the interrelation of firms and research centres in the case of Thailand, in which these two actors are co-located in a planned science park. The next chapter reviews the literature on science parks and public-private research partnerships to provide the grounds for the investigation and analysis.
CHAPTER 4
Science Parks and Public-Private Research Partnerships

This chapter reviews concept of science parks to gain an insight into the development of the concepts and how science parks play a role in technological innovation and economic development of a nation, especially in developing countries. Science park by itself is a setting environment with complex interaction between science park actors. Local government promote interaction between science and industry through science parks by means of public-private research collaboration. In this respect, the chapter also review public-private research collaboration to recognise its characteristics, processes, and its influencing factors in order to provide basis for understanding how science and industry link work in the context of science park. The chapter hence comprises of three parts. The first section discusses about the science park concept. The second part reviews characteristics of public-private research collaborations, its process and influencing factor. The chapter ends with a conclusion in section 4.3.

4.1 What do we know about science parks

4.1.1 Concepts and evolution

Technological innovation in the period of 1950s to 1970s was conceived as a linear process model flowing from the upstream scientific research activities in universities to downstream activities of application, product development, manufacturing, and marketing in enterprises. It is on the basis of this linear model of innovation that the concept of science parks was evoked and several science parks have been built anticipating that heavy investment in scientific research activities would result in successful technological innovation and increased economic benefits (Massey et al., 1992).
Science parks emerged in the U.S. in the early 1950s (Link and Link, 2003). The first science park was Stanford Research Park founded by Stanford University in 1951 in response to the demand for industrial land near university resources and an emerging electronics industry, which was closely tied to a prominent electronics department at Stanford University. The park functioned as an interface between university and industry, turning R&D outcomes from the university to market. It also effectively built up mutual benefits between academics and industries in developing a number of spin-off companies. Accordingly, the Silicon Valley high-technology industrial agglomeration was created. The growth of microelectronics firms during the 1960s became the prosperous sequence of Silicon Valley, followed by the emergence of the computer industry and the internationalisation of the industrial structure of the region during the 1970s and 1980s (Saxenian, 1994; Saxenian, 1996).

The next science park of note is the Research Triangle Park in North Carolina founded in 1959. The underlying principle of this Park differs from the Stanford Research Park in that it aimed to stimulate the declining economy of North Carolina during the 1950s. Hence the Park was set up with an attempt to attract industries and research companies into the area central to three universities (i.e. Duke University in Durham, North Carolina State University in Raleigh, and the University of North Carolina at Chapel Hill). The advantage of the park is the three outstanding universities, a world class research institute, a favorable geographic location and climate, and the continuity of entrepreneurship development (Link and Scott, 2003a). The Research Triangle Park has grown auspiciously as the largest research park in the world, home to over a hundred research and development organisations such as IBM and Cisco Systems.

After the renowned outcomes of the science park concept in the U.S., the science park movement in the UK started in the 1970s, using the U.S. approach to bridge the gap between academia and innovation. The first two science parks in the UK were the Herriot Watt Science Park and Cambridge Science Parks, which were established in 1972. Until the mid-1980s, both science parks moved forward very slowly and produced little impact on their local economies, which largely went unnoticed. During the mid
1980s, the UK science parks have been boosted as a consequence of two principle grounds. The first one is because the universities were challenged to make themselves more relevant to the needs of industry in order to receive additional funding from the government. The second one is attempts of local government and regional development plan to promote industrial resurgence and create job opportunities after the severe recession of 1979-81 by using a range of policy initiatives, of which science parks became one of the most significant (Quintas et al., 1992). Nonetheless, the UK science parks differ from most of the U.S. science parks in that they have been evoked from individual technology-based entrepreneurs who act as bridging agent between academic and industry, rather than innovation by large vertically-integrated industrial corporations as in most of the U.S. science parks (Massey et al., 1992).

Science parks in the U.S. and the U.K. appear to have similar approaches in linking commercial enterprises and academic research. Interestingly, science parks in many European countries are established to create regional and economic development through promoting knowledge-based activities. France and Germany are the two typical examples. The Sophia-Antipolis in France was established in 1972, where the central government played a significant role in creating a new city by putting together all the necessities of economic activities including research laboratories, high-tech firms, residential facilities, and various services. Despite the strong support from the government, the Sophia-Antipolis developed slowly in the late 1970s. It only started to engage in technological activities by the early 1990s (Cooke, 2001). In addition, the emergence of science parks in Germany, which started in the early 1980s, were the attempt of regional and local authorities to counteract the effect of economic decline (Grayson, 1993). Note that Germany’s science park schemes are known as innovation centres, and have a primary objective to create new enterprises.

The concept of science parks also expanded from the West to the East in the early 1980s. The real growth of science parks in the East, especially in Asia-Pacific, was revealed in the 1990s (McQueen and Haxton, 1998). Somewhat contrasting to the original functions and grounds of the concept of science parks in the West, most of the science parks in the
East are a top-down approach from the government to facilitate technological growth and increase technological competency of the countries. The science parks in most Asian countries were also established as a policy instrument for the purpose of assisting economic development towards knowledge-intensiveness and/or industrialisation (Lin, 1997; Xue, 1997).

From the examples of science parks mentioned, it could be discerned that the concepts underlying the emergence of science parks vary principally due to their causes of establishment, local economic structure, and settings. These diversities result in different models of science parks globally. In spite of these differences, one commonality of the original function of the science parks is to link academics and firms in order to diffuse R&D results to industry. The fundamental reason for this function is the belief that locating firms close to universities would result in the flow of knowledge from academia to firms and thus to the commercial market. This function is based on two assumptions, the linear model of innovation and that the geographical proximity of researchers and enterprises could make the process of knowledge transfer possible (Massey et al., 1992). Massey et al. (1992) indicate twenty-five different functions and objectives that science parks are believed to execute, among these are: to encourage the formation of new technology-based firms (NTBFs) and the growth of the existing NTBFs; to stimulate spin-off firms started by academics; to facilitate links between HEI and industry, to create synergy between firms; to improve the performance of local economy and the image of the location, etc. Grayson (1993) also categorises the basic objectives commonly acknowledged for science parks as technology transfer, economic development, and property development.

It is apparent that the concepts of science parks evolve overtime. When the concept started in the West in 1950s and 1960s science parks was used to link between academic and industry. Later on in the 1970s, it can be seen as a means to encourage collaboration between university and industry, create spin-off companies, and benefit from the proximity. In 1980s, it was expected to facilitate innovation development in firms. Science park in the 20th century was to assist the creation and growth of technological
entrepreneurs. The 21st century science park, termed as 3rd generation science park, is anticipated to playing some wider and desirable role in the economic or technological development of the region (Allen, 2007). In that, science park is regarded as an integral part of academic activities and influence on the university’s curriculum, graduate destination pattern and research agenda.

As science park concept has evolved over time, academic studies of science parks are also diverse. The literature indicates that there are four stream of academic studies in the science park literature (Phan et al., 2005). These include those that focus on performance of the companies located in science parks, those that attempt to provide an assessment of the science parks themselves, those that focus on the systemic level of the university, region or country, and those that examine the individual entrepreneur or teams of entrepreneurs in these facilities. Nevertheless, there is no systemic framework to understand the relationship between these multiple levels of analyses due to the dynamic nature of science parks, consequently leading to theoretical and empirical gaps in the study of science parks.

4.1.2 Definitions and types of science parks

Although the history of science parks dates back for more than half a century, the term ‘science park’ has no uniformly accepted definition. This could be for the reason that the concept of science parks engages diverse forms in different times and places, as previously discussed. Accordingly, there are several similar terms used to describe similar development, such as ‘research park’, ‘technology park’ and ‘innovation centre’ etc. (Monck et al., 1988). The term ‘research park’ is mostly used in the U.S., while ‘science park’ and/or ‘technology park’ are frequently used in the U.K. and other European countries, and ‘science and technology industrial park’ is widely used in Asia (McQueen and Haxton, 1998). However, there have been intentions to distinguish these terms. Based on their major in-house activities, research park have more activities concerning knowledge creation, while technology park involve more knowledge application and commercialisation, and science park are in between (Grayson, 1993). In
addition, Westhead (1997) claims that science parks reflect an assumption that technological innovation stems from scientific research and that parks can provide the catalytic incubator environment for the transformation of “pure” research into production.

Science parks appear to have a variety of definitions. Amongst these definitions, the one given by the International Association of Science Park (IASP) is now broadly accepted and used since it encompasses different models of science parks currently existing worldwide and other identifications, such as technology parks, research parks, technopole etc. According to IASP, a science park is an organisation managed by specialised professionals, whose aim is to increase the wealth of community by promoting the culture of innovation and the competitiveness of its associated business and knowledge-based institutions. To enable these goals to be met, a science park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets; it facilitates the creation and growth of innovation-based companies through incubation and spin-off processes; and provides other value-added services together with high quality space and facilities. This definition infers the importance of science parks as a tool or an instrument to create wealth through facilitating innovation in firms. This is because as firms become more innovative they are more competitive and therefore contribute to the increase economic level of their communities/regions.

It could be said that almost all science parks, maybe except the Stanford Research Park, have been inspired more or less by at least a model of prior science park in their initial establishment. A science park then develops and grows in its own way according to specific local context and objectives. In fact, every science park has its unique version or model. Even the three prominent science parks in the US (Stanford Research Park, Research Triangle Park, and Boston Route 128) all arose by different routes and mechanisms (DesForges, 1986).
Although the literature specifies that no general models of science park exists (Hansson et al., 2005), categories of science parks have been constructed according to physical manifestations and consequent attributes, development goal, functions, and orientation (Hu et al., 2005; Zhang, 2005b). One example of science park categories includes park/campus-style, centre/incubator style, and city/region style. The other is innovation/incubation-oriented, R&D-oriented, and production-oriented.

### 4.1.3 Significance and effectiveness of science parks

Castell and Hall (1994) list three main motivations for the establishment of science parks: reindustrialisation, regional development, and creation of synergies. However, science parks are often seen as, or are hoped to be, the solution to complex political and economic issues in society (Autio, 1998). The heart of these expectations is the belief that science is a catalyst to economic growth through its contribution to innovation and further development of high-tech firms. For this reason, science parks have long been considered as policy instruments which endeavour to promote research-based industrial and innovative activity (Quintas et al., 1992; Löfsten and Lindelöf, 2002). The knowledge-related natures of science parks are expected to ease knowledge transfer processes such as diffusing knowledge locally, promoting high-tech firms, and establishing links between knowledge-creating actors (e.g. universities, research centres) and knowledge-exploiting actors (e.g. local institution, public organisation, and private firms). In this aspect, it is anticipated that science parks can help to increase the diffusion of new and advanced technologies/knowledge among firms and subsequently boost the competitiveness of firms and regions.

Science parks have a number of roles, only one of which is to provide the ‘catalytic environment’ needed to transform basic science into commercially viable innovation (Westhead, 1997). This particular environment of science parks fosters proximity between researchers and firms to enable them to increase interaction and transfer of valuable scientific knowledge into a commercial context (Hansson et al., 2005), offer knowledge and expertise to businesses located on-site (Löfsten and Lindelöf, 2002),
enable academics at the local research centres to commercialise their research ideas (Storey and Tether, 1998), as well as promote and facilitate linkages of various types such as research links and technology transfer between the park tenants and the host institution, or by acting as nodes within regional systems innovation (Quintas et al., 1992; Quintas, 1996).

Nevertheless, several studies indicate that the expectation versus actual performance of science parks is questionable as most science parks have failed to perform their intended function (Massey et al., 1992; Quintas et al., 1992; Vedovello, 1997). An imperative reason to this failure is the fallacy that geographical proximity between knowledge sources and local firms is sufficient to foster the spatial diffusion of information, technologies and innovation (Vedovello, 1997). Another vital reason is the governance structure of science parks which may lead to inappropriate policies (Monck et al., 1988; Löfsten and Lindelöf, 2002). Specifically, Massey et al. (1992) argue that science parks are nothing more than “high-tech fantasies” as the concept is not a practical account of what happens in reality. They argue that science parks are not a major source of technology development, and that geographical proximity between a university and a science park accounts for very little in promoting technology transfer. Instead, they found that many science parks are unlikely to generate productive synergies for firms and universities as they are physically isolated from the surrounding society. In a similar vein, Vedovello (1997) found that the type of interactions and linkages between on-park firms and adjacent universities are more of an informal type, not of a formal academic type as stated, again casting doubt on the geographical proximity of science parks.

While the significance of science parks is a somewhat controversial issue, previous studies suggest different methods to evaluate the impact and effectiveness of science parks. Many studies evaluate science parks by comparing the performance of firms located on the park and off-park firms (Westhead, 1997; Löfsten and Lindelöf, 2002; Löfsten and Lindelof, 2003; Siegel et al., 2003a; Siegel et al., 2003b). Hansson et al. (2005) argue that a comparative study of firms located on and off science parks does not reflect
a complete picture of science parks; rather they suggest that science parks should be assessed based on their role in the science-industry relationship. Quintas (1996) proposes several methods for science park assessment including an evaluation of net benefits and costs, measurement of inputs (in terms of investment flows or resources consumption) and outputs (in terms of science park tenants’ performance, or the performance of the regional economy), and evaluation of linkages (such as linkages between tenants and host, linkages between tenants, linkages between tenants and organisations outside the park). In addition, an empirical study by Phillimore (1999) contends that interactions and networking occurring in science parks are an important attribute of the park development. Therefore, science parks should be evaluated by involving feedback loops and the creation of synergies through a diverse range of information networks.

Nonetheless, among the diverse methods of science park evaluation there are two dilemmas. First, in the case of comparative studies of on parks and off park firms as well as output-oriented evaluation, these can never achieve enough hindsight other than a very long-term evaluation. Second, in the case of process-focused evaluation, linkages may be difficult to detect and their feature significantly hard to evaluate at any given point of time.

4.1.4 Science parks as a tool for regional development

With regard to regional development, science parks are usually regarded as a mechanism for developing university-industry interaction or as an arena for spin-out ideas from university research to ‘take off’ during market introduction (Cooke, 2001; Etzkowitz and Kloxsten, 2005). To an increasing extent, however, science parks are also viewed as a cluster of knowledge-based (and often technology-based) firms and organisations promoting a favourable regional development. By attracting external companies to locate in a region’s science park, or by facilitating spin-out ideas from the region’s university to flourish and grow, a science park obviously contributes to its region’s development (Ylinenpää, 2001). Accordingly, science parks have become a
prominent element in regional development strategies. They are seen as a means to increase a region’s innovative ability and to affect the rates of job creation and unemployment in particular.

Therefore, it is essential for less-developed countries, which always lack well-developed industrial clusters, to nurture such clusters, especially for technology-based industries, for their economic development. A science park can contribute to regional development in less-developed countries in an instrumental way by developing of such cluster (Hu et al., 2005). The proximity among companies in a science park stimulates company learning, creating compatible knowledge spill over effects and establishes a positive feedback among various local agents. It could be argued that the concept of science parks promotes location-specific cluster formation, provides efficient technological infrastructure and mature innovation-production interaction, as well as competitive advantages. Ultimately, science parks are a policy tool for regional development for many less-developed and developing countries.

Science parks are increasingly being promoted to facilitate technology transfer and regional development because they often lead to fast-growing, geographically-clustered firms within industries. The Taiwanese government has aggressively developed science parks during the past two decades in order to establish industrial clusters by stressing the importance of technology-based regional development strategies (Hu et al., 2005). Also, China is amongst the nations that have led their newly developed science parks to industrial clusters, such as semiconductor, computer, and telecommunication firms, in an attempt to promote growth of industry clusters and innovation (Tan, 2006).

4.1.5 Science parks in emerging economies

It is undeniable that emerging economies are increasingly becoming key players in the global economy in terms of production and manufacturing of emerging industries such as information technology and biotechnology. Besides the production and manufacturing functions, emerging economies are also increasing their development
pace in R&D and innovation to sustain in today’s knowledge intensive world and highly competitive market. Several countries in Asia have been exploiting the concept of science parks to raise their innovative capabilities and increase their country’s competitiveness. It could be said that nowadays science park initiatives are a national development agenda as well as regional and local one in emerging economies. Many countries have been implementing their science park schemes, while others are still in the planning process to have one.

Today, there are over 200 science parks in Asia and the number is still growing. Japan is the pioneer in developing science parks in Asia. Currently, there are about 150 science parks in Japan. Tsukuba Science City, which was started in the early 1970s, is the oldest and the most well-known science park in Asia, even though some people may consider Tsukuba as more than simply a science park. China started its effort in developing science parks in the mid-1980s, and now have around 100 parks, of which more than half of the parks were approved by the national government and the rest are approved by local government. To date, Korea, Taiwan, and Malaysia have two parks each. Singapore has one park in operation and the recent One-North initiative is being developed. Thailand also has one park up and running, while three more university science parks are being evolved.

As developing countries in Asia have been seeking to enhance their scientific and technological capability in order to underpin their economic growth, science parks have become a new strategy for Asian countries to develop science and technology and to ensure the rapid transfer of R&D results to high-tech industries. Therefore, science parks have become the vanguard of the dynamic high-tech industries in Asia. The governments in Asian countries have played a leading role in promoting the development of science parks. In most cases, the national governments have provided financial support to build infrastructure and supporting environment. Many have also offered various tax incentives to attract firms to locate in these parks. In many cases,

33 www.iasp.ws
administration functions in the park are provided by government or quasi-government agencies. However, it is also interesting to note that universities in Asia have played relatively minor roles in science parks, whereas universities are typically among the key players in science park initiatives in Europe and U.S.

Among the countries in Asia, there are wide differences in their efforts to develop science parks due to diversification of their social and economic backgrounds. Accordingly, science parks in Asia can be classified into four groups based on their orientations.

**Japan and Korea**

In the effort to develop science parks, Japan and Korea put emphasis on basic and applied research. Also, their science parks are more domestically-oriented. They have no deliberate effort to attract foreign companies to settle in their parks. In terms of scale of development, their science parks are considered as large scale oriented science parks covering city/region development.

The Japanese science parks are very diverse. They vary greatly in their activities and size; some focus strictly on research, while others also conduct incubation, licensing and spin-off processes. Many Japanese science parks began to operate in the bubble era - the late 1980s and the early 1990s; where there were national policies aimed to reallocate industries that created higher value added from big cities to rural areas and to develop agglomerations of such businesses in the regions. The policies were intended to balance the location of agglomerations of specific businesses in the nation. Other relevant policies also appointed several regions to develop agglomerations of R&D-related activities. Based on this scheme, twenty-six regions were approved to promote agglomerations of specific businesses based on property-based initiatives such as science parks (Fukugawa, 2006).

Tsukuba Science City, the well-known and the first science park development in Japan, has forty-eight national research and educational institutes and more than 10,000
researchers, representing 30% of all national research agencies and 40% of their researchers. Also, more than 200 private research facilities are now established or planned in Tsukuba. In addition to Tsukuba, many more science parks have been planned in Japan. These science parks are intended to be both innovative R&D centers and high-technology production centers. Nevertheless, relatively many of the Japanese science parks can be described as unsuccessful as they have been able to foster only a limited number of achievements. The fundamental problems of Japanese science parks are R&D oriented approach based on the traditional technology innovation theory, majority of R&D activities center in Tokyo, and less experience of Science parks management (Park, 2000).

South Korea has followed Japanese science and technology policies because of its similar industrial structure. Therefore, in developing science parks, the two nations seem to face similar problems. However, the differences in national economic stage between the two nations reflect diverse focuses in the main strategy of science and technology policies. Japanese science and technology policies aim for the country to become a high-tech leading nation in the world, while South Korea is focused on the development of independent technological capacity as well as sustainable economic development. By March 2000 there were thirty-three science park projects in South Korea. Among these, only two of them are in operation, nineteen are under construction, and twelve are still in planning phase. Taedock Science Town, one of the two parks in operation, has more than 1,000 Ph.D. level researchers in fourteen research institutes. The town is also the home of three technical universities. It has become the centre of science and technology in Korea. Five more science towns have been planned in Kwangju, Pusan, Taegy, Chunju, and Kangleung. Development work has started in some of these new science towns.

Taiwan, China, and Malaysia

In these countries, science parks are oriented towards the development of high-tech industries, much closer to the end of manufacturing side of the spectrum when compared with science parks in Japan and Korea. Taiwan’s Hsinchun Science Based
Industrial Park has achieved great success in nurturing high-tech industries since its founding in 1980. Firms located in the Park are mostly in computer, semiconductor, and telecommunication industries. The integrated circuit (IC) industry was created and has become the dominant industry in the park. Malaysia's Technology Park Malaysia (TPM), completed in mid-1995, also focuses on high-tech manufacturing. China's effort in establishing science parks is unique both in terms of its large scale and fast speed. Beginning in the middle of 1980s, China has established fifty-two New-High-Tech Development Zones (NHTZs) at the national level. Roughly similar numbers of NHTZs have also been started at the local level. The main objectives of these NHTZs are (1) to promote the commercialization of high-tech R&D results, and (2) to become industrial bases for high-tech industries and experimental sites for structural reform of China's innovation system.

**Singapore and Thailand**

Science parks in Singapore and Thailand put their top priority on industrial R&D rather than academic research. The development plan for science parks in the two nations started in the 1980s. Singapore started the construction in early 1982 and opened the Park in 1984. The science parks in Singapore have been developed with two objectives, i.e. to attract foreign corporations, and to provide an environment in which R&D-intensive national firms can grow (Koh et al., 2005). After Singapore Science Park I had been fully occupied with over 120 multi-national companies and local R&D firms, Singapore Science Park II started to operate at the end of 2001.

On the other hand, Thailand started its construction in the late 1990s and officially opened the Park in 2002. Similar to the objectives of Singapore’s science parks, Thailand Science Park has dual objectives in assisting technology-based start-up companies as well as promoting the large local and international companies to invest in research and development in Thailand. The Thailand Science Park housed about fifty local and international companies. The science parks in Singapore and Thailand are designed to promote industrial R&D with the possibility of limited light production. Singapore's science parks are internationally-oriented with many multinationals located in the park.
Although it can be said that Thailand's science park is still in the development stage, it is also very hospitable to foreign companies. It is interesting to note that no special incentive is offered by Singapore's science park, which is partly due to the fact that the demand for entering the park has exceeded the supply. Thailand’s science park, on the other hand, offers tax incentives and other special services to attract firms to locate in the park.

4.1.6 Policies for science parks: lessons from Taiwan and Singapore

The primary task of innovation policies is to promote learning processes involving interaction between organisations and individuals. These involve ensuring good communication between academic institutions and industrial firms, as well as encouraging knowledge creation at firm level. Considerable resources are being devoted to science parks as policy instruments aimed at promoting research-based industrial and innovative activity (Quintas et al., 1992). The innovation policies related to science parks have emphasised facilitating and maintaining links between academic research and industry to improve the economic level of the countries (Turpin et al., 1996; Barnes et al., 2002).

However, innovation policies to promote collaboration and networking between public and private sectors using science parks as a policy tool differ extensively in developed and developing countries according to economic performance and technological capabilities of the countries. Most of the existing science parks in developed countries focus on R&D activities in academic institutions and the transfer of R&D results to industry, while most science parks in developing countries stress on promoting technological competencies of innovative firms and focusing on demand-motivated R&D. In the following, policy to promote collaboration and networking by means of science parks taking the experiences of developing countries such as Taiwan and Singapore in focus.
Taiwan

Taiwan has been quite successful in using science parks as a strategy to promote industrial R&D and to develop high-tech industries (Xue, 1997). Hsinchu Science Park, established in 1989 to attract high-tech firms to invest in industrial R&D and stimulate the growth of high-tech industry in Taiwan, has been acclaimed as a model for other developing countries which desire to establish their own science parks. To attract high-tech investment, the government formulated a series of financing and tax policies which provide great incentives for high-tech firms to come to the Park. Some of these policies include: (1) companies in the park can enjoy five-year tax exemption period, or an accelerated depreciation of machinery and equipment; (2) after the five tax-free years, the rate for all taxable income will not exceed 20%; (3) import of machinery and equipment, raw material, and semi-processed product are tariff free for the park tenants; and (4) for strategic key industries, 200% of the return on investment is tax-free, and the additional portion will be taxed at the reduced rate of 10%. In terms of policies to promote industrial R&D, instead of trying to transfer R&D results from universities and research institutions, various incentives and mechanism are set up to encourage firms in the Park to increase their R&D investment and upgrade their R&D activities from improvements on imported product or process to new product and process development. In this aspect, firms can apply for an R&D Incentive Grant or joint investment from the Science and Technology Development Fund or other government set-up venture capitals. R&D spending for process development and new product development can be entirely deducted from income tax.

Besides the attractive investment policies, the active recruitment of overseas R&D personnel has greatly helped the accumulation of advanced S&T knowledge and research skills in the Park (Xue, 1997). These personnel are Chinese college graduates who had gone for advanced studies in industrialised countries, especially in the U.S., and continued their career there. These personnel are at the technological frontier of their field. Their experience and substantial skills have helped the Park to leapfrog many steps in accumulation process.
Policies to promote collaboration and networking between firms in HSP and universities and research institutions have been implemented by means of the well-known Industrial Technology Research Institute (ITRI). ITRI, set up in 1973, is a government research institution focused on industrial R&D, has played a key role linking research to application. It is responsible for conducting two types of technical work: firstly, developing innovative technologies for the establishment of new high-tech industries, and secondly, the integration of relevant technologies into existing industries to improve their manufacturing processes and quality (Hsu and Chiang, 2001). It also undertakes the introduction, assimilation, and improvement of foreign technology and then transfers the results to private industries. The specific technology or product development and commercialisation are mainly conducted by the industries. Locating in close proximity to each other, ITRI is an active player in R&D activities in HSP. It has become a major source of innovation for firms in the Park, providing directions for firms’ R&D effort in specific product and process development, as well as offering services of advanced research when firms’ own effort in product and process development encounters difficulties (Xue, 1997). Consequently, it is not surprising that about one-third of ITRI’s research funding comes from private contracts; many of them from firms in HSP, and about 80% of the firms in HSP have collaborated with ITRI.

A study by Lee and Wang (2003) reveals that although policies to promote industrial R&D using tax incentives, science parks, and public research institutions have been successful, some of these tools may no longer adequate, as the country moves towards knowledge-based economy. Consequently, the government has introduced new tools such as venture capital, e-commerce, innovation incubators, and the “open laboratory” system. The “open laboratory” system means research institutes provide laboratory access for enterprises to use (Hsu and Chiang, 2001). It has two primary functions. One is the promotion of cooperative research projects which enables research institutes and firms to have better access to facilities for the purposes of maximising existing resources and to one another. The other is the hosting of an incubator centre that benefits researchers or entrepreneurs by providing a favourable R&D environment and various
assistance resources to minimise investment risk before commercialisation can take place.

The case of Hsinchu Science Park could be considered as an exemplar illustrating the synergy of “local buzz” and “global pipelines” as mention in Section 4.2.4. Although the policies related to science parks and industrial R&D in the case of HSP can be useful for policy implication in other developing countries, it is still essential to be aware that the practices of the park depend on local context and specific national circumstances.

**Singapore**

The Singapore Science Park I, one of the earliest parks founded in economies at the developing stage, is ranked the second most popular in the Asia Pacific region. The primary motivation of the government to establish SSP is the provision of infrastructure to attract the location of R&D activities by global corporations (Wong, 1999). This includes the creation of a supporting infrastructure for MNCs, consisting of domestic suppliers, services providers, and potential business partners. Aiming to create specific places for capturing globalising R&D activities, the Singapore government has introduced various initiatives to generate agglomeration economies for R&D activities (such as superior physical infrastructure, generous financial incentives and the proximate location of universities and research institutes) (Phillips and Yeung, 2003). However, unlike in the case of Hsinchu, private sector participation was limited; there was little interaction between the actors within the SSP, although it has improved in recent years (Koh et al., 2005). Although policies for SSP stress the importance of MNCs locating in the Park, it is indicated that although the MNCs located in the Park conduct R&D, knowledge creation and spill-over in the park is rather limited. In addition, Koh et al. (2005) note that although there were attempts in the 1990s to enhance R&D capabilities of SSP by locating a large national IT laboratory and two venture capital firms in SSP with anticipation to turn this into successful high-tech spin-offs, this was not successful for the most part.
On the one hand, SSP has achieved the primary goal to attract MNCs and fulfilled an impressive property development. On the other hand, it provides implication that policies emphasising high-tech infrastructure and investment benefits are unlikely to enhance R&D activities in SSP. In this regard, Saxenian (1994, p.161) critically notes that spatial clustering alone does not create mutually beneficial interdependencies. A study of SSP by Phillips and Yeung (2003) contend that the lack of significant R&D activities in SSP can be explained by the fact that the level of “institutional thickness”34 and “embeddedness” in the park is relatively low. This in turn reduces the possibilities for local firms to reap the advantages of geographical clustering.

4.1.7 Factors contributing to the development of science parks

There are several factors involved in the development of science parks. The literature indicates that linkage between firms and academic research is central to the concept of science parks (Quintas et al., 1992). For this reason, it is pointed out that the ability to develop links between local academic institutions and firms is often regarded as the key decisive factor by which to judge the success of the science park development (Westhead and Batstone, 1998). This is because firms had chosen to locate in a science park to benefit from informal and formal links with local academic institutes. Therefore, effective methods of linking science park tenants to the facilities and resources provided by local research organisation are a necessary condition for the development of science parks. Siegel et al. (2003b) also support that linkages between science parks tenants and local academic and research institutes are considered as a mean to promote technology transfer between science and industry.

Additionally, dimensions of proximity are also considered as another critical factor for the development of science parks (Felsenstein, 1994). Proximity between firms and academic institutes promotes the exchange of ideas through both formal and informal networks (Lindelöf and Löfsten, 2004), as well as supports close and ongoing interaction.

34“Institutional thickness” can be interpreted in four dimensions: a strong and obvious institutional presence; high level of interaction among institutions in a local area; development of sharply defined structures of interaction and coalition, and mutual awareness of being involved in a common enterprise. (AMIN, A. & THRIFT, N. (1994) *Globalisation, Institutions and Regional Development*, Oxford, Oxford University Press.)
among them, and these interactions are by no means unintentional (Saxenian and Hsu, 2001). Geographical proximity, in particular, has worked as a driving force for interaction between academic research and firms (Vedovello, 1997), but by itself it does not seem to be an important factor for strengthening U-I interaction, especially formal interaction such as collaborative research and development (Quintas et al., 1992). Massey et al. (1992) also argue that geographical proximity between academic research and firms in science parks only serves as a weak promoter of the technology transfer.

Nevertheless, a more recent study argues that the geographical proximity of firms clustering within science parks increases the likelihood of interaction among high-tech personnel and the expansion of their professional networks, thus promoting innovation (Hu et al., 2005). In this relation, geographical proximity gradually promotes organisational and social proximity within science parks via the development of industrial networks and interaction among high-tech talent. By and large, the various dimensions of proximity act as complements rather than substitutes (Oerlemans and Meeus, 2005).

In addition, the literature also stresses other factors of science park development. Minshall (1984) puts the availability of human resource in high technology as a critical factor. Saxenian (1994) stresses networking between organisations in the park and adjacent academic institutions as an important ingredient in making a successful science park. Wallsten (2001) values the availability of venture capital as a significant support mechanism of science parks. Luger & Goldstein (1991) conclude in an extensive study that park policies and procedures are also critical factors influencing the success of park development. According to Kang (2004), development and success factors of science parks could be classified into three categories: factor related to location, factor related to facilities and services provision, and factors related to support mechanisms.

In relation to processes of interaction and knowledge creation, a study by Bathelt et al. (2004) indicates that it is a combination of local interaction (i.e. “local buzz”) and extra-regional linkages (i.e. “global pipelines”) that creates a process of knowledge creation.
and interactive learning which accounts for the success of a geographical proximate organisation in the long-run. “Local buzz” refers to the informal, spontaneous, and sometime even accidental exchange of knowledge that takes place as a result of social relations in the local or regional milieu, while “global pipelines” are described as formal, structured, and thoroughly planned linkages that are more or less detached from such social relations (Moodysson, 2008). In other words, “local buzz” is knowledge spill over inside the same industry, place or region, and “global pipelines” is international relations and knowledge flows.

In general, it is rather complicated to identify general factors for the success of science parks because the objectives, preconditions, development processes, and the roles played by government, industry, and academic institutions are extremely diverse. These factors also evolve over time. Take Hsinchu Science Park (HSP) in Taiwan as an exemplar, in the early years of the park development, high-quality of infrastructure was needed to support technology start-ups and help develop national capabilities in high-tech manufacturing. There was active involvement of government in the development of HSP (Lee and Yang, 2000), as several mechanisms were introduced to facilitate the transfer of know-how from research institutions to the private sector. At the subsequent development of the park, agglomerative effects became important because it is the private sector that drives subsequent development and the success of the park (Saxenian and Hsu, 2001). Some of the critical factors that contributed to the success of HSP are active involvement of the government, accumulation of knowledge and skill, and a focus on manufacturing and demand-motivated R&D (Xue, 1997). Although the success factors of HSP cannot be generalised, they do have implications for developing countries.
4.2 Public-private research partnerships

In section 4.1 the notion of science park implies collaboration between actors in their spatial relation. The collaboration between actors, such as firms and public research institutions, in a science park is considered as a key activity of their innovation process. Studies indicate that interactions between industrial firms and public research institutes are increasingly critical for industrial innovation and competitiveness (Mansfield, 1998; Cohen et al., 2002). There are a wide varieties of cooperation mechanisms, ranging from joint research projects and spin-off companies to consulting relationships, training and personnel mobility (D’Este and Patel, 2007). Research partnerships between the public and private sectors are one form of inter-organisational collaboration that has gained increasing attention in recent years (Fontana et al., 2006). In other words, public-private research partnerships are sub-set of the concept of inter-organisational interaction reviewed in section 3.2. Cooperation between public and private partners is importance in the development and creation of technological innovation (Hagedoorn et al., 2000; Schartinger et al., 2001) and lead to faster use of the results provided by basic research (Mansfield, 1998). Therefore, effective collaboration between firms and research organisations is considered as a precondition for the industrial development of any country (Barnes et al., 2002).

While many studies currently focus on the analysis of cooperation between firms and research organisations (Hagedoorn et al., 2000; Schartinger et al., 2001; Barnes et al., 2002; Mora-Valentin et al., 2004), this study specifically devotes attention to research collaboration. This is because collaboration between firms and research organisations embodies government intervention into innovation process. For that reason, it is examined more carefully from a technology policy perspective. In this section, important features of R&D collaboration are reviewed including: characteristics of R&D collaboration between public and private sector; the different ways to initiate and formulate research partnerships; and factors influencing R&D collaboration.
4.2.1 Characteristics of public-private R&D collaboration

Hagedoorn et al. (2000) broadly define research collaboration as an innovation-based relationship that involves a significant, or at least partly, effort of research partners in undertaking research and development activities. They also suggest that there are at least two dimensions to characterise research partnerships. One is in terms of the members of the relationships, and the other is in terms of the organisational structure of the relationship. However, these two approaches are related and need not be considered independently. This study hence takes both dimensions into account in an attempt to review the public-private R&D collaboration holistically.

4.2.1.1 Nature of the research partners

From the perspective of characteristics of research partners involved in research partnerships, the main differences between public research organisations and private firms are considered as follow.

(a) Research objectives

There are differences in research objectives between these two types of organisations. Basically, academic research carried out by academic institutions and public organisations is undertaken to obtain new knowledge, whereas applied research conducted by private firms is aimed towards a specific practical use of research results. Although research institutions in some countries have recently become more market-oriented and focused their scientific activities on applied research and consultancy to firms rather than basic research (Coccia, 2008), they still have differing goals and discrepancies regarding economic benefits and costs of research activities.

(b) Research motivations

Initially, public research organisations and industrial firms have very different motive for research collaboration (Rappert et al., 1999; Mora-Valentin, 2000). While public research organisations mainly expect to benefit from external funding, new directions for research, access to industrial resources and practical experience, private firms expect
to gain access to expertise and resources in government laboratories, gain earlier and easier access to new knowledge, research results and intellectual property rights, and possibly attract public research subsidies. However, these differing motives create interdependence between firms and public research organisations thereby motivating them to collaborate (Geisler, 1995).

In a more specific example, Autio et al. (1996) illustrate the diverse motivations for research collaboration between industry and big research organisations and classify research motivations into six dimensions: technological, strategic, financial, political, educational, and epistemic. Following the study of Autio et al. (1996), Montoro-Sanchez et al. (2006) consider reasons for research cooperation from the viewpoints of research organisations and firms. These reasons are summarised in Table 4.1.

<table>
<thead>
<tr>
<th>Motivation</th>
<th>Research Organisations</th>
<th>Firms</th>
</tr>
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| Financial  | • Additional financial resources  
            | • Public funding          | • Additional financial resources  
            |                           | • Public funding           |
|            |                        |       | • Cost saving                     |
|            |                        |       | • Tax incentives                   |
| Technological | • Access to industrial experts, their experience, and materials | • Access to resource, knowledge, technological and scientific advance  
|            |                        |       | • Innovation on products and process |
| Strategic  | • Access to strategic resources  
            | • Improve image, prestige, reputation  
            | • Citations, publications          | • Competitive advantages  
            |                              | • Risk reduction                    |
|            |                        |       | • Launch new business and access to new markets  
            |                              | • Improve image, prestige, reputation |
| Academic   | • Training in the firm  
            | • Mobility of personnel      | • Training of employees  
            |                           | • Recruitment                    |
| Political  | • Adaption to governmental initiatives | • Adaption to governmental initiatives |

The four main reasons, ranked by priority, for public research organisations to cooperate with private firms are: (1) finding additional and alternative financial sources; (2) improvement of image and reputation; (3) access to a firm’s technology, knowledge and expertise; and (4) securing public subsidies (Montoro-Sanchez et al., 2006). Other
studies (Howells et al., 1998; Meyer-Krahmer and Schmoch, 1998; Lee, 2000) have also indicated that funding is a primary concern for research organisations to link with industry, because public research organisations are increasingly facing budget constraints supplied by the government. In addition, these studies mention about other motivations for research organisations to collaborate with firms, which include gaining insights into practical knowledge; testing application of technology; promoting innovation through knowledge transfer; gaining excess to complementary expertise, equipment and facilities; and responding to government policy.

On the firm side, the most important reasons for firms to cooperate with research organisations are to improve their competitive position, to launch new products and services, to gain access to partner’s technologies and to enter new markets (Montoro-Sanchez et al., 2006). Other studies (Lee, 2000; Caloghirou et al., 2003) also support the notion that firms collaborate with research organisations principally to gain benefits in technological and financial terms. Lee (2000) shows that firms partner with academia primarily to gain increased access to new research and discoveries, and to make significant progress toward the development of new products and processes. Coleghirou et al. (2003) point out that firms collaborate with academia to access complementary resources and skills, to benefit from research synergies leading to cost savings or improvements in R&D productivity, to stay abreast of major technological development, to obtain funding and to share R&D costs.

(c) Nature of research

The differences in the nature of basic and applied research result in discrepancies in how academic researchers and private firms perceive the relevance and significance of research. Even though academic researchers conduct research on the topics that they consider to have commercial significance, these topics may not match the relevance of applied research undertaken by private firms (Spencer, 2001). Also, it has been noted that academic researchers often cannot judge the commercial viability of different solutions (Rosenberg and Nelson, 1994). The research results therefore do not advance technological competitiveness of private firms. Also, on the one hand academic
researchers may prefer to see innovation more as a linear process which proceeds from basic to applied research and then to development, production and diffusion (Godin, 2006). On the other hand, the innovation process in private firms is considered as chain-linked, consisting of feedback loops between different steps in the process and all the steps are side-linked to research (Kline and Rosenberg, 1986). For this reason, it is assumed that research in private firms is mainly for solving problems that emerge along different stages of the innovation chain (i.e. design, testing, and production etc.) rather than being a source of innovative ideas. This different view of research can sometimes cause difficulties in research collaboration.

(d) Research cultures

Furthermore, public research organisations and private firms have fundamentally different cultures (Cyert and Goodman, 1997). In principal, public research organisation create and disseminate knowledge, while private firms operate in a highly competitive environment. Their concern about time horizons of research activities therefore differ. Most firms think about time in terms of meeting short-term constraints. For public research organisations, research time-frames are much longer and more flexible in terms of deadlines. Additionally, they have divergent languages; whereas academic researchers usually consider term such as ‘variables’ to be very important in research activities, firms are often less concerned about it.

Cyert and Goodman (1997) also highlight that public research organisations and firms have different basic assumptions about work, specifically performance evaluations. Most academic researchers receive a salary and tenure from their organisation. They are also evaluated from outside the organisation by their professional reference group for their reputation. In contrast, most managers are evaluated by their superiors by specific results from the research collaboration. This motivational difference can impede researchers in getting involved in R&D collaboration. In addition, Roediger-schluga (2007) asserts that appraisal and promotion in science is based on publication records, requiring codification and disclosure of research output, whereas appraisal and promotion in industry is based on the ability to generate profits. Hence, the different
incentive structures between the two partners can introduce a fundamental tension in their research collaboration.

(e) Research governance

The governance of research in public organisations and private firms tends to differ fundamentally (Dasgupta and David, 1994). Public organisations proceed with research under the norm of 'open science', while firms operate in the mode of 'proprietary technology'. In open science, the objective is the rapid growth of the stock of reliable knowledge, i.e. maximising the expansion of the accessible knowledge base. In proprietary technology, the objective is to maximise the flow of economic rent from existing knowledge assets (David et al., 1998). Research in the former mode is curiosity-driven and rewarded through 'winner takes it all' precedence rules, leading to the rapid codification and disclosure of research results. Research in the latter mode is driven by profit expectations and rewarded by financial profits. To maximise economic benefits and to avoid imitation, new knowledge is kept secret for as long as possible. This implies a reluctance to codify and publish core knowledge.

(f) Utilisation of new knowledge

The difference in research governance between science and industry underpins a discrepancy regarding the use of new knowledge. Public research organisations attempt to disseminate knowledge and research findings to the public (Mora-Valentin, 2000). On the contrary, in order to have advantage over their competitors, private firms protect new knowledge obtained through research and demand confidentiality and/or delay of publication of research results. Although intellectual property rights protection may help lessen the constraint on using knowledge produced from public-private research collaboration, this is less likely to be the case when the collaboration involves uncertainties with respect to research results and neither party can define meaningful limitations for any resulting intellectual property (Hall et al., 2001; Veugelers and Cassiman, 2005).
4.2.1.2 Types of R&D collaboration

R&D collaboration benefits firms and public labs in many ways, depending on the objective of the research partnership. Rothaermel and Dees (2004) link an exploration-exploitation framework of organisational learning to research partnership and introduce a very useful distinction between exploration and exploitation alliances. Exploration alliance focuses on developing new knowledge or technologies despite considerable uncertainty about practical options. Exploitation alliance focuses on improvement of established knowledge or technologies to make production more efficient.

The main concern of exploration alliance is on expanding the resource base and managing uncertainty. Collaborating with industry may allow public labs to widen the scope of their research and/or to accelerate the development process of new knowledge. On the firms’ side, they may collaborate to gain access to and acquire new knowledge and skills, as well as to develop new proprietary capabilities. They may use research collaboration as a relatively inexpensive and flexible means for learning about and experimenting with novel technological solutions.

For exploitation alliance, uncertainty reduces efficiency and cost, and competitive concerns become relatively more important partnering motives. Exploitation alliance may help firms to speed up product development, to set or to promote technological standards, and to co-opt competition, as well as help public labs to materialise their research industrial uses.

Rothaermel and Dees (2004) also specify that publication is less problematic in exploration alliance, because inputs from the alliance tend to be of a more fundamental and thus generic nature. For that reason, R&D partnerships between science and industry tend to be more frequent in the exploration phase of industrial innovation processes.

A study by Revilla et al. (2005) explains types of research collaboration, particularly its practices and characteristics, by presenting a two-dimension taxonomy of research
collaboration, based on learning processes and knowledge management. The first dimension is focused on the stage of technological development at which the collaboration operates, i.e. new knowledge versus existing knowledge. The second dimension relates to the knowledge management approaches that support the inter-organisational learning process, i.e. the extent to which research collaboration focuses more on structural versus social practices. These dimensions are summarised in Figure 4.1.

![Figure 4.1 A two-dimensional taxonomy of research collaboration and knowledge and learning processes (Revilla et al., 2005)](image)

Exploitative research collaboration involves R&D projects that focus on existing knowledge and manage the learning process in a structured way. In this situation, knowledge transfer is necessary to the consolidation of activities as well as competencies. R&D projects in this type of research collaboration are oriented towards achieving efficiency and reducing risk in operations.

Strategic research collaboration supports the creation of new knowledge, which is applied in relation to existing and structured processes. The aim of this collaboration is to develop future competitive advantages and enhance internal capability to face future changes. An R&D consortium created to develop a new concept is a good example of this type of research collaboration. The key challenge here is to effectively transfer the new knowledge to the research partners.
Interactive research collaboration incorporates R&D projects that increase scope and depth of existing knowledge by socialising members around certain problems. This type of research collaboration differs from the two previous types in that it emphasises joint work and greater interaction between the research partners. It builds up competencies and skills that, locally applied, generate a better understanding of the key processes or variants of existing products.

Integrative research collaboration includes R&D projects that aim to construct and acquire new knowledge and manage the learning process with a social approach. In this situation, there is no available knowledge where the relevance for further expansion can be judged. R&D projects here are risky and relatively less tangible because it involves creating new knowledge that breaks the existing linkages between the new knowledge and the prior knowledge.

4.2.2 How R&D collaboration is organised

4.2.2.1 Formation process

The R&D collaborations between science-industry are largely initiated and formed through the use of already established contacts, which are often formed through an educational/professional network or through previous smaller-scale cooperative projects (Schartinger et al., 2002). However, in cases where R&D collaboration has been formed without prior contact, the collaboration has a clear goal based on a particular need for new knowledge by the firm (Thune, 2007).

Thune (2007) distinguishes four modes of formation process of R&D collaboration based on two aspects, i.e. embeddedness and inducement. Embeddedness means the extent to which the collaboration is formed using pre-established network contacts and prior ties to the partners. Inducement means the extent to which the partners have a particular need for resources. These modes of formation process of R&D collaboration include: (1) created collaboration; (2) needs-driven collaboration; (3) opportunity-driven collaboration; and (4) interdependence-driven collaboration. Created collaboration is the
relationship that is formed by external agents, whereby previous links between the research partners and demand for resources to be obtained through the collaboration are absence. Needs-driven collaboration is formed because of a strategic need for resources, but with weak embeddedness of the partners. Opportunity-driven collaboration is formed based on established contacts and prior interaction experience, however where the need for specific resources is less important. Finally, interdependence-driven collaboration is derived from previous established contacts and prior collaboration, in which the partners share common understandings and have a clear strategic need for the knowledge.

4.2.2.2 Interactions process

Theoretical frameworks for understanding the basis of interactions and relationships of university-industry cooperation are proposed by Bonaccorsi and Piccaluga (1994) and Geisler (1995) as mentioned in Chapter 3. Although these two theoretical frameworks are constructed primarily for studying university-industry relationships, it is considered reasonably broad in scope and thus suitable for adoption in this thesis. The studies on interactions of research organisations and firms are relatively marginal in volume compared to the ones relating to U-I relationships. Also, most of the literature consider university and research organisations as academic institutes. They have many features in common, apart from the fact that research organisations have a propensity to conduct applied research rather than basic research, and they do not oblige to teaching and training. Hence, the borrowing concepts of U-I relationships are applied in this study.

According to Bonaccorsi and Piccaluga (1994), a concept model for studying inter-organisational relationships (IOR) between university and industry (U-I), as discussed in section 3.2.1, is constructed from two bodies of knowledge. One is economic analysis of technological innovation, which gives important insights into a firm’s motivation to enter into U-I IOR and the characteristics of the knowledge transfer process. The other is inter-organisational theory, which underscores organisational dimensions of U-I IOR concerning the organisational structure of the relationship and the coordinating procedures adopted. Bonaccorsi and Piccaluga (1994) propose that the combination of
the characteristics of the knowledge transfer process and the organisation of the relationships influence performance of the relationships.

In line with Bonaccorsi and Piccaluga (1994), to explain the underlying principle and persistence of cooperative R&D, Geisler (1995) proposed a theory of inter-organisational relationships that apply to industry-university alliance by borrowing the concepts from two theories of inter-organisational relationships, which are theories of interdependency and theories of interaction. In relation to the interdependency theories, the role of interdependency has been emphasised in the origin and maintenance of inter-organisational cooperative relationship. Moreover, it is proposed that resources needed and perceived benefits motivate R&D cooperation for both university and industry. While interdependency theories focus on the impacts of the external environments on inter-organisational relationships, interaction theories explore the internal development of the relationship itself and stress the impacts of the process of the relationship. Specifically, interaction theories argue that the emergence of inter-organisational relationships results from previous associations between the parties, mutual trust and commitment.

4.2.3 Factors influencing R&D collaboration

4.2.3.1 Firms characteristics: size and R&D capacity

The literature indicates that firm size is one of the tenet factors determining propensity of firms to collaborate with research organisations and influencing performance of their R&D collaboration (Cohen et al., 2002; Mohnen and Hoareau, 2003). Studies show that firm size is consequential in science-industry collaborative research (Santoro, 2002). It also has a positive and significant effect on cooperation, in the sense that the larger the firm, the greater the propensity to cooperate (Bayona et al., 2001; Cassiman and Veugelers, 2002). In addition, Fontana et al. (2006) note that the rationale underlying the role of firm size in influencing R&D collaboration is that large firms have more resources to help them establish R&D relationships with public research organisations.
than smaller firms do. These resources include financial, technical, and human resources, which are more easily available in large firms.

However, while large firms have a higher propensity to collaborate with research organisations because they possess greater capability to exploit the benefit from the collaboration than small firms do, these large firms may be less successful in terms of R&D collaborative projects. On the other hand, smaller firms may be less likely to get involved in science-industry cooperation. They may possibly perform better than large-sized firms in utilization of results from research collaboration. Despite the fact that large-sized firms often have many advantages over small-sized firms, it appears that size alone does not play a critical role in facilitating knowledge transfer activities (Santoro and Gopalakrishnan, 2000). Even small firms can be successful in acquiring external knowledge and perform better in R&D collaboration when their internal R&D capacity is appropriate. It is therefore suggested that the ‘relative’ (i.e. the research) size of the firm rather than its overall size should be considered in this context (Fontana et al., 2006).

Furthermore, Robertson and Gatingnon (1998) note that the influences of firm size over the decision of a firm to cooperate appear to contradict themselves. For a firm to cooperate, it will thereby acquire complex knowledge that is currently lacking (Cohen and Levinthal, 1990). To be able to absorb such capabilities, it is therefore necessary that firms have their own knowledge base that is only obtained if it has previously carried out research activities. Although small-sized firms require cooperation with others to handle certain research projects due to their limited resources, the smaller the size of the firm, the greater the market considerations and less important the questions related to technological development (Bayona et al., 2001).

In essence, the main objective of firms to get involved in R&D collaboration is to acquire complex knowledge that they lack. For firms to absorb external knowledge, it is necessary that they have knowledge base, which is obtained collectively through previous research activities carried out internally (Cohen and Levinthal, 1990). Mohnen
and Hoareau (2003) put forward that in-house R&D effort increases the propensity to cooperate. Firms that conduct in-house R&D are able to gain knowledge from collaborating with research organisations. These firms are thus likely to possess a high technological capability that allows them to absorb knowledge developed outside the firm (Schartinger et al., 2001). However, this is less likely to be the case for small firms, since sometimes the small firms have a scarce knowledge base due to the absence of technological and research abilities.

4.2.3.2 Characteristics of researchers and their organisations

It is important to recognise that the ones who actually interact with industry are the researchers. Academic researchers choose to interact with industry for a diverse set of reasons (Howells et al., 1998; Meyer-Krahmer and Schmoch, 1998; D’Este et al., 2005). Therefore, focusing on the researchers and factors influencing their interaction with industry is necessary to improve our understanding about academic-industry interaction. This is also particularly important for designing policies facilitating and fostering public-private R&D interaction.

Looking at the characteristics of individual researchers, the literature indicates that ‘integration’ skills of individual researcher is a vital factor influencing the likelihood of academic-industry interaction (D’Este and Patel, 2007). In this aspect, ‘integration’ skills of researchers refer to individual capabilities necessary to integrate the two worlds of scientific research and manufacturing and product application. It also refers to the capacity to balance and align conflicts between academia and industry (e.g. the norms of ‘open science’ and ‘proprietary technology’). Academic researchers who interact with industry more frequently are more likely to build the capability necessary to bridge the gap between scientific research and applications.

Furthermore, the environment (such as organisation routines and culture and policies) within which the researchers are embedded is likely to have greatest influence on their behaviour regarding academic-industry interaction (D’Este and Patel, 2007). These environments primarily involve the characteristics of organisations that are associated
with the orientation of the organisation towards technology transfer activities (Di Gregorio and Shane, 2003; Siegel et al., 2003a). In addition, the scale of resources, in terms of either personnel or research income, and the quality of research can be considered a necessary condition for attracting industry interest (Schartinger et al., 2001). Nevertheless, D’Este and Patel (2007) contend that individual characteristics have a much stronger impact in explaining the extent and variety of interactions between academic and industry than the characteristics of research organisations as previous studies have suggested.

4.2.3.3 Trust and prior established relationships

Trust between research organisations and collaborating firms is an important ingredient in the development of the relationship and contributes to the success of their collaboration (Klofsten and Jones-Evans, 1996; Davenport et al., 1999a; Davenport et al., 1999b). This is because trust fulfils the corresponding aims of the partners (Santoro and Chakrabarti, 1999) and increases the chances of survival of their relationships (Geisler, 1995). When trust is built between collaborating organisations, they develop confidence about their partner’s abilities and expected behaviours, leading to cooperation rather than scepticism (Das and Tang, 1998). When a high level of trust exists, the collaborating firm is more willing to share their unique knowledge with the research organisation and in turn, the research organisation is able to provide the kinds of knowledge that the firm needs (Santoro and Gopalakrishnan, 2000).

However, trust between the firm and research organisation can take considerable time to develop and only evolve incrementally with repeat relationships (Davenport et al., 1999a). To encourage trust, the literature indicates that both prior experience of working together and prior experience of collaboration are important factors in facilitating public-private collaborations (Barker et al., 1996; Barnes et al., 2002).

Several studies suggest that the outcome of the cooperative relationships would be better if the partners have had previous cooperative experiences (Dill, 1990; Geisler et al., 1990; Geisler, 1995; Cyert and Goodman, 1997; Davenport et al., 1999a). Recent
studies provide support evidence in this context. A large scale study emphasises that previous links between the partners is among one of the factors influencing the success of R&D collaborations (Mora-Valentin et al., 2004). The accumulation of the previous links also helps increase the chance of success of the next research collaboration. Furthermore, R&D collaborations between firms and research organisations are formed in several distinct ways depending on the availability of pre-existing relationships between the research partners and successful collaborations that grow out of prior established relationships (Thune, 2007). Those researchers with a record of past experience are more likely to be involved in a greater variety of interactions with industry and also to engage more frequently across a wider set of interaction channels (D’Este and Patel, 2007).

4.2.3.4 Partner commitment and communication

For the success of collaboration projects, every collaborative agreement requires a high level of commitment by the partners involved in the project. Several studies show that the higher the degree of participation and involvement of the partners and the senior executives, the more effective the cooperative relationship will be (Geisler et al., 1991; Bonaccorsi and Piccaluga, 1994; Klofsten and Jones-Evans, 1996; Cyert and Goodman, 1997; Davenport et al., 1999a; Davenport et al., 1999b). Barnes et al. (2002) support that senior management commitment is needed to provide a collaborative project the required degree of commitment, attention, and priority. Moreover, Mora-Valentin et al. (2004) also confirm that commitment has a positive influence on the success of cooperation between firms and research organisations.

Likewise, an appropriate communication system between the partners leading to a regular exchange of information between them is also fundamental for the success of the collaboration (Bonaccorsi and Piccaluga, 1994; Davenport et al., 1999a). Individuals develop common purposes and concepts about their situation though frequent communication, thereby facilitating cooperative relationships because these concepts act in a similar way (Van de Ven and Walker, 1984). In addition, Mora-Valentin et al. (2004)
also indicate that there is a link between communication and development of the relationship through commitment and trust.

4.2.3.5 Cultural issues

Conspicuously, firms and research organisations have different research cultures. These differences are reflected in differing perspectives and priorities of the collaboration. Following Barnes et al. (2002), it is illustrated that while industrial partners desire quick results, academic partners aim through its research activities to achieve certain important academic objectives (e.g. the publication of research results in academic journals, to perform further research for specific application and through this research develop new knowledge). Therefore, a balance between the requirements of industry and academia must be achieved if the collaboration is to be successful. This requires that each partner understands the needs and constraints of the other and strive toward a solution that would effectively provide them mutual benefit.

4.3 Conclusion

This chapter presented the notions and significance of the science parks concepts (section 4.1) and the characteristics, processes and influencing factors of public-private research partnership (sections 4.2). It is apparent that science parks is a fuzzy concept and evolves over time as science parks have gone through different stages of development. The initial concept of science parks was to facilitate flow of technology from academic to industry. Later on science parks were used to increase collaboration between science and industry and enhance local and regional competencies. Recently, the creation of technological entrepreneurs and knowledge-based firms are central to science parks concept.

Although the concepts of science park have been implemented with different objectives, roles of science parks as a policy tool to promote research activities and linkages between firms and academic research have never been changed. Science parks can be seen as a model where elements of innovation process come to play. This implies that
science parks concept have long been involved complex interaction between academic researchers and firms in their spatial proximity. This interaction entails collaboration and diffusion of knowledge locally between firms and local institutions and is expected to boost the competitiveness of the firms and regions.

However, how interaction and collaboration between firms and local institutions in science park function is context specific and depend on the characteristic of partners and nature of the collaboration per se. Regions or nations need to find their own way to develop science parks concept based on factors underpinning their local context. For this reason, this study investigates interaction and collaboration between firms and local institutions in the Thai context where research centres and firms are located in a planned science park. Following from this aspect, the next chapter formulates research question and demonstrates a research methodology to address the research question.
Chapter 1 has introduced the key issues, the main research questions, and the object of the study. Chapter 2 has presented the system of innovation in the Thai context. Chapter 3 has reviewed theoretical frameworks and concepts which used to construct conceptual framework of this study. Chapter 4 has visited science park concept and public-private research partnership which underpin the empirical work of the case being studied. This chapter proceeds with elaborating the research methodology. The chapter firstly introduces the research approach (section 5.1) which leads to two research themes (section 5.2). The research methodology present how this study is carried out (section 5.3). The chapter ends with conclusion in section 5.4.

5.1 Research approach

The objective of this study is to explore and understand the factors underpinning interactions of public research organisation (PRO) and industry R&D partnerships in a catching-up economy in order to provide implications for policy design and implementation. The study is fundamentally based on the innovation system approach (as reviewed in section 3.1) which emphasises the importance of interactions among firms, public research institutions and technology policy for innovation success (Lundvall, 1992; Nelson and Rosenberg, 1993a). Drawing from literature on innovation systems, a country’s innovative performance and competitiveness depends on the performance of individual actors and the interactions engaged in by the different actors of the innovation system (Nelson, 1992; Freeman, 1995; Edquist, 1997). Interactions among different actors within the innovation systems are crucial for their knowledge production, accumulation and diffusion (Lundvall and Johnson, 1994). The growth in such interactions leads to improved innovative performance of an innovation system, and innovation systems grow through complementary interactions between innovators
and their partners (OECD, 2002b). Thus, a study on the prevalence and importance of interactions and linkages as well as on factors that influence the specific linkages providing evidence of the complexity of the activity and information is necessary to recognise a dynamic model of interactions and their resulting outcomes. This information can make a valuable contribution to understanding innovation systems and can help determine the influence of government programmes to encourage greater knowledge sharing or technology diffusion (OECD, 2005). Corresponding to these lines of reasoning, it could be argued that interactions and linkages of the actors are the key ingredient of the innovation process. Therefore, to provide a better understanding of the complex interactions and linkages within the innovation environment, understanding how the system works through the study of interactions of the actors is the key to success policy design and implementation.

With regard to the importance of interactions of actors in the innovation process, studies indicate that there has been an increasingly significance of collaboration between firms, research partnerships and public-industry linkages as a central concern for government policy (OECD, 1998; OECD, 1999). However, collaborations can take various forms depending on degree of formalisation, which range from informal contacts and information flows, such as offering general advice, to formal arrangements in innovative projects in which collaborative partners actively participate on a specific piece of work (Katz and Martin, 1997). Formal arrangement of collaboration such as collaborative research has a significant impact on innovation systems by creating and strengthening networks which are essential for development of innovation clusters (Liyanage, 1995). Furthermore, it has been highlighted that public institutions promote the development of R&D network as part of their technological policy, with the purpose to enhance competitiveness and technological capabilities of the country (Edquist, 1997; Hagedoorn et al., 2000). In other words, there have been presumptions that fostering interactions and linkages, especially R&D cooperation, between PRO and industry help to strengthen the system of innovation that they are embedded in.
It is commonly evident that public research organisations are facing a key challenge of meeting a nation's needs. PRO in both developed and catching-up economies have played a wide diversity of roles with regard to their corresponding innovation systems in order to support the technological competitiveness of the country. However, factors involved in their interactions with industry are country specific. While many studies have highlighted interactions and linkages of PRO and industry in developed countries, this study takes an experience of a catching-up country, Thailand, as a case study with the attempt to contribute to the knowledge of encouraging interactions between PRO and industry in adverse conditions.

In relation to the Thai context, the government has put great effort to promote public-private research partnerships to increase the technological competence of local industry. The National Science and Technology Development Agency (NSTDA), a public research institution in Thailand responsible for conducting and supporting technological advancement of the country, is a focal point of the investigation in this thesis. A significant policy initiative of NSTDA is that it concentrates National Research Centres (NRCs) in Thailand Science Park (TSP) and deliberately accommodates technology-based firms on the same premise (see section 2.2). Additionally, NSTDA and NRCs have recently been encouraged to change their R&D strategies and the organisation of R&D activities to better function to meet the needs of industry (see section 2.3). This policy move is intended to improve R&D relationships between PROs and industry.

The policy move to promote research partnership between public and private sectors and the unique settings of NSTDA, NRCs, and TSP, especially the agglomeration of public research institutions and technology-based firms in close physical proximity, drive the key interest of this study to focus on industry links of public research institutions by cautiously investigating the linkages in two aspects. The first aspect centres on the way in which locating technology-based firms and the research centres in the science park influences their informal and formal interactions. The focal point of interest in their relations here is the formal interactions in the form of R&D collaborations. Thus, the first research theme is to test the assumption of the importance
of co-location on linkages and interactions of the local actors, i.e. local firms and the research centres in particular, with key emphasis on their R&D collaboration. The second aspect captures the concern about R&D collaborations of the research centres and industry to explore the ways in which the research centres collaborate with firms in R&D collaborative projects. Hence, the second research theme is to recognise characteristics and factors which determine their research partnerships.

This study deliberately connects the two themes together in order to recognise the dynamics related to linkages and interactions of public research institutions and the industry R&D collaboration in the specific context of Thailand. This is to account for both localised factors and other influencing factors involving in public-industry R&D partnership. It is anticipated that an understanding of the influences of locating the research centres and technology-based firms together and the determinants of how industry and the research centres collaborate in R&D projects provide better knowledge and insightful information for appropriate STI policy design and implications that concentrate on the promotion of public-industry R&D partnership in particular.

5.2 Research themes and relevant research questions

5.2.1 Theme 1: Co-location of actors and their collaboration

Studies demonstrate that geographical proximity favours interactions between actors in innovation systems (Park, 2003; Doloreux and Parto, 2004; Lindelöf and Löfsten, 2004). Occasionally, it is in some way misleadingly perceived by some policy-makers that short geographical distance enhances the process of innovation, resulting in rather inappropriate policy being devised and implemented. In fact, geographical proximity only facilitates innovation activities and interactive learning by strengthening the other dimensions of proximity, such as technological proximity and social proximity (Vedovello, 1997; Boschma, 2004; Boschma, 2005b). Accordingly, it is crucial to isolate analytically the effect of geographical proximity from the other forms of proximity to
determine whether geographical proximity really matters in the process of innovation (Howells, 2002).

With reference to the notion of proximity reviewed in section 3.3 and the questionable of the benefits of co-location in the case of TSP. This study carefully examines the policy initiative that NSTDA has chosen to locate its research centres and technology-based firms together in the science park. This policy initiative is assumed to boost public-private interactions and emphasising geographical agglomeration as a central way to organise relationships between firms and public laboratories. Hence, the focal consideration of the first research theme is on the geographical concentration of actors and formation of interactions and linkages in general, and R&D collaboration in particular, in the context of Thailand. Thus, the first main research question is formulated as follows.

**Research question 1:**

To what extent does co-location (i.e. physical proximity) influence the likelihood of interactions between firms and research centres located in science parks in the case of Thailand?

From the first research question, it is also motivating to investigate further the collaboration between public research institutions and local technology firms. Apart from being physically close together, what other factors play a role in their linkages and interaction, especially in their R&D collaboration? Therefore, the sub-research questions emerge as follows.

**Sub-research questions:**

(1.1) What is the extent and type of interaction of local actors (i.e. firms and research centres)?

(1.2) What are the factors influencing interaction of local actor?
5.2.2 Theme 2: Research collaboration of PRO and the industry

It is assumed that collaboration in research is a good thing and that it should be encouraged; there have also been various initiatives launched with the aim to develop collaboration between PRO and industry (Katz and Martin, 1997). Empirical studies also demonstrate that external links of firms with academic and government laboratories, such as collaboration in research activities, are of critical significance for their innovative performance (Hagedoorn et al., 2000; OECD, 2002a; Schartinger et al., 2002; Belderbos et al., 2004). Thus, to devise policies to promote technological competitiveness through R&D collaboration, it is necessary to understand the way in which collaborative partners interact and factors that influence their collaborations.

Therefore, further from the first research theme focusing on co-location and R&D collaboration, the second theme centres at how the R&D collaboration between the NRCs and industry is carried out in order to identify factors influencing their interactions. Identifying these factors can help in defining appropriate policy tools targeted at encouraging interactions and linkages of actors in innovation systems.

According to the way in which public-industry research collaborations of the Thai NRCs are organised, their innovation process is considered primarily as a linear process of innovation. R&D activities are carried out by the NRCs and transferred to related industries. In most cases, the NRCs are producers and suppliers of technological knowledge, while firms are technology users who commercially exploit the technological knowledge. Revealing the dynamics of interactions between the NRCs and the industry in R&D collaborations will deepen knowledge and understanding regarding industry links of the public research institutions. Thus, factors involving interactions between the Thai NRCs and industry in relation to their R&D collaboration will be explored in the following research question.
Research question 2:
What is the nature of R&D collaboration between research centres and firms in the case of Thailand?

To answer this question, sub-questions are formulated to explore the nature of their collaboration and influencing factors.

Subsequent research question:
(2.1) What are the types of R&D collaboration that exist between research centres and firms?
(2.2) How are R&D collaborative projects between research centres and firms operated?
(2.3) What are the partners’ motivations for participating in R&D collaborations?
(2.4) What are the determinants of and barriers to interactions between R&D collaboration partners?

In light of the two research themes and questions presented, this thesis ultimately look at how NSTDA, through the arrangement of the NRCs and Science Park, is able to better meet the needs of industry/country in supporting science and technology development and advancing technological capability.

5.3 Research methodology

5.3.1 Research design

According to the type of research questions being asked in this study, a case study approach is used as a research method. The case study method is appropriate to address ‘how’ and ‘what’ questions and allows for deep and detailed understanding of complex phenomena (Yin, 2003). ‘How’ questions are likely to favour the use of explanatory case studies, while ‘what’ questions could be exploratory or about prevalence. Thus, this thesis is both explanatory and exploratory in nature. The case study is particularly suitable for this explanatory and exploratory research because it allows insights into the
interaction of actors in an innovation system to be gained, by deliberately investigating the contextual conditions within the boundary of the case, as well as discovering how and what phenomenon is happening, what leads to what, and relationships link different events.

5.3.2 Research operationalisation

5.3.2.1 Research framework and units of analysis

The research framework of this study involves R&D relations and interactions of public-industry in the specific context of the National Science and Technology Development Agency (NSTDA) in Thailand. The actors included in this particular setting are: (1) the National Research Centres (NRCs) under the roof of NSTDA, and (2) technology-based firms, which include both local firms located in TSP and the external ones that have R&D collaboration with the NRCs. In addition to studying the relations and interactions of the actors, i.e. public research institute and industry, influencing factors that shape their interactions are also considered in the studied framework.

The conceptual framework of this study is constructed from three theoretical frameworks: i.e. the concept of local innovation system; the notion of proximity; and the inter-organisational relationships. These three concepts are combined to study the local setting whereby research centres and firms are co-located in a planned science park. The local system of innovation approach is used for the reason that its notion is helpful in investigating actors and their interactions, as well as to account for institutional factors influencing the way in which the actors interact in the innovation system. With regard to the perspective of the systems of innovation concept (Edquist, 2005), organisation components in this study include firms, the science park, the NRCs, and NSTDA, while institution components include policies related to public-industry links in general, and research collaboration in particular. The organisations (or the actors), their relationships, and the relations between the organisations and institutions are analysed. Interactions of the actors are investigated using implications from theories of
inter-organisational relationship. The concept of proximity is employed to give explanation for the way in which proximity of actors influence their interaction.

Therefore, there are multiple units of analysis in this study. With regard to the first research theme, the units of analysis entail firstly the interactions between technology-based firms locate in the TSP and the NRCs, secondly the firms themselves, and thirdly the NRCs. For the second research theme, the units of analysis include firstly the R&D collaborations of the NRCs and the industry, secondly the NRCs, and lastly NSTDA’s policies related to conducting R&D collaborations with the industry.

5.3.2.2 Sampling Frame

In this study, the focus is on research cooperation between government laboratories and firms. While the first research theme aims to investigate the relationships of local actors (i.e. local firms and the NRCs), the second research theme attempts to examine the relations of the NRCs and firms locate elsewhere outside TSP. In order to carry out the study with respect to these two research themes, the sampling frames are presented in three elements.

(1) Research Centres:
The first element is the NRCs. Although, there are four NRCs under the roof of NSTDA, three centres are included in this study as they were established during the same period (i.e. around early and mid-1980s) and have extensive records and achievements in their R&D profiles. These three centres are the National Centre for Genetic Engineering and Biotechnology (BIOTEC), the National Metal and Materials Technology Centre (MTEC), and the National Electronics and Computer Technology (NECTEC). The centre that is excluded is the National Nanotechnology Centre (NANOTEC) due to the fact that it was only established in 2004. As such, its performance regarding relations with industry is relatively premature to include in this study. The contexts of these research centres have been presented in Chapter 2 (section 2.2).
(2) Local firms in TSP:

The second element is the firms located in TSP. There were altogether forty-two tenant firms in TSP as of March 2007 when the empirical data was collected. The park management classifies tenant firms into three groups based on their key activities. The first group is marked as R&D intensive tenants, which consists of thirty firms. The second group is tenants who primarily provide support and services related to R&D activities (e.g. food testing, patent filing and intellectual property protection, and environmental management consultant), which consists of nine firms. In addition, the third group is tenants who provide other services for quality of life (such as food and beverage), which consists of three firms. Moreover, the park management categorises the first group of tenants who are labelled as R&D intensive firms into three sub-groups corresponding to the technology sectors of the three NRCs. With respect to this arrangement, nine firms are in the biotechnology sector, twelve tenants in the metal and advanced materials sector, and nine tenants in the ICT and computer and electronics sector respectively (See Appendix 1: Tenants in Thailand Science Park). The composition of tenant firms in TSP is presented in Figure 5.1.

Figure 5.1 Composition of firms in Thailand Science Park (as of March 2007)
This study attempts to investigate the relations and interactions between public and industry with emphasis on R&D collaboration, thus the sample frame are those thirty firms marked as R&D intensive tenants. Information and detailed activities of these tenants were gathered from internal documents of TSP and discussions with TSP managers in order to verify whether they conduct their R&D activities in the TSP or only use the space and facilities provided for other business purposes. Table 5.1 displays a summary of proposed and actual activities of the R&D tenants in TSP.

By working with TSP managers and reviewing company data to verify activities of the firms marked as R&D intensive tenants, about half of those tenants were filtered out of the sampling frame. Some of these tenants basically used TSP as an administrative and coordinating centre, and some did not function in the park on a regular basis. Thus, nine firms were selected as informants for this thesis on the basis of extensive activities and functions in TSP: four are from the biotechnology sector; three are from the metal and advanced materials sector; and two are from the ICT, electronics and computer sector. The four firms from the biotechnology sector are Alltech Biotechnology Corp., Ltd., Betagro Science Center Co., Ltd., Delphi Health Service Co., Ltd., and Stem Cell for Life Co., Ltd. The three firms from the metal and advanced material sector are Advance Dental Technology Center (ADTEC), Golden Water Polymer Co., Ltd., and Intri-Plex (Thailand) Ltd. The two firms from the ICT, electronics and computer sector are Embedded Technology Co., Ltd. and Mobilis Automata Co., Ltd.
<table>
<thead>
<tr>
<th>Sector</th>
<th>Tenants</th>
<th>Proposed activities</th>
<th>Actual activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrial Biotechnology</td>
<td>1. Alltech Biotechnology Corp., Ltd.</td>
<td>Asia-Pacific Bioscience Centre for R&amp;D in feed additives</td>
<td>R&amp;D</td>
</tr>
<tr>
<td></td>
<td>2. Betagro Science Center Co., Ltd.</td>
<td>Laboratory and testing services for Betagro Group</td>
<td>R&amp;D and testing services</td>
</tr>
<tr>
<td></td>
<td>3. Delphi Health Service Co., Ltd.</td>
<td>DNA testing services</td>
<td>R&amp;D and testing services</td>
</tr>
<tr>
<td></td>
<td>4. Concept Foundation</td>
<td>Office for a non-profit organisation for health and family planning in developing countries</td>
<td>Administrative office</td>
</tr>
<tr>
<td></td>
<td>5. Health Concepts International Ltd.</td>
<td>Testing services for pharmaceutical products</td>
<td>Testing services</td>
</tr>
<tr>
<td></td>
<td>6. Hemotrans Co., Ltd.</td>
<td>R&amp;D for artificial blood</td>
<td>n/a (too early to indicate)</td>
</tr>
<tr>
<td></td>
<td>7. Shiseido (Thailand) Co., Ltd.</td>
<td>Shiseido South East Asia Research Centre for cosmetic</td>
<td>R&amp;D liaison unit with BIOTEC</td>
</tr>
<tr>
<td></td>
<td>8. Sipso Tropical Drink Co., Ltd.</td>
<td>Production of food products from jasmine rice</td>
<td>Light production</td>
</tr>
<tr>
<td></td>
<td>9. Stem Cell for Life Co., Ltd.</td>
<td>Cord blood bank services and R&amp;D in stem cell</td>
<td>R&amp;D</td>
</tr>
<tr>
<td>Metal and Advanced Material</td>
<td>1. Advance Dental Technology Center (ADTEC)</td>
<td>R&amp;D in advance dental technology and dental services (a joint)</td>
<td>R&amp;D</td>
</tr>
<tr>
<td></td>
<td>2. Business System Service Co., Ltd.</td>
<td>Provide Web-based RoHs Compliance Management System (RCMS)</td>
<td>Administrative office</td>
</tr>
<tr>
<td></td>
<td>3. Ceramics Institute</td>
<td>A technology transfer centre in industrial ceramic industry</td>
<td>MTEC coordinating office</td>
</tr>
<tr>
<td></td>
<td>4. Design &amp; Engineering Consulting Service Center (DEEC)</td>
<td>Provide consultancy and training in engineering design and fine element</td>
<td>MTEC outreach unit for computer-aided engineering (CAE) services</td>
</tr>
<tr>
<td></td>
<td>5. Golden Water Polymer Co., Ltd.</td>
<td>R&amp;D in printing and coating products</td>
<td>R&amp;D</td>
</tr>
<tr>
<td></td>
<td>6. Intri-Flex (Thailand) Ltd.</td>
<td>Precision mechanical component design for data storage business, focusing on HDD</td>
<td>Development engineering</td>
</tr>
<tr>
<td></td>
<td>7. Mouldmate Co., Ltd.</td>
<td>R&amp;D in solid pneumatic tires</td>
<td>Coordinating office</td>
</tr>
<tr>
<td></td>
<td>9. Polyplastics Marketing (T) Ltd.</td>
<td>R&amp;D in engineering plastic</td>
<td>Coordinating office</td>
</tr>
<tr>
<td></td>
<td>10. SCG Construction Co., Ltd.</td>
<td>R&amp;D in ceramic and tile for construction</td>
<td>R&amp;D</td>
</tr>
<tr>
<td></td>
<td>11. Siam Polymer Engineering and Consultation Co., Ltd.</td>
<td>R&amp;D in natural latex glove and technology transfer in the area of rubber and latex</td>
<td>Coordinating office</td>
</tr>
<tr>
<td></td>
<td>12. Thai Ceramics Co., Ltd.</td>
<td>R&amp;D in ceramics and ceramic tiles for construction industry</td>
<td>Coordinating office</td>
</tr>
<tr>
<td>Information and Communication</td>
<td>1. Embedded Technology Co., Ltd.</td>
<td>R&amp;D, design prototype for electronic devices</td>
<td>R&amp;D</td>
</tr>
<tr>
<td></td>
<td>2. G Softbiz Co., Ltd.</td>
<td>R&amp;D in Thai software for PDA and mobile phone</td>
<td>Coordinating office</td>
</tr>
<tr>
<td></td>
<td>3. Hard Disk Drive Institute</td>
<td>Implement the development plan for strengthening HDD industry of the country</td>
<td>Coordinating office</td>
</tr>
<tr>
<td></td>
<td>4. Mobilis Automata Co., Ltd.</td>
<td>R&amp;D in automation system, motion control system and industrial software</td>
<td>R&amp;D</td>
</tr>
<tr>
<td></td>
<td>5. NICT Asia Research Center</td>
<td>A collaboration centre for R&amp;D in telecommunication among public and private sectors, and academic institutes</td>
<td>Administrative office</td>
</tr>
<tr>
<td></td>
<td>6. Office of Computer Clustering Program (CCP)</td>
<td>Provide training and consultancy in IT, and system development</td>
<td>One of NSTDA unit, administrative office</td>
</tr>
<tr>
<td></td>
<td>7. Open Lab</td>
<td>Provide services and facilities for R&amp;D in ICT to promote collaboration between academics and industry</td>
<td>NECTEC’s services for SMEs</td>
</tr>
<tr>
<td></td>
<td>8. Sapphire R&amp;D Co., Ltd.</td>
<td>Software house to prepare software for manufacturing under CMM Standard</td>
<td>Coordinating office</td>
</tr>
<tr>
<td></td>
<td>9. Western Digital (Thailand) Co., Ltd.</td>
<td>Provide trainings in cooperation with the Hard Disk Drive Institute (HDDI)</td>
<td>Coordinating office</td>
</tr>
</tbody>
</table>
(3) R&D collaborative projects:

The third element is R&D collaborative projects which are used as a tool to investigate R&D relations between the NRCs and industry. Regarding the R&D collaborative projects between the NRCs and firms between 2004 and 2007, there were forty-seven ongoing and finished R&D collaborative projects. Amongst these projects, twenty-two were carried out by BIOTEC, fifteen by MTEC, and ten by NECTEC.

Based on a secondary analysis of profiles of these collaborative projects focusing particularly on the research partners, it was found out that some of these projects were research collaborations between the NRCs and universities as well as public research organisations, which is not relevant to the focus of this study. The secondary analysis therefore filtered out six collaborative projects. These projects were collaborations between BIOTEC and universities and public research organisations. Consequently, forty-one researchers who were head of the collaborative projects between research centres and firms were contacted by e-mail for possibility to conduct in-depth interview. Due to limitation of accessibility to the researchers, it turned out that nineteen researchers were willing to spare their time to provide information and share their experience about research partnerships with industry. As a result, nineteen cases of R&D collaboration between firms and research centres were studied in this thesis. This study thus consists of ten projects from BIOTEC, six projects from MTEC, and three projects from NECTEC.

Table 5.2 lists the nineteen cases being studied. However, the identification of the partner firms was asked to be kept anonymous in this study. The listing of the collaborative projects presents thus only the project title, research laboratory, and project duration as well as time period. In addition, synopses of these cases are presented in Appendix 7.
<table>
<thead>
<tr>
<th>Case</th>
<th>Project title</th>
<th>Laboratory conducting the project</th>
<th>Project duration and period of time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(a) A study of conception rate and early pregnancy losses on the transfer of in vitro produce bovine embryos</td>
<td>Animal Physiology Laboratory, BIOTEC Central Research Unit (BCR)</td>
<td>1 year each (a) Feb 07 - Jan 08</td>
</tr>
<tr>
<td></td>
<td>(b) Studies of nutritive value feeding, feeding value, and animal response of forage cane in cattle</td>
<td></td>
<td>(b) Aug 07 - Jul 08</td>
</tr>
<tr>
<td>2</td>
<td>(a) Bioremediation of salinity land using salt tolerant tree</td>
<td>Plant Physiology and Biochemistry Laboratory, BCR</td>
<td>1 year each (a) Feb 07 - Jan 08</td>
</tr>
<tr>
<td></td>
<td>(b) Improving rice cultivation and developing rice species for bio-remediated salinity land</td>
<td></td>
<td>(b) N/A</td>
</tr>
<tr>
<td>3</td>
<td>Biototechnology application of digestive enzymes for pulp and paper production process</td>
<td>Enzyme Technology Laboratory, Bioresource Technology Unit, BIOTEC</td>
<td>1 year Jun 07 - May 08</td>
</tr>
<tr>
<td>4</td>
<td>Optimisation of micro-propagation techniques of ornamental plant</td>
<td>Plant Molecular Biology – Starch Biosynthesis Laboratory, BCR</td>
<td>1 year Jul 06 - Jun 07</td>
</tr>
<tr>
<td>5</td>
<td>Expression and characterisation of enzymes for animal feed production</td>
<td>Microbial Cell Factory Laboratory, Bioresource Technology Unit, BIOTEC</td>
<td>1 year Jun 07 - May 08</td>
</tr>
<tr>
<td>6</td>
<td>Development of feed for Black Tiger Prawn</td>
<td>Centre of Excellence for Marine Biotechnology, BIOTEC</td>
<td>6 months May 07 - Oct 07</td>
</tr>
<tr>
<td>7</td>
<td>Extraction of Thai-plant derived for cosmetics products</td>
<td>Bioresource Technology Unit, BIOTEC</td>
<td>3 years Jan 05 - Dec 07</td>
</tr>
<tr>
<td>8</td>
<td>Study of microbial diversity on facial skin</td>
<td>Food Biotechnology Laboratory, BCR</td>
<td>1.5 years Oct 07 - Mar 09</td>
</tr>
<tr>
<td>9</td>
<td>Isolation and categorisation of microorganism from Thai natural resources for pharmaceutical uses</td>
<td>Mycology Research Laboratory, BCR</td>
<td>2 years Jul 06 - Jun 08</td>
</tr>
<tr>
<td>10</td>
<td>Prototype production of Umani, a food additive from soya bean</td>
<td>Biochemical Engineering and Pilot Plant R&amp;D Unit (BEC), BIOTEC</td>
<td>3 months Dec 06 - Feb 07</td>
</tr>
<tr>
<td>11</td>
<td>Development of production process of medical grade stainless steel for orthopedic devices</td>
<td>Plastic Technology Laboratory, MTEC</td>
<td>6 months Jun 05 - Dec 05</td>
</tr>
<tr>
<td>12</td>
<td>Development of production process for commercially pure titanium and titanium alloy (Ti-Al-4V) for automotive industry (2-phase project)</td>
<td>Near-net-shape Metal Forming Technology Laboratory, MTEC</td>
<td>7 months 1 year Apr 06 - Oct 06 Jan 07 - Dec 08</td>
</tr>
<tr>
<td>13</td>
<td>Application of 3D scanner technology for automotive spare parts production</td>
<td>Automotive and Alternative Fuel Laboratory, MTEC</td>
<td>9 months Aug 04 - Apr 05</td>
</tr>
<tr>
<td>14</td>
<td>Development of large packaging for overseas transportation of rubber resin</td>
<td>Plastics Technology Laboratory, MTEC</td>
<td>6 months Sep 05 - Mar 06</td>
</tr>
<tr>
<td>15</td>
<td>Development of transmission systems for small form tractor</td>
<td>Automotive System and Mechatronic Laboratory, MTEC</td>
<td>2 years Oct 05 - Sep 07</td>
</tr>
<tr>
<td>16</td>
<td>Development of innovative plastic films covering greenhouse to reduce solar heat</td>
<td>Polymer Technology Laboratory, MTEC</td>
<td>2 years Sep 08 - Aug 10</td>
</tr>
<tr>
<td>17</td>
<td>Speech technology synthesis engine (text-to-speech synthesis engine)</td>
<td>Human Language Technology Laboratory, NECTEC</td>
<td>3 years Oct.06 - Sep. 09</td>
</tr>
<tr>
<td>18</td>
<td>Development of electronic nose for food industry</td>
<td>Nanoelectronic and MEMS Laboratory, NECTEC</td>
<td>1 year May 06 - Apr. 07</td>
</tr>
<tr>
<td>19</td>
<td>System development for telecommunication business</td>
<td>Embedded System Technology Laboratory, NECTEC</td>
<td>6 months N/A</td>
</tr>
</tbody>
</table>

Table 5.2 Lists of R&D collaborative project being studied
5.3.3 Data collection

The main method used for data gathering is in-depth interviews, both face-to-face and by telephone. The interviewing method is used to achieve depth and roundedness of understanding in complex phenomenon and its contextual account (Mason, 2002). Hence, using an interview method can provide data and insight into the complexity of R&D interaction between public research institutes and industry. There were four main groups of informants (see Appendix 2) to explain the interaction. The first group was the firms located in TSP. The second group was the executives and management of NSTDA, NRCs, and TSP. The third group was the researchers of BIOTEC, MTEC, and NECTEC who worked with industry in R&D collaborative projects. The fourth group was NSTDA’s policy officers.

For the first group of informants, nine face-to-face interviews were conducted using an interview guide (see Appendix 3) to acquire information regarding their location choices, interaction experience with other actors in the TSP, and effects of local setting and services of the TSP on their innovation activities.

For the second group of informants, two kinds of interview guides (see Appendix 4) were developed to draw together information from diverse perspectives of local organisations in relation to implementation of policy to promote public-private linkages. Seven semi-structured interviews with one TSP management, two NSTDA and TSP top executives, and four NRCs executives and management were conducted.

For the third group of informants, nineteen telephone interviews were conducted. The informants were asked questions primarily about R&D collaboration activities, the involvement of research partners, and the way in which they interact (see Appendix 5). Emphasis is placed on their interactions and collaboration in particular.

For the fourth group of informants, two unstructured interviews were conducted. The reason for using this type of interview is not only to obtain depth information but to unpack the complicated issues by encouraging the informants to talk about NSTDA’s
policy and issues related to public-private links, rather than to answer specific questions. However, a topic list was used during the interviews to set out a list of points that would be covered (see Appendix 6).

In total, thirty-seven interviews were conducted between 20 March 2007 and 22 September 2008. All interviews were recorded, transcribed and then analysed. To supplement the data collection from interviewing, secondary data was gathered from websites, internal documents of NSTDA, the NRCs, and TSP, as well as published reports.

5.3.4 Data analysis

In terms of data analysis, template analysis and data matrices were used to thematically organise textual data for data analysis and interpretation. While template analysis is used to generate themes from textual data (King, 2005), data matrices can be used to organise large amounts of data into a simple form – e.g. a table – to get an overview of data for exploratory analysis (Nadin and Cassell, 2005). According to King (2005), using a template analysis technique is to develop a ‘template’ comprising of a list of codes representing themes identified from textual data. Developing the template is a iterative process. However, a well-designed template provides useful structure to present the findings. In relation to Nadia and Cassell (2005), a matrix provides a descriptive summary of the issues related to the research questions and permit analysis within and across cases offering emergent findings for further interpretation.

In this thesis, ‘a priori’ themes were identified in advance from the assumptions of the research study and literature. These themes were used for initial coding and developing the initial template. After that the initial template was revised as themes were modified and interview transcripts were read and interpreted. The final template used for presenting the findings was developed after the research themes and questions were re-polished. A matrix was constructed from the final template to provide an overview of all interviews and to display the coded data in tabular format. Complementary with the use of template analysis, the columns represent a selection of the themes that emerged...
from the template analysis, while the rows represent each interviewee. Accordingly, the matrix was analysed across both rows and columns providing emerging findings from the cross-matrix analysis.

5.3.5 Exploiting the conceptual framework and analytical frame

The conceptual framework of this study is structured by drawing from three theoretical concepts namely: the concept of systems of innovation, the theory of inter-organisational interaction, and the concept of proximity (as described in Section 3.4.1). The concept of systems of innovation is emphasised to examine the constitution and functioning of the local system of innovation being studied. The theory of inter-organisational interaction is used to investigate the interrelation of the system’s components, while the influence of proximity on interaction of the actors in this system is scrutinised based on the concept of proximity.

Specifically, in terms of data analysis Chapter 6 considers the concept of proximity as its main analytical ground. Chapter 6 is in response to the first research theme, i.e. co-location of actor and their collaboration. In Chapter 7 an analytical frame is developed (as described Section 3.4.2) to help analyse the empirical data collected from the R&D collaborative projects. Chapter 7 corresponds with the second research theme, i.e. research collaboration of public research organisation and industry.

5.4 Conclusion

This chapter has introduced the research method for this thesis. It has discussed the research approach of this thesis which led the course of research to the two related research themes, and the operationalisation of the research. These two research themes are linked with two main research questions. The first theme enquires about influence of co-location on interaction and linkage between firms located in science parks and adjacent research centres, particular emphasis is placed on their R&D collaboration. The second theme enquires into the way in which the research centres collaborate with firms
through R&D collaborative projects. The study sought to explore and understand characteristics of the R&D collaboration between the research centres and their partner firms. In addition, the research investigates determinants and detrimental factors of their interactions.

According to the two research themes, the results of this research are presented in the next two subsequent chapters. In each chapter of findings, particular evidence from the study is described and discussed concurrently.
CHAPTER 6
Co-location of research centres and industrial firms:
The Case of Thailand Science Park

This chapter presents the findings from the empirical study of the interactions of the local actors in the Thailand Science Park (TSP). The chapter attempts to address the first research theme, i.e. the co-location of the research centres and local firms and the influence of proximity on their relations. The discussion in this chapter is based on interviews with nine firms located in TSP and executives of three NRCs (BIOTEC, MTEC, and NECTEC). As explained in Chapter 5, amongst the forty-two tenants in TSP (as of March 2007), thirty were marked R&D intensive firms. However, not all of these firms were active in R&D activities; some tenants were consultancy firms, while the others were institutes/organisations using the facilities in TSP for other means – e.g. administrative and coordinating centre. Therefore, it is noteworthy that the arguments presented in this chapter reflect only the firms in TSP that conduct R&D, not the firms in the park at large.

The structure of this chapter comprises four sections. Section 6.1 displays characteristics of the informant firms and their motivation for locating in TSP. Section 6.2 reveals interactions that the local firms experienced, both locally and externally. Section 6.3 elaborates on factors influencing the relations and interactions of the local actors. The chapter ends with conclusions in section 6.4.
6.1 Characteristics of firms in Thailand Science Park

6.1.1 Diversity of firms doing R&D in TSP

As already mentioned (in section 5.3.2.2), not all tenants marked as R&D intensive firms were doing R&D. Those who were classified by TSP as R&D intensive firms were diverse in terms of their business and research activities in the park. Even though they were in the same technology sector as TSP classified them, their business and research activities were less likely to be strategically-related, neither as customer-supplier relationship nor as competitors. Table 6.1 presents the technology sectors and business activities of the interviewed firms and reflects the diversity of the firms in the park.

An example of diversity of the tenants can be seen in the metal and advanced materials sector. They exhibited nothing in common regarding research interests: one intensively carried out R&D in chemical ingredients – i.e. pigments for printing industry; one was involved in development engineering of precision metal stamping; and one worked on advanced materials for dental uses and relevant techniques. A range of research interests of the firms in the biotechnology sector appeared to be minimal amongst the three technology sectors in the park. However, there was no inter-firm collaboration among the firms in the biotechnology sector to be found. This was also the case for firms in the ICT, electronics and computer. Therefore, it could be contended that the diversity of firms reflects the characteristic of the park in terms of the extent and intensity of inter-firm relationship. The more the firms’ diversity is, the less propensity of interaction and collaboration exists.
<table>
<thead>
<tr>
<th>Tenant firms</th>
<th>Technology sector</th>
<th>Business activities</th>
<th>Founded in TSP</th>
<th>Employee</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Golden Water Polymer</td>
<td>Metal and advance material</td>
<td>R&amp;D in pigments for printing industry</td>
<td>2001</td>
<td>2002</td>
<td>13</td>
</tr>
<tr>
<td>B. Mobilis Automata</td>
<td>ICT, electronics &amp; computer</td>
<td>Software development and system integration, with specialisation in motion control and CNC machine</td>
<td>2003</td>
<td>2003</td>
<td>12</td>
</tr>
<tr>
<td>C. Embedded Technology</td>
<td>ICT, electronics &amp; computer</td>
<td>Engineering and development of electronics components and prototype, with specialization in embedded system</td>
<td>2004</td>
<td>2004</td>
<td>5</td>
</tr>
<tr>
<td>D. Betagro Science Centre</td>
<td>Biotechnology</td>
<td>Agro-Industry; testing for food and feed quality, monitoring animal health and diagnostic of infectious disease</td>
<td>1967</td>
<td>2004</td>
<td>60</td>
</tr>
<tr>
<td>E. Stem Cells for Life</td>
<td>Biotechnology</td>
<td>Cord blood banking</td>
<td>2006</td>
<td>2006</td>
<td>8</td>
</tr>
<tr>
<td>F. Alltech Biotechnology</td>
<td>Biotechnology</td>
<td>Solid state fermentation, development of natural enzymes complex for animal feeds</td>
<td>1998</td>
<td>2006</td>
<td>20</td>
</tr>
<tr>
<td>G. Dephi Health Services</td>
<td>Biotechnology</td>
<td>Bioinformatics and molecular technology, and genotyping and genetic testing services</td>
<td>1985</td>
<td>2007</td>
<td>4</td>
</tr>
<tr>
<td>H. Intri-plex (Thailand)</td>
<td>Metal and advance material</td>
<td>Development and engineering of precision metals for stamping</td>
<td>2005</td>
<td>2005</td>
<td>70</td>
</tr>
<tr>
<td>I. Advance Detal Technology Centre (ADTEC)</td>
<td>Metal and advance material</td>
<td>R&amp;D in advanced materials for dental uses</td>
<td>2005</td>
<td>2005</td>
<td>10</td>
</tr>
</tbody>
</table>
6.1.2 Motives of firms to locate in Thailand Science Park

Locating technology-based firms close in distance to the research centres is considered as putting these two actors in geographical proximity. According to theories of localisation, the geographical proximity of actors reduces the cost of accessing and absorbing knowledge spillovers, and the presence of knowledge resource centres has a critical impact on the location decisions made by new firms (Audretsch et al., 2005). Thus, it could be argued that the motivations of firms regarding their location choice are driven by the perceived benefits of the location. In line with the theories of localisation, evidence from the interviews with firms located in Thailand Science Park suggest that the common perceived benefits of TSP is having linkages with adjacent research centres and getting access to resources and facilities of the research centres. Table 6.2 presents their initial concerns, ranking in descending order from the most common one.

Table 6.2: Initial reasons for the establishment in the TSP

<table>
<thead>
<tr>
<th>Initial reasons</th>
<th>No. of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Having connection with national research centres</td>
<td>8</td>
</tr>
<tr>
<td>Getting access to shared equipments and/or facilities</td>
<td>5</td>
</tr>
<tr>
<td>Having good company image and reputation from location in the TSP</td>
<td>2</td>
</tr>
<tr>
<td>Recruitment of recent university graduates from AIT and TU</td>
<td>1</td>
</tr>
<tr>
<td>Ease of legitimacy in setting up R&amp;D related business</td>
<td>1</td>
</tr>
</tbody>
</table>

It is evidenced that the first and foremost common reason that firm considered when made their decision to locate in the TSP was the anticipation to have linkages with the national research centre relevant to their business activities, in which eight out of nine interviewed firms shared the same view. The second common initial reasons was related to facilities and resources of TSP, which five out of nine firms shared the view that access to shared equipment provided in TSP was importance to their consideration. The image of location of the TSP is found to be the third common reason for locating in the TSP. Only two interviewed firms had cited this as their initial concern to locate in TSP. The least common initial reasons that made firms decide to locate in TSP were
related to recruitment of graduates from nearby universities and the ease of legitimacy in setting up R&D related business.

The next two sub-sections highlight the concerns of interviewed firms in relation to the first two most common initial reasons to locate in TSP.

6.1.2.1 Linkage with proximate research centres

As evidenced from this study that the anticipation to have linkages with proximate research centres relating to their business activities was the most common initial reason of firms to locate in TSP. According to the views of the respondents, the notion of ‘linkage’ meant different things. These ranged among loosely coupled interactions and linkages - such as face-to-face contact which could help build up and maintain connection with researchers for knowledge exchange and benefit from spillover effect, to stronger forms of interactions – such as getting access to laboratory equipments and facilities provided by related research laboratories on site, as well as having formal research collaboration with the research centre.

The following quotes from the interviewed firms illustrate that firms had different views regarding the ‘linkage’ when they discussed what made them decide to locate in TSP.

*The first reason to locate our R&D unit in TSP is because we would like to gain access to MTEC’s researchers and their knowledge and expertise. (Firm A)*

*The first and foremost reason for us is the connection with NRCs. We choose to locate in TSP because we want to be close with the NRCs. We expect that locating here will provide us R&D environment leading to connection with the NRCs and their researchers. (Firm D)*

*We decided to locate in TSP because we want to collaborate with BIOTEC. We recognise that BIOTEC has stated the important of R&D in stem cells as one of their research area. I wish to see collaboration between public and private sector in R&D business. (Firm E)*
It is worth mentioning that the two firms which the founder had worked as researcher at NECTEC shared similar initial reasons to locate in TSP regarding linkage with research centre. The following quotes illustrate their concerns.

Locating in Thailand Science Park helps us to keep connection and collaboration with friends and colleagues at NECTEC. (Firm B)

As I was an employee of NECTEC, I want to maintain connection with people at the centre. Being close in distance with them is convenient for me to interact with my former colleagues. (Firm C)

6.1.2.2 Research facilities and resources

From the interviews, apart from having linkages with proximate research centres, one of the reasons to locate in TSP was to benefit from facilities and resources provided. However, it is noteworthy that this was not the first initial concern for local Thai firms. On the other hand, research facilities and resources were considered as the first initial reasons for international firms to make their decision to locate in TSP. The following statements illustrate their concerns.

TSP give us very quick and easy way to move into laboratory setting and start doing our research very quickly with limited investment from our headquarter. So, the existence of laboratory facilities at the park is the first initial reason for being located here. (Firm F)

With BIOTEC, we know that they have a large number of scientists working in the area of fermentation, which is one of our core competencies. So, having access to those scientists is another important reason driving us to move into TSP. Also, they have core facilities of technical equipments which we can have access to apart from this lab space that we are provided. This is good because we do not have to invest in some equipment on our own. (Firm G)

6.2 Interaction of the local actors

Unambiguously, the interviewed firms expected that co-location would facilitate face-to-face communication, informal linkages, and perhaps formal linkages with researchers. Some firms looked forward to progressively benefiting from spillover effect and tacit knowledge transfer from the research centres. Some firms were more
aggressive in seeking opportunities for formal linkages with the research centres, such as collaborative research. Whether and in what way firms actually linked with their proximate research centres are discussed further in the following sections.

6.2.1 Local firms and their interactions with research centres

The findings exhibit that only two out of nine interviewed firms have had formal interaction with the research centre (in the case of NECTEC). Note that previously the founders of these two firms worked as NECTEC researchers before they became entrepreneurs. Therefore, in this circumstance initiating formal interaction between these two firms and NECTEC was relatively at ease. The formal links established were R&D contracts, resulting from previous contacts and collective informal links. The firms described how their formal interactions with NECTEC took place.

We had an outsourcing project from NECTEC during the first year of the company. We would not be able to get this project if we were located outside the TSP. Perhaps, this is because I had worked with NECTEC before started my company. Although we have no further outsourcing project from NECTEC, I benefit from personal connection with NECTEC staff, whom are my friends and previous colleagues. (Firm C)

Initially, we had expected to receive some outsourcing projects from NECTEC but later realised that it is rather complicated for public R&D organisation to contract out their R&D to a startup enterprise. Instead, we do outsource our R&D to NECTEC personal, taking the advantage of knowing these people and their expertise personally as colleagues and friends. (Firm B)

It is apparent that most of the interactions between the local firms in TSP and research centres were in the form of informal interactions, such as personal contact, meetings and networking events. Informal interaction is considered in the literature as the most common type of linkage between firms and academic/research institutes (Monck et al., 1988; Massey et al., 1992; Westhead and Storey, 1994). The informal interactions may be significant channels facilitating knowledge transfer between the local actors. An interviewed firm illustrates the significant of informal interaction with proximate research centre:
We are, perhaps, amongst the first tenants of the TSP. But unfortunately, there has been no formal links with MTEC. However, we are very much happy with several forms of informal links, especially using testing services and invaluable discussions with researchers whom are within simply reach from our lab. The discussion and information exchange with them help us a lot to in our work. (Firm A)

In addition, a firm in the biotechnology field demonstrated that it was trying to establish formal interactions with BIOTEC by means of informal interaction, taking advantage of geographical proximity to the research centre. The following quote illustrates its efforts.

We have been in the TSP only almost a year. So far, there have been three constructive meetings with BIOTEC researchers to discuss common R&D interests. Our mother company in the U.S. had some work with BIOTEC in shrimp industry before. So, we are looking forward to continue the meetings and discussions any possibilities in R&D collaboration. (Firm F)

The findings are also consistent with the argument that face-to-face interactions between the local actors cannot alone generate synergies (Torre and Rallet, 2005). In other word, formal interaction requires much more than spatial concentration of local actors. For example, as Firm F indicated that it requires several rounds of meetings and discussions to match research interest of firm and research centre and to seek out mutual benefits between the research partners.

6.2.2 Interactions between local firms and their external links

Similar to the findings of interaction between firms and the research centres, linkages and interactions between local firms were limited. Until now, there has been no formal interaction between the local firms. There exists only informal links and social interactions. However, it is premature to indicate whether formal interaction between local firms will be established.

We see business potential with one of the tenant. Regarding that they have their own supply and are willing to establish different types of research collaboration. We have some companies in the U.S. that might be interested working with them. We are exploring for any possibilities in this matter. However, it is still in very early stage to say any further. (Firm G)
The findings also indicate that the interviewed firms actively interact and link with their suppliers and customers, and other technology resources located elsewhere outside TSP during their innovation processes. Some of the firms have established formal links with academic institutions nationwide.

*Due to our research strategy, we are not likely to establish joint research collaboration with other companies here in the TSP, unless they could provide us the services that we need. Instead, we have established relationship with several universities in Thailand by acting as R&D funding for their research projects.* (Firm F)

The results which indicate limited interaction among local firms and between local firms and research centres coincide with the study by Brimble and Donor (2007) which indicate that firms tend to source their knowledge from customer/supplier rather than universities or academic institutes.

### 6.3 Influencing factors of the interaction between firms and research centres in Thailand Science Park

While section 6.2 has discussed the interaction experiences of the local actors in TSP without arguing about what may cause the way in which their interaction and linkage take place, this section focuses the discussion on this issue. This study suggests two types of factors that may have effects on interactions between firms and research centres in TSP. The first factor is related to institutions and organisations, which in this sense are the TSP itself and the local actors. The second factor is related to the proximity of the local actors.

#### 6.3.1 Institution factors and actor-specific factors

##### 6.3.1.1 Local context and characteristics of Thailand Science Park

According to Torre and Rallet (2005), the synergies of actors can only develop between those who share common representations. Evidence from the low level of the extent of
interaction between local actors in TSP concurs with this statement. This is because the local firms in TSP are from different business sectors. They do not have familiar representations and do not belong to the same industrial network. This is due to the local context and characteristics of TSP itself. The fact that Thailand depends primarily on agricultural and extractive industries and downstream processing of the products of these industries (such as food products, wood and paper, petrochemical and plastics). Most of private R&D is in these industrial sectors, thus propelled TSP to encompass a broad industry base to serve the needs of the country. In addition, TSP is obliged to support industrial firms in related technology fields of the national research centres. Moreover, private R&D in Thailand is relatively limited in terms of number of firms, their researchers, and R&D expenditures. Because of these contexts, TSP has a relatively narrow market of prospective firms. Within existing choices, the park has to cater for all technology-based firms with respect to technology of the national research centres, i.e. biotechnology, metal and advanced materials, electronics and computer, and nanotechnology. As a result, the local firms that TSP accommodates are fairly diverse in terms of their business interests and R&D related activities. Consequently, this lowers the propensity for creating synergies between the local actors or to establish network of firms within TSP, let alone the network of local firms with external economic actors.

The explanations for the absence of synergies in TSP are two-fold; both are rooted in the local context of TSP itself: one is that their businesses and customers are diverse; and the other is the low-density of tenants in the park. There is a deficiency in terms of forces behind the formation of cluster firms in TSP. Moreover, apart from their dissimilarity in business areas, most of the tenants look outwards for markets and customers located outside the park. These make it less possible that the relationships between them as business partners or service provider and recipient will be developed. In fact, several interviewed firms indicated that the TSP would provide location advantages over other business locations if there was clustering of firms in the same technological specialisation. It may be feasible that the tenants become future partners or competitors, if there was a high-density of tenants in related business or specific business cluster within the park.
6.3.1.2 Openness of the actors

The findings suggest that the degree of openness and trust between local firms and proximate research centres influences the way in which these local actors interact. The issue of trust and openness is found to be one of the distinctions between BIOTEC and MTEC in their relationships with local firms. On the one hand, local firms in BIOTEC’s related technology fields are more open-minded and optimistic towards working with BIOTEC. They are enthusiastic to welcome BIOTEC researchers to their lab or have social contact with them at the corridor or coffee corner. On the other hand, some of the local firms in MTEC’s related technology fields are more likely to keep R&D activities to themselves within their laboratories. They are possessive about their research activities and reluctant to share or exchange idea about it with others. An MTEC executive revealed this surprise behavior of firms located in their building.

*Cooperation between MTEC and local firms in TSP has been very limited. We experience that firms treat their R&D as private activities and do not want us to get involve. We recognise this unwillingness from the complaint that they do not quite appreciate when our researchers walked by their laboratories and (either intended or unintended) look into their room. They read between the line that this we were exploring their secret.*

This kind of pessimistic view toward MTEC researchers jeopardises the benefits of geographical proximity in facilitating face-to-face interaction between local actors.

In general, the interaction of MTEC and local firms was relatively less comparing to BIOTEC. This is because in MTEC most of researchers themselves did not actively interact with local firms. Both firms and researchers see each other as competitors, not allies. However, MTEC did have a number of interactions, both formal and informal ones; with firms located outside TSP.
6.3.2 Proximity of actors

6.3.2.1 Geographical proximity

The findings suggest that physical proximity of firms and research centres in TSP is less likely to influence their interaction, especially formal interaction. This corroborates with literature that co-location of firms and research centres is not sufficient for formal linkage and interaction (Vedovello, 1997; Thune, 2009). With reference to effects of geographical proximity presented in literature (Boschma, 2005b; Oerlemans and Meeus, 2005; Torre and Rallet, 2005), geographical proximity of the local actors specifies that the location advantage of TSP thus only accounted for the presence of the national research centres, not the linkages between research centres and local firms as was expected. However, this study suggests that informal interactions, which entail random meetings and informal contacts, are facilitated by the spatial relation of the local actors in TSP. For this reason, it is possible to argue that agglomeration of firms and research centre is not a propensity for the implementation of formal linkage (such as research contract, research collaborative project, and other forms formal interactions having explicit agreement) between the local firms and research centres.

The findings about the negative influence of geographical proximity call attention to the improvement of the dynamics and chemistry of the local actors within TSP. Creating synergies between the local actors is an essential element for the park to progress to the next development phase. Otherwise, it will become primarily a prestigious real estate development. For the reason that a proximity that is merely geographic in nature can provide the basis for the presence of an agglomeration of firms, yet not necessarily for the presence of an innovation system (Kirat and Lung, 1999).

Evidence from this study affirms that geographical proximity does not influence coordination between the local actors. This can be seen from the case where a local firm and MTEC tried to exercise establishing R&D partnerships through strategic R&D agreements and joint research teams; i.e. using the effect of organisational proximity to
activate interaction learning. Unfortunately, their efforts did not succeed. An executive of MTEC described this experience:

> Although we have Siam Cement PCL which is a large private firms as a TSP tenants and their R&D activities are very much related to our work. After several meetings of discussion for R&D collaboration, it turned out that we somehow could not work together. This is because we have different points of view and different pace of work.

A similar statement was found when this interviewed firm tried to partner with MTEC. The firm mentioned that MTEC was slow in terms of research administrative and the research interest of firm and MTEC still did not match. This firm also indicated that the way the firm and MTEC gave importance to research tasks were somewhat different. It was the matter of contrasting non-commercial and commercial research purposes. The firm also stated that the collaborative research efforts were said to be only at management level, not much had been recognised at the level of the individual researcher of MTEC. In this case, it could be contended that it was the absence of organisational proximity that hindered the meaningful collaboration between MTEC and this firm.

The empirical investigation also reveals effects of other dimensions of proximity such as technological proximity and social proximity which are discussed in the next two sections.

### 6.3.2.2 Technological proximity

The interview data from both local firms and top management of the research centres affirmed that the cause of limited existence of formal interaction, especially R&D collaboration, between local firms and proximate research centres was the different natures of their R&D activities and the diversity of R&D interests between local firms and the research centres. According to an executive of BIOTEC, the different natures of R&D activities between the local actors hindered R&D collaboration of the centre and local firms:
We have to admit that most of our research projects are in basic research in advanced technological fields. We do not have much implementation of the applied science or industrial research. We work primarily on upstream research, while firms focus their interests on downstream or near market research. The differences in research interests and technological capability of the partners are considered as the key barriers for us to work with local firms. Also the other barrier is that they may not convince that we are competence partner, due to our track record in industrial R&D. Therefore, collaboration with private sectors is difficult. (BIOTEC’s executive)

An interviewed firm also expressed similar thought regarding the natures of R&D activities of local firms and research centre. Besides, diversity of R&D interests seemed to obstruct the formal interaction regarding R&D cooperation.

We have been determined to collaborate with BIOTEC since we moved into the TSP. Despite a number of informal interactions, no concrete research project yet arrived. This is possibly because of the differences in development scale and R&D interests. As private company we tend to emphasise on pilot scale R&D rather than lab scale development which carry out in the research centre. Although, BIOTEC and our company involve in agricultural biotechnology, we have difference area of research interests. We concentrate on livestock, while BIOTEC focus on shrimp and diary cattle. Nevertheless, we are always enthusiastic to work formally with BIOTEC and will keep exploring our opportunities. (Firm D)

Findings suggest that firms and research centres were less likely to learn from each other and exchange their knowledge, given that the various activities within the scope of their relationships did not match or were interdependent. This factor can be referred to as technological proximity (Kirat and Lung, 1999). The low level of technological proximity is partly resulted from the local context of TSP itself, in that the park tends to caters for all technology-based firms rather than being more selective to increase technological proximity of local actors.

### 6.3.2.3 Social proximity

The findings suggest that although firms and research centres were located in close physical proximity, the extent of their interaction, either inter-firm or between firm and research centre, was relatively low and less intense. In the case that they did interact, it was the other forms of proximity which facilitated their interaction, not geographical proximity. The findings coincide with the literature that geographical proximity does
not facilitate coordination (Torre and Rallet, 2005) but other dimensions of proximity do (Boschma, 2005b; Oerlemans and Meeus, 2005; Torre and Rallet, 2005).

This line of reasoning coincides with the evidence in the case of formal interaction between NECTEC and its former researchers who set up technology based firms in TSP. In this case, it was the function of social proximity that facilitated the collaboration between the local actors. The relational embeddedness of the actor increased their willingness to cooperate (Boschma, 2005a). The exchange of knowledge between the firms and NECTEC in this case was based on trust, relationship, and their previous experience (Oerlemans and Meeus, 2005).

This confirms that in the case of TSP even though there is spatial relation between local actors, interactive learning is less likely to be triggered by geographical proximity. Based on the evidence, one of the factors that may be needed to activate interactive learning between local actors in TSP is social proximity. Social proximity supports relationships between actors when organisational and institutional proximity are absent and can facilitate interactive learning by trust and experience (Boschma, 2005a).

### 6.4 Conclusion

This chapter presented evidence that the firms located in TSP were diverse in terms of their business sector. Having connection/networking with adjacent research centres was the most common motive for firm to locate in TSP. However, it seems that their expectations have been not materialised much. The extent to which co-location (i.e. physical proximity) influence the likelihood of interaction between firms and research centres located in TSP was limited. The findings indicated that there were relatively less formal interactions between local actors; most of their interactions were informal ones (e.g. social meetings). There were only two firms out of nine interviewed firms that had formal interactions with their research partners. The empirical findings coincide with the claim that geographical proximity between partners is not an important influence on
the existence or strength of links, at least for those related to the research activity (formal category of links) (Vedovello, 1997).

There are two types of factors that have effects on the interaction between firms and research centres in this study. The first one is institution factor and actor-specific factor. The institutional factor is the context of TSP itself; the diversity of firms. The actor-specific factor is the openness of firms and research centres in working together, as friends and family. The second factor is connected with three types of proximity of actors: i.e. geographical proximity, technological proximity, and social proximity. Obviously, geographical proximity of the local actors in TSP was insufficient for their formal interaction. Too little technological proximity of the local actors, due to diversity of firms in TSP and depth and breadth of research interest of the research centres hindered the chance that firms and research centres could jointly work together. On the other hand, it has been shown that social proximity of actors, which based on social relation and trust, facilitates the likelihood of their formal interaction.

It could be argued that the value added of TSP to its tenants was only its image. On the one hand, the science park concept in Thailand has been overestimated regarding its impact. On the other hand, the concept is underestimated in terms of other impacts. There was too much expectation on the science park. In addition, co-location of firms and research centre in the case of TSP should consider beyond the proximity that is only geographical in nature in order that TSP can play a better role in building a bridge between firms and research centres.

In sum, with reference to the concept of science parks in Thailand, geographical proximity is considered as a necessary condition for informal interaction between research centres and local firms, but an insufficient condition for them to engage in interactive learning and innovate. However, in various activities of the research centres they do collaborate with other academic and public institutions as well as industrial firms located elsewhere. In that case, in what way they work with external firms is worth considering enhancing an understanding about public-private research
partnerships in the case of Thailand. Thus, the next chapter explores the collaborative projects between research centres and firms.
This chapter presents the findings and analysis from the study of R&D collaborative projects of the three national research centres (i.e. BIOTEC, MTEC, and NECTEC) and their partner firms, which were conducted between 2004 and 2009. In particular, this study investigates interactions of the research partners in the course of their R&D collaborations by interviewing researchers leading the research collaborative projects. The attempt of this investigation is to explore the nature of R&D collaborations between national research centres and industry.

This chapter consists of six sections presenting the structure and processes of R&D collaboration between the research centres and firms. The chapter begins with an overview of the R&D collaborative projects being studies in section 7.1. Section 7.2 describes the background conditions of the projects by presenting characteristics of the collaborating firms and previous relationships between the research partners. Section 7.3 discusses how the R&D collaborative projects are organised by way of exemplifying motives of the collaborations, interaction strategies, attitudes of researchers toward R&D collaboration with industry, and time span of the collaborative projects. Section 7.4 depicts the way in which R&D collaborative projects are operated in four project typologies found in this study, namely: interactive; exploitative; explorative; and strategic R&D collaborations. Section 7.5 presents factors influencing R&D collaboration based on an analysis of the way in which the partners work together and the concerns of researchers. Finally, the chapter ends with the conclusion in section 7.6.
7.1 Overview of the R&D collaborative projects

This study takes into account nineteen cases of R&D collaborative projects of NSTDA from 2004 to 2009, in which ten cases were BIOTEC projects, six cases were MTEC projects, and three cases were NECTEC projects. This section is to provide a portrait of the projects being studied. The first part of this section briefly sketches profile of these projects and the second part comprehends types of R&D activities and nature of technology involved with the nineteen projects.

It is noteworthy to mention that the cooperative nature of the R&D collaborative projects studied in this thesis imply that the research centres and partner firms share research expenses, facilities and resources, as well as their knowledge in carrying out research activities within the projects. In case that research results can be patented, the research partners hold co-ownership of the patent. This distinguishes collaborative project from outsourcing project or contract research in which the ownership of research results belong solely to firm because they are responsible for research expenses inclusively. Compare to R&D collaborative project, outsourcing project or contract research involves less joint effort in research activities between the research partners. Interaction between research partners is considerably less; most of research tasks are taken by research centres. In short, collaborative project requires research partners to work together, while outsourcing or contract research does not. For this reason, R&D collaborative project is worthwhile to study research partnership between science and industry.

7.1.1 Outline of the R&D collaborative projects

In most of the cases studied, the research need originated from the partner firm and the research idea was formulated jointly between the researcher and the partner firm. There were only a few cases in which a research idea was introduced to firms by researchers (Case 1, project (b) and Case 18). Regardless of the origin of the research idea, once the project was organised as research collaboration between the research centres and firms,
project funding was shared equally between the two parties. In terms of project administration, the research centres took control of administrative tasks of the projects as well as managing research expenses.

With regard to industrial sectors, the research centres worked with firms in diverse sectors according to technological relevance of the collaborative projects and related technology fields of the centres. For BIOTEC, amongst the ten cases of R&D collaboration, six cases were with firms in the agriculture business, whereas two cases were with firms in the cosmetic industry; one case was with a firm in the pharmaceutical industry, and the other was in the food industry. For MTEC, three of their partner firms were in the automotive industry, while the other three were in medical instrument manufacturing, rubber industry, and chemical industry respectively. For NECTEC, two partner firms were in IT business and the other one was a winery yard.

The time span of the collaborative projects ranged from three months to three years. With reference to size, origin, and sector of the partner firms, the research centres collaborated with firms of all sizes ranging from SME to large enterprise, local and international firms, in a wide range of industrial sectors corresponding to their technology fields. The outcomes of the collaborative projects included new/improved products and/or processes, and new knowledge for further applications of technologies. Almost all the partner firms have had previous experience interacting with the research centres both through informal and formal interaction (such as seminars, trainings, and previous contract and collaborative research). To provide a background for the discussion in this chapter, Table 7.1 sketches brief profiles of the nineteen cases. In addition, synopses of these cases are presented in the Appendix 7.
## Table 7.1 Profiles of the R&D Collaborative Projects

<table>
<thead>
<tr>
<th>Case</th>
<th>Project Description</th>
<th>Laboratory</th>
<th>Nature of the project</th>
<th>Project outcome</th>
<th>Budget in THB (approx. in GBP)</th>
<th>Time span</th>
<th>Firm Size</th>
<th>Origin</th>
<th>Sector</th>
<th>Previous experience with NSTDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(a) A study of conception rate and early pregnancy losses on the transfer of in vitro produce bovine embryos (b) Studies of nutritive value feeding, feeding value, and animal response of forage cane in cattle</td>
<td>Animal Physiology Laboratory, BIOTEC Central Research Unit (BCR)</td>
<td>(1) Field study of new production process (2) R&amp;D of new product</td>
<td>(1) Improved process (2) Information for new product development</td>
<td>(1) 4,288,000 (£ 69,610) (2) 645,000 (£ 10,470)</td>
<td>1 year for each project</td>
<td>Large</td>
<td>Local</td>
<td>Agriculture</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>(a) Bioremediation of salinity land using salt tolerant tree (b) Improving rice cultivation and developing rice species for bio-remediated salinity land</td>
<td>Plant Physiology and Biochemistry Laboratory, BCR</td>
<td>(1) Application of existing technology (2) Integration of technology for new product and process</td>
<td>(1) Improved process (2) New product</td>
<td>N/A N/A</td>
<td>3 years for each project</td>
<td>Large</td>
<td>Local</td>
<td>Agriculture</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Biotecnology application of digestive enzymes for pulp and paper production process</td>
<td>Enzyme Technology Laboratory, Bioresource Technology Unit, BIOTEC</td>
<td>Application of technology for new production process</td>
<td>Knowledge for new production process</td>
<td>2,179,000 (£ 35,373)</td>
<td>1 year</td>
<td>Large</td>
<td>Local</td>
<td>Agriculture</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Optimisation of micro-propagation techniques of ornamental plant</td>
<td>Plant Molecular Biology – Starch Biosynthesis Laboratory, BCR</td>
<td>Process development</td>
<td>New/improved product &amp; process</td>
<td>265,700 (£ 4,313)</td>
<td>1 year</td>
<td>SME</td>
<td>Local</td>
<td>Agriculture</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Expression and characterisation of enzymes for animal feed production</td>
<td>Microbial Cell Factory Laboratory, Bioresource Technology Unit, BIOTEC</td>
<td>Application of technology for new production process</td>
<td>Knowledge for new production process</td>
<td>1,102,000 (£ 17,890)</td>
<td>1 year</td>
<td>Large</td>
<td>Local</td>
<td>Agriculture</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Development of feed for Black Tiger Prawn</td>
<td>Centre of Excellence for Marine Biotechnology, BIOTEC</td>
<td>Product development</td>
<td>New/improved product</td>
<td>340,000 (£ 5,667)</td>
<td>6 months</td>
<td>SME</td>
<td>Local</td>
<td>Agriculture</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Extraction of Thai-plant derived for cosmetics products</td>
<td>Bioresource Technology Unit, BIOTEC</td>
<td>R&amp;D-intensive and exploitation of the co-ownership of patent</td>
<td>Knowledge for new product development</td>
<td>N/A</td>
<td>3 years</td>
<td>Large</td>
<td>Overseas</td>
<td>Cosmetic</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Study of microbial diversity on facial skin</td>
<td>Food Biotechnology Laboratory, BCR</td>
<td>R&amp;D-intensive</td>
<td>Knowledge for new product development</td>
<td>1,468,500 (£ 24,475)</td>
<td>1.5 years</td>
<td>Large</td>
<td>Overseas</td>
<td>Cosmetic</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Isolation and categorisation of microorganism from Thai natural resources for pharmaceutical uses</td>
<td>Mycology Research Laboratory, BCR</td>
<td>R&amp;D-intensive</td>
<td>Knowledge for new product development</td>
<td>400,000 (£ 6,494)</td>
<td>2 years</td>
<td>Large</td>
<td>Overseas</td>
<td>Pharmaceutical</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 7.1 Profiles of the R&D Collaborative Projects (continued)

<table>
<thead>
<tr>
<th>Case</th>
<th>Project</th>
<th>Laboratory</th>
<th>Nature of the project</th>
<th>Project outcome</th>
<th>Budget in THB (approx. in GBP)</th>
<th>Time span</th>
<th>Firm Size</th>
<th>Firm Origin</th>
<th>Firm Sector</th>
<th>Previous experience with NSTDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Prototype production of Umani, a food additive from soya bean</td>
<td>Biochemical Engineering and Pilot Plant R&amp;D Unit (BEC), BIOTEC</td>
<td>Application of technology for new product and process</td>
<td>New product and process</td>
<td>460,680 (£ 7,479)</td>
<td>3 months</td>
<td>Large</td>
<td>Local</td>
<td>Food</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>Development of production process of medical grade stainless steel for orthopedic devices</td>
<td>Plastic Technology Laboratory, MTEC</td>
<td>Application of technology for process and product development</td>
<td>New process and improved product</td>
<td>1,178,800 (£ 19,136)</td>
<td>6 months</td>
<td>SME</td>
<td>Local</td>
<td>Medical instruments</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Development of production process for commercially pure titanium and titanium alloy (Ti-Al-4V) for automotive industry (2-phase project)</td>
<td>Near-net-shape Metal Forming Technology Laboratory, MTEC</td>
<td>R&amp;D for development of production process</td>
<td>New process and improved product</td>
<td>1,005,208 (£ 16,318) and 1,634,162 (£ 26,528)</td>
<td>6 months and 1 year</td>
<td>Large</td>
<td>Overseas Automotive</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>Application of 3D scanner technology for automotive spare parts production</td>
<td>Automotive and Alternative Fuel Laboratory, MTEC</td>
<td>Process development</td>
<td>Improved process</td>
<td>1,622,400 (£ 26,338)</td>
<td>1 year</td>
<td>SME</td>
<td>Local</td>
<td>Automotive</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Development of large packaging for overseas transportation of rubber resin</td>
<td>Plastics Technology Laboratory, MTEC</td>
<td>Product development</td>
<td>Improved product</td>
<td>549,250 (£ 8,916)</td>
<td>6 months</td>
<td>SME</td>
<td>Local</td>
<td>Rubber</td>
<td>No</td>
</tr>
<tr>
<td>15</td>
<td>Development of transmission systems for small form tractor</td>
<td>Automotive System and Mechatronic Laboratory, MTEC</td>
<td>Product development</td>
<td>Improved product</td>
<td>4,310,280 (£ 69,972)</td>
<td>2 years</td>
<td>Large</td>
<td>Local</td>
<td>Automotive</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>Development of innovative plastic films covering greenhouse to reduce solar heat</td>
<td>Polymer Technology Laboratory, MTEC</td>
<td>Application of existing technology for new product</td>
<td>New product and process</td>
<td>N/A</td>
<td>2 years</td>
<td>Large</td>
<td>Overseas Chemical</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Speech technology synthesis engine (text-to-speech synthesis engine)</td>
<td>Human Language Technology Laboratory, NECTEC</td>
<td>Software application development</td>
<td>New application system</td>
<td>4,500,000 (£ 73,052)</td>
<td>3 yrs.</td>
<td>Large</td>
<td>Both local &amp; overseas</td>
<td>IT</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Development of electronic nose for food industry</td>
<td>Nanoelectronic and MEMS Laboratory, NECTEC</td>
<td>Application of technology for new product development</td>
<td>New product</td>
<td>132,500 (£ 2,151)</td>
<td>3 yrs.</td>
<td>SME</td>
<td>Local</td>
<td>Winery</td>
<td>No</td>
</tr>
<tr>
<td>19</td>
<td>System development for telecommunication business</td>
<td>Embedded System Technology Laboratory, NECTEC</td>
<td>System integration and development</td>
<td>New application system</td>
<td>1,125,000 (18,263)</td>
<td>1 year</td>
<td>Large</td>
<td>Local</td>
<td>IT</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: Average annual exchange rate in 2008, £ 1 is THB 61.60 (http://www.hmrc.gov.uk/exrate/yearly_rates.htm)
7.1.2 Types of R&D activities and the nature of technology involved

R&D is a term that covers three activities: basic research, applied research, and experimental development. The OECD’s definitions of ‘applied research’ and ‘experimental development’ seem to be to some extent interchangeable. In this respect, Bone (2005) proposed that the criteria to distinguish between applied research and experimental development should also rest upon the generality of expected research results. In that experimental development refers to results expected to be valid for a single material, product, device, process, system, operation, method, or service, while outcomes expected from applied research should instead concern materials, products, devices, processes, systems, operations, methods and services.

By and large R&D activities conducted by the three national research centres of NSTDA (i.e. BIOTEC, MTEC, and NECTEC) are considered as applied research and technological development. In this context, the term technological development means the process of research and development of technology drawing from the pool of research results. As presented in Chapter 2 (Section 2.2.2 and Figure 2.3), NSTDA positions itself as an intermediary organisation between academia and industry, in that academic research in university focuses primarily on basic research or upstream research, and industry emphasises mainly on industrial research or downstream research activities. NSTDA’s R&D activities are applied research oriented towards downstream research focusing on application of technology and product/process development for industrial uses. Corresponding to the main research activities of NSTDA, types of R&D activities involved with the collaborative R&D projects analysed in this study thus associated primarily with applied research and technological development.

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35 OECD Factbook 2009: Economic, Environmental and Social Statistics (p 164)
36 According to OECD’s definitions of R&D, ‘basic research’ is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, and ‘applied research’ is original investigation undertaken in order to acquire new knowledge which directed primarily towards a specific practical aim or objective. While ‘experimental technology’ is systematic work, drawing on knowledge gained from research and practical experience that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed. (OECD, Frascati Manual, Paris, 2003)
It is also noteworthy to consider the nature of technology involved in the R&D collaborative project studied; how innovation in each project happened. This helps to better understand the profile of R&D collaborative projects in this study. In the context of this study, the nature of technology involved with R&D collaborative projects was seen in four categories: problem-solving and minor development; application and integration of technology; technological development; and emerging of new technology. These four categories were adopted and adapted from Arthur’s (2009) arguments on types of innovation. Arthur describes four mechanisms of innovation. These include: (1) new solutions developed out of small standard engineering advances; (2) new technologies developed by change in their internal parts or by addition of those parts through structural deepening; (3) radical new technologies developed through the process of innovation; (4) emergence of novel technologies that build and creatively transform industries over time (Arthur 2009, p. 163-164). He also stresses that once these various mechanisms of innovation are in motion, technology continues to create and recreate itself.

With reference to Arthur (2009), it could be discerned that the projects in this study that fall within the problem-solving category were the projects in Case 13 and Case 14. In these two cases, the context of research projects involved mainly solving specific technical problems within the partner firms. Note these two cases were MTEC’s project. Case 13 was to solve production problem of automotive spare parts, while Case 14 was to find alternative type of packaging for transporting and shipping rubber resin overseas.

There were seven projects in this study that the nature of technology involved could be described as the application and integration of technology. This included three collaborative projects of BIOTEC (i.e. Case 3, 5, and 10), two of MTEC (Case 11 and 15), and two of NECTEC (i.e. Case 17 and 19). These projects entailed the pools of research results from previous work of the research centres. These research results were adapted and incorporated into the firm in order to enhance the performance of the firm’s production process and bring about new product or process.
Interestingly, seven projects in this study could be ascribed that the nature of technology involved intertwine and overlap between application and integration of technology as well as technological development. These were the projects in Case 1, 2, 4, and 6 of BIOTEC, Case 12, 16 of MTEC, and Case 18 of NECTEC. Here, the nature of technology involved complexity in enhancing performance of technologies by varying the components within the technologies and developing new technologies. In Case 4, for example, the nature of technology in this project involved both developing appropriate process for micro-propagation of ornamental plant for export market and discovery of new variety of the ornamental plant being researched. Another example is Case 16, where the collaboration entailed modification of polymer additives and using these additives in the process of producing plastic film which can reduce solar heat for greenhouse uses. This plastics film is claimed to be a new improved product in the market.

Also, there were three projects in which the nature of technology involved entailed creation of radically development of new technologies. These were projects in Case 7, 8, 9 of BIOTEC. One good example here is Case 7, which was the extraction of Thai-plant derivatives for application in cosmetic products based on exploitation of patents which BIOTEC and the partner firm are co-owners. Ownership of the results of this project will again be shared between the research partners.

In sum, it could be argued that the R&D collaborations analysed in this study were applied research and technology development projects. In relation to the nature of technology involved in the projects, a large proportion of the projects (seven out of nineteen projects) were described to entail changes in the systems or subsystems of technologies to fit specific purpose of the partner firms. Another large proportion of the projects studied (seven out of nineteen projects) was ascribed to have the nature of technology overlap between application and integration of technologies and technological development. Only a small proportion of the projects studied was depicted as problem-solving type (two out of nineteen projects) and solely technological
development type (three out of nineteen projects). There was no project in this study in which the nature of technology involved was emergence of new technologies.

7.2 Background conditions

Using the analytical framework constructed to examine how firms and research centres interrelate in relation to their R&D collaborations, which was introduced earlier in Chapter 3, this section presents background conditions of their relationship in two aspects. Firstly, the characteristics of collaboration firms in which firm size, origin and sector, their R&D activity and technological relatedness to the collaborative projects are illustrated. Secondly, the contractual factors, which involve various types of previous relationships between research centres and partner firms, are portrayed. The consequences of these background conditions are discussed at the end of this section.

7.2.1 Characteristics of collaborating firms

7.2.1.1 Size, origin, and sector

In terms of firm size, empirical evidence from this study indicated that amongst the nineteen cases of collaborative projects between the research centres and industrial firms, the number of projects with large firms was greater when compared with those with SMEs. Thirteen cases (70%) were projects between the research centres and large firms and only six cases (30%) were projects with SMEs. Looking at each research centre and size of firms they worked with, it appeared that the majority of BIOTEC partner firms were large enterprises (i.e. eight cases were with large firms and only two cases were with SMEs). Whereas for MTEC, the proportion of R&D collaborative projects with large enterprises and with SMEs was relatively equal (i.e. three cases were with large enterprise and the other three were with SMEs). For NECTEC, it could be seen that the centre had one project with a large local firm, one with a local SMEs, and the other one with several partners including one local SME, one large local firm, and an international organisation.
Turning to the origin of the partner firms, amongst the nineteen cases of collaborative projects, there were thirteen cases of R&D collaboration between the research centres and local firms. Collaboration between the centres and international firms was found in five cases, and there was one case that involved both local and international firms. Focusing on each research centre, BIOTEC worked with local partners in seven cases and with international firms in three cases. MTEC had four cases of collaborative projects with local firms and two cases with international firms. For NECTEC, amongst the three cases being studied, the centre had one project with a large local firm, one with local SMEs, and the other with local and international partners.

Looking at the industrial sectors of firms, firms in the agriculture sector made up the majority of R&D collaborative projects with BIOTEC; six out of the ten projects studied were with firms in this industrial sector. The other industrial sectors that BIOTEC had R&D collaboration with were scattered among pharmaceutical, cosmetics, and chemical. For MTEC, the centre had a propensity to work with firms in the automotive sector, i.e. three out of the six project studied were with firms in this industry. The other industrial sectors of firms that worked with MTEC in R&D collaboration included advanced materials, rubber, and chemical. For NECTEC, one project was between the centre and SMEs and large local IT firms as well as a government organisation from overseas. The other two projects of NECTEC consisted of one with a large local telecommunication service provider and another with a small winery. Table 7.2 presents a summary of the nature of industrial firms that have research collaborative projects with BIOTEC, MTEC, and NECTEC.
Table 7.2  Summary of size of firms, sector and origin

<table>
<thead>
<tr>
<th>Research centre</th>
<th>Size of partner firms</th>
<th>Sector</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOTEC</td>
<td>SME (2)</td>
<td>Agriculture (2)</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td>Large (7)*</td>
<td>Agriculture (4)</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cosmetic Industry (1)</td>
<td>International</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pharmaceutical (1)</td>
<td>International</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food (1)</td>
<td>Local</td>
</tr>
<tr>
<td>MTEC</td>
<td>SME (3)</td>
<td>Medical instruments</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rubber</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automotive</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td>Large (3)</td>
<td>Chemical (1)</td>
<td>International</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automotive (2)</td>
<td>Local (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>International (1)</td>
</tr>
<tr>
<td>NECTEC</td>
<td>SME (1)</td>
<td>Winery</td>
<td>Local</td>
</tr>
<tr>
<td></td>
<td>Large (2)</td>
<td>IT</td>
<td>Local (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>International (1)</td>
</tr>
</tbody>
</table>

* One of BIOTEC’s partner firm has two collaborative projects with the centre.
The firm is counted only once in the summary table.

It was evident that the characteristics, in terms of size, origin and industrial sector, of the partner firms working with the research centres were varied. Clearly, the most common major partner for conducting R&D collaborative project with the research centres in this study was local large enterprises. A possible explanation was that most Thai SMEs were classified in the labour-intensive up to the skill-intensive level (Intarakumnerd et al., 2002; Bakiewicz, 2005). Only a small number of SMEs were in the technology-intensive level. Research collaboration between firms and research centres involved sharing research expenses, either in cash or in kind, which hindered the likelihood of research collaboration between SMEs and the research centres. This is because some SMEs may not be able to afford the research expenses, or they may be able to afford it but were reluctant to invest because of the fact that research activities are a lengthy process. Most SMEs were likely to look for short-term benefits rather than long-term ones. Thus, investing resources, time, and effort in research activities was not likely to be the case for Thai SMEs. Therefore, it was understandable to see that the research centres tended to work with large firms rather than with SMEs in conducting R&D collaborative projects.
In relation to industrial sectors having R&D collaborative projects with the research centres, agribusiness firms were the major research partner of BIOTEC. Automotive parts manufacturers were the main research partner of MTEC. In the case of NECTEC, their research partners were somewhat diverse. This was coherent with the R&D profile of Thai firms. Amongst the number of enterprises reported to invest in R&D activities in Thailand (934 enterprises, in 2005)\textsuperscript{37}, enterprises in food industry shared the greatest proportion (245 enterprises, in 2005)\textsuperscript{38}. The second and third largest industries that accounted for R&D expenditure in the Thai manufacturing sector were enterprises in chemical industry (133 enterprises) and machinery industry (100 enterprises)\textsuperscript{39}, while there were relatively small number of enterprises in telecommunication (2 enterprises) and computer technology (27 enterprises) that invest in R&D activities\textsuperscript{40}. The facts from the industrial outlook of the country support and reflect the likelihood of industrial sector partnering with the research centres in this study.

7.2.1.2 R&D activity

Findings in relation to characteristics of collaborating firms also indicate that the R&D activity which firms have in-house influenced how they interacted with the research centres during the collaborative project. The partner firms engaged in R&D collaboration with the research centres had different degrees of internal research activities. Some of the firms had relatively high intensity of internal research activities; they had dedicated R&D units and research staffs who were responsible for internal research activities and who worked correspondingly with the researchers during collaborative projects. These firms tended to have rich communication and interaction with the researchers during the collaborative projects. The researcher within these firms were also mentioned to be actively participating in the project in terms of conducting research tasks, providing feedbacks, integrating research results with their existing knowledge, and relating it to industrial uses. In contrast, some firms that appeared to have limited in-house activities and resources relating to research and development

\textsuperscript{37} NSTDA, Report on National R&D Survey 2005
\textsuperscript{38} Ibid.
\textsuperscript{39} Ibid.
\textsuperscript{40} Ibid.
were likely to contribute less in terms of performing research tasks in the collaborative project. Instead, they tended to act as passive research partners, leaving most of research work to the researchers.

In addition, empirical evidence from this study revealed that the partner firms with relatively higher R&D internal activities were more likely to have a continuous relationship and interactions with the research centres. They were also likely to have longer project durations. On the contrary, the partner firms with relatively less internal research activities tended to have shorter project duration (i.e. less than one year). They were more likely to have one-off research collaborations with the research centres. Furthermore, the findings pointed out that it was somewhat problematic for these firms to assimilate research results to industrial use. In order to highlight the significance of firm’s R&D intensity, three following case examples are given as follows.

In Case 1 the partner firm, a cattle farm, had been doing in-house research activities on artificial insemination of cattle extensively. The firm had worked with universities and other public research organisations in various ways, such as consultancy services, collaborative research projects, and technology transfer projects. Having experience of research partnership with academic partners had built up the firm’s R&D capability and facilitated accumulation of internal technical knowledge. This collaborative research between the firm and BIOTEC, which aimed to improve the conditions and processes of artificial insemination of cattle, consequently helped increase the firm’s technological capability in the related technological field. At the end of this project, the firm effectively incorporated the research results and new technique from the collaborative project into their production and commercially exploited it successfully. Furthermore, the firm and BIOTEC also established another collaborative project to study utilisation of forage cane as cattle feed. This project was conducted alongside the project on artificial insemination of cattle. It implied that the firm had a certain level of resources in-house to operate two collaborative projects, which were in rather different fields though at the same time related to the business line of the firm.
Similarly, in Case 4 the partner firm had worked with BIOTECA and other academic institutes for several years in the field of plant biotechnology before engaging in this R&D collaborative project with BIOTECA. Therefore, it could be said that absorptive capacity of this firm was relatively high according to their background. This collaborative research project between the firm and BIOTECA was the second phase of continuing work to improve the process of breeding ornamental plants for export to European markets. The consequence of active participation of the two parties provided BIOTECA the opportunity to innovate in a new technique for micro-propagation of ornamental plants, whilst allowing the partner firm to take ownership of the specific breeds of the ornamental plant developed.

Case 13 presented the opposite account to the previous two examples. It demonstrated that when a firm’s R&D intensity was relatively low, the firm consequently lacked the ability to take on the benefits of external knowledge. This was an important factor in explaining how the collaborative project was organised. In this case, the objective of the collaborative research was to apply 3D scanning technology in order to fabricate metal moulds for manufacturing automotive spare parts. The project aimed to enable the partner firm to use the new technology and adapt it to suit their production line. However, since the firm barely did research activities in-house, they therefore lacked the technological capability to fully incorporate the new technology into their production process. Consequently, they tended to rely on the researcher to do almost all of the work during the project. Moreover, when the project was completed the firm was not able to make use of new knowledge from the collaborative project and integrate it into their production line. Instead of implementing the research result in-house and learning by doing, they had to have MTEC do some of the work in relation to this new knowledge on contract research as they lacked the ability to fully utilise research results and new knowledge from the collaborative project into commercial use.

Examples from Case 1 and Case 4 pointed out that existence and intensity of research activities in the partner firms helped facilitate the process of knowledge transfer and exchange. The phenomenon found in Case 13 indicated that the contrasting level of a
firm’s internal research activities reflected how the firm performed in the collaborative project. In this aspect, it can be contended that the research centres were more likely to collaborate with R&D intensive firms as these firms were active at the technological frontier and were able to exchange knowledge with the research centres and learn new knowledge from the collaborative projects.

### 7.2.1.3 Knowledge bases

The findings also showed that it was not only the availability of in-house specific technical knowledge that appeared to be an important factor for firms to efficiently work with research centres and reap the benefits of the research collaboration. Knowledge bases in which the research partners, especially the partner firms, had accumulated were also a substantial issue contributing to the structure of collaborative projects. This was manifested in Case 3 and Case 5, which will now be elaborated in more detail.

Case 3 and Case 5 were both collaborative projects between BIOTEC and large firms. The partner firm in Case 3 was Thailand’s largest integrated paper and packaging producer and the one in Case 5 was one of Thailand’s leading integrated agribusiness enterprises. In these two cases, the partner firms had relatively high level of internal research activities and strong production experience. Nevertheless, they exhibited somewhat modest interactions in the collaborative projects with BIOTEC, performing more like passive research partners. The underlying reason was that these two firms possessed fairly little knowledge relating to the technology involved in the collaborative projects. The projects in Case 3 and Case 5 involved knowledge and technology about applications of digestive enzymes, in which BIOTEC researchers were fairly competent in this technological area. Both firms desired to use the digestive enzyme, which is a bio-ingredient, to substitute some of chemical ingredients being used in their production processes. Although they had been doing internal research activities, these activities had rarely involved technological knowledge related to enzymes technology. Considering this circumstance, they had fairly little technical knowledge in relation to the collaborative projects they had with BIOTEC. In this regard, BIOTEC researchers
were the dominant research partner, performing almost all of the research tasks. Moreover, when it came to the implementation of the research results in their prototype production, the firm seemed to be fairly reluctant to take action due to the lack of relevant technical knowledge and their lower competency in assimilating research results to their production process. Consequently, the research results from the collaboration only added new technological information to the partner firms, but it was not exploited commercially.

### 7.2.2 Previous relationships between research partners

From the interviews, it was found that the way in which collaborative R&D between firms and research centres started diverged amongst the nineteen cases studied. Findings showed that R&D collaborations between the firms and the research centres resulted from both previous formal and informal interactions of the research partners. The previous formal interactions involved consultancy projects, contract research, collaborative research, and joint research agreements. The previous informal interactions entailed a range of association and communication between the research partners, including interpersonal contacts, referral from other organisations or experts, and proactive approach of the researcher. Table 7.3 presents the different types of previous relationships between the research partners found in this study. Each type of relationship will be discussed in more detail in the subsequent sections.

<table>
<thead>
<tr>
<th>Previous relationships of research partners</th>
<th>No. of cases</th>
<th>Research Centres</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Formal interaction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consultancy work</td>
<td>2</td>
<td>BIOTEC</td>
</tr>
<tr>
<td>Contract research</td>
<td>1</td>
<td>BIOTEC</td>
</tr>
<tr>
<td>Previous collaboration</td>
<td>2</td>
<td>BIOTEC (1), MTEC (1)</td>
</tr>
<tr>
<td>Joint research agreement</td>
<td>4</td>
<td>BIOTEC (3), MTEC (1)</td>
</tr>
<tr>
<td><strong>Informal interaction</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interpersonal contact</td>
<td>6</td>
<td>BIOTEC (3), MTEC (3)</td>
</tr>
<tr>
<td>Referral</td>
<td>2</td>
<td>MTEC (1), NECTEC (1)</td>
</tr>
<tr>
<td>Proactive approach of researcher</td>
<td>2</td>
<td>NECTEC</td>
</tr>
</tbody>
</table>
7.2.2.1 Consultancy work

From the study, there were two cases of R&D collaborative projects that stemmed from consultancy projects, i.e. Case 1 and Case 2, in which both of them were BIOTEC’s projects. In these two cases, the researchers who were head of the collaborative projects had worked as research and technological consultants for the partner firms for a few years before the two parties engaged in R&D collaborative project. The consultancy tasks involved mainly technological advice regarding the firm’s in-house effort in technological improvement and problem-solving. Both researchers revealed that the successes of their consultations helped to develop trust and confidence, confirm the research competence of BIOTEC’s researchers, and build up their partner’s good reputation. They also expressed that the preceding consultancy projects collectively tied the partner firms and BIOTEC, especially in their research interest and interpersonal relationships, resulting in the ease of formation of the subsequent R&D collaborative projects. This was because rich interaction, good interpersonal relationships, and trust between research partners had been translated into more willingness to share and exchange their proprietary knowledge and resources.

7.2.2.2 Contract research and previous collaboration

The findings demonstrated that the R&D collaborative projects proceeding from previous contract research and collaborative research shared relatively marginal proportion among the studied cases. There was only one project (Case 10) that resulted from contract research. And there were two cases that followed from previous collaborative research (Case 4 and Case 12).

Explicitly, it was also pointed out that in fact the project in Case 10 could have been carried out as a continuing contract research project. However, it was set up as collaborative project because the rationale behind the continuous research partnership was mainly related to intellectual property rights (IPR) of the research results. In this

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41 Interviews with two BIOTEC researchers, one from Animal Physiology Laboratory and the other from Plant Physiology and Biochemistry Laboratory, on 5 August 2008 and 6 August 2008 respectively.
42 Interview with BIOTEC researcher, Biochemical Engineering and Pilot Plant Unit, 22 September 2008
circumstance, BIOTEC considered that the IPR of the new process being developed from this project should be shared between the research centre and the firm. This was because BIOTEC anticipated that the process being developed could be further exploited into various applications in the future. If the project was organised as contract research, the research results and the rights to further use the developed process would belong entirely to the partner firm. Opting for collaborative research in this situation allowed BIOTEC and the partner firm to become co-holders of the registered patent. As a consequent, BIOTEC had the rights to use the patented process for further technological applications, but in non-commercial purposes and not in the way to advantage competitors of the research partners for a period of five years, while the partner firm shared ownership of the patent and had propriety over the developed product. Although having joint patent, the researcher revealed that the relationship between BIOTEC and the partner firm was not considered as a rich and deep research partnership. There was a relatively less interpersonal relationship among individuals of the research partners. The reason was that the project was only three months. The firm simply partnered with BIOTEC to source new knowledge and for strategic reasons.

On the other hand, the R&D collaborative project in Case 4 and Case 12 followed from previous research collaboration between the partner firms and BIOTEC and MTEC respectively. In Case 4, the genesis of the previous collaborative project started from regular interpersonal contact between the firm and BIOTEC researchers. Although the firm was a small enterprise, it was considered as a technology-oriented firm, that used technology as a key component for the firm’s competitive advantage. It therefore had a technological capability that allowed them to absorb the knowledge developed outside the firm. The researcher interviewed mentioned that this firm usually sourced external knowledge from their partnership with universities and public research organisations. Particularly, in the past few years there had been continuous research interactions, both in formal and informal ways, between the firm and BIOTEC43. As a consequent, the firm and BIOTEC had developed a strong tie of research partnerships as well as deep

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43 Interview with BIOTEC researcher, Plant Molecular Biology Laboratory, 8 August 2008
relationship between individuals, which facilitated their ongoing R&D collaboration and transfer of knowledge.

Case 12 involves two collaborative projects between MTEC and a large Japanese automotive parts manufacture. The origin of their research collaboration is based on referral from the Japanese MIM (Machine Injection Moulding) consortium. Initially, the Japanese partner preferred contract research to confirm knowledge and expertise of MTEC before engaging in research collaboration. However, MTEC researchers foresee that the collaborative projects benefit in a larger extent in terms of knowledge sharing between the partners, human resources, research facilities, and technological opportunities for local industry. MTEC researchers have convinced the firm to jointly work in collaborative project. Subsequent to their first collaborative effort, there has been successive collaboration between the research partners.

7.2.2.3 Joint research agreement

According to the interviews there were four collaborative projects, i.e. Case 7, 8, 9, and 16, that emerged from joint research agreement between the firms and research centres. The first three were BIOTEC’s projects and the other one was MTEC’s project. A distinctive feature of this previous relationship between research partners was that the experience of research centres and partner firms before engaging in the joint research agreement were at the organisation level involving formal visits of top executives of the firms and senior researchers or management of the research centres. The interactions and relationships were driven by the top management of the two research partners.

The activities within the joint research agreements covered not only R&D collaborative effort but also exchange of research staff, trainings, and joint ownership of patent, if it is granted. The joint research agreement was considered long-term research partnership, which usually involved three to five years commitment of research cooperation between the partner firm and research centre. Conspicuously, the partner firms that have a joint research agreement with the research centres were large international firms that had high internal R&D intensity and absorptive capacity. In particular, the partner firm in
Case 7 and Case 8 was Shisedo Co. Ltd.; a major Japanese hair care and cosmetics producer, the one in Case 9 was Novartis International AG; a multinational pharmaceutical company, and the one in Case 16 was Merck KGaA; a German-based chemical and pharmaceutical company.

7.2.2.4 Interpersonal contact

The findings demonstrated that interpersonal contact made up the majority of previous relationships of R&D collaboration between firms and research centres. It counted for six cases among the nineteen cases; three out of the six cases were of BIOTEC (Case 3, Case 5, Case 6) and the other three were of MTEC (Case 11, Case 13, Case 14). The types of interpersonal contacts varied among the projects. In some projects, firms had associated with the researchers and the research centres via technical events such as seminars, conferences, and meetings. In the other projects, firms acknowledged that researchers and research centres had the expertise relevant to their interest. They then explored R&D collaboration opportunities by making contact directly with the researchers.

7.2.2.5 Referral Proactive approach of researchers

The last two types of previous relationships, which are referral and proactive approach of researcher, were considered as the previous relationship between research partners that had the least degree of ties of relationships. The referral relationship referred to the situation in which partner firms recognised the expertise of the research centres but had not worked together or contacted each other before. Three cases, which were developed from referral, were Case 15 which was MTEC’s case and Case 19 which was NECTEC’s case. In Case 15, the firm was referred to a MTEC researcher by a university researcher who had worked as technology consultant to the firm. In Case 19, the referral came from a top executive of NECTEC who acted as senior consultant to a member of the board of the partner firm.
Interestingly, two of NECTEC collaborative projects, i.e. Case 17 and Case 18, resulted from a proactive approach of researchers in finding industrial partners for R&D collaboration. This type of previous relationship of R&D collaboration was found to be quite remarkable but rather unusual among the projects studied, and within the community of the researchers at the national research centre in Thailand. While in the other projects the researcher and research centre played a rather passive role in the establishment of R&D collaboration, the researchers leading these two projects were very much proactive in terms of finding the research partners. However, this approach appeared to result in quite successful research collaboration.

However, prior experience of working together, either formally or informally, was an important success factor for the development of R&D collaboration between firms and research centres.

7.2.3 Discussion

The findings about role of firm size were in line with literature in that large enterprises had a higher probability of collaborating with the research centres. The rationale underlying the role of firm size in affecting the propensity of the firm to collaborate with research centres was that large enterprises had more resources to help them establish research relationships with the public research organisations, whereas SMEs had smaller available resources to develop such relationships (Fontana et al., 2006). In addition, considering the status of the partner firms, it was observed that none of the firms engaged in collaborative R&D with the research centres were a start-up firm. It appears that the findings contradict with recent empirical investigations on relationships between public research organisations and industry.

The literature indicates that usually larger firms and start-ups have a higher tendency to work with government research organisation and benefit from them (Mohnen and Hoareau, 2003; Laursen and Salter, 2004). A possible explanation for the evidence in this study is that since research collaboration between the firm and research centre involves sharing research expenses either in cash or in-kind, which most of start-up firms in
Thailand may not be able to afford. Furthermore, because of the fact that research collaboration is a lengthy process, start-up firms are likely to look for short-term benefits rather than long-term ones. Thus, investing resources, time, and effort in research activities is not likely to be the case for Thai SMEs.

The findings also support the idea that the intensity of R&D activities carried out by firms influence the extent of their involvement in cooperation with research organisations (Fontana et al., 2006). Firms that invest in R&D are likely to possess a high technological capability that allows them to absorb the knowledge developed outside the firm (Schartinger et al., 2001). In this aspect, they have “absorptive capacity” which enables them to recognise the value of new, external knowledge, assimilate it and apply it to commercial ends (Cohen and Levinthal, 1990). According to Cohen et al (1990), firms with a high general level of technological competence, measured by firms’ R&D intensity, have a higher absorptive capacity that enables them to learn and exploit new knowledge. In short, internal research activities appear to enhance the ability of a firm to internalise external knowledge, and thus generate economic benefit from it.

With regard to a firm’s research ability, technological competence of the research partners in the specific and relevant area associated with the research project affects the firm’s absorptive capacity (Mowery et al., 1996; Peter and Michael, 1998). In addition, this finding is consistent with the study by Santoro and Bierly (2006), which recognises that both technological capability and technological relatedness of research partners are importance facilitators for knowledge transfer in research collaboration.

Moreover, the findings also evidently underline two facilitators of R&D collaboration between firms and research centres; one is interpersonal relationships and the other is trust. This finding is explained by the fact that while interpersonal relationships between individuals in the partner firms and researchers help transfer tacit knowledge between the research partners, trust between them enables more open communication and facilitates their R&D collaboration (Santoro and Bierly, 2006). Nevertheless, it is not straightforward to build up trust among research partners. It takes some years and
repeated collaboration to develop trust between research partners (Davenport et al., 1999a). Once trust between research partners is established it helps maintain continuous interactions and R&D relationship, as evidenced in Case 1, 2, and 12 from this study.

Although it is not possible to identify clearly from the findings which types of previous relationships are the dominant ones that influence the establishment of R&D collaborative projects between research centres and partner firms. It could be contended that prior experience of working together, either formally or informally, is an important factor for the development of R&D collaboration between firms and research centres. This is consistent with Schartiger et al. (2001) that previous experience of research partners is crucial in reducing barriers and renders interactions between firms and research centres more likely. The findings also confirm the statement of Barker et al. (1996) that prior experience of the research partners working together can be as important to collaboration success as collaborative experience.

### 7.3 Organising R&D collaboration

This section presents findings about the ways in which R&D collaborative projects between research centres and partner firms are structured. In relation to the analysis framework constructed to examine interaction between firms and research centres presented in Chapter 3, this section explains how R&D collaborations are organised by way of underlining issues beyond the interactions of the research partners during the project organisation stage. The section starts by presenting different research motivations, from the point of view of the researchers, of working with industrial firms. Subsequently, the strategies of their interaction are presented in light of the nature of the knowledge transfer process involved in the collaborative project. The chapter moves on to reveal the attitudes of researchers towards working with industrial partners. The duration of the collaborative project is also indicated. The importance of physical distance between the research partners is justified. The findings on organising R&D collaboration are discussed to close the section.
7.3.1 Motivations of R&D collaboration

The previous section explored how firms and research centres interact in the course of their R&D collaborations and illustrated their relationships with respect to background condition (i.e. characteristics of firms and previous relationship between research partners) of the R&D collaborative projects. This section presents the findings and analysis of motivations of R&D collaborations from the interviews. The researchers discussed the motivations for entering into collaborative projects with firms, and the different motives that the firms had when they entered into R&D collaborative projects with the research centres. This study emphasises the exploration of public-private R&D collaborative projects from the perspective of the public sector; for this reason the motives of firms are inferred from the opinions of the researchers, which are not necessarily representative of how the firms think. The motivations for R&D collaboration from the interviews have been analysed following from the framework of motivation for research cooperation studied by Autio et al. (1996) and Montoro-Sanchez (2006). These studies suggest that firms and research organisation work together due to financial, technological, strategic, educational, and political motivations.

By analysing the occurrence of each motivation mentioned by the interviewees, the findings suggest that technological motivation is the main motivation for both research centres and firms to set up research collaborative projects, as it is the most frequently cited motivation for entering research collaboration in this study. While firms desire to gain access to knowledge and technology of the research centres, the research centres consider practical implementation of research results for industrial use. Besides technological motives, strategic motive is the second most cited motivation for research collaboration. Firms’ strategic motives to work with the research centres include developing new/improved products and processes, gaining access to facilities and resources of the research centres, and obtaining new technological knowledge from the collaborative project. Strategic motives of the research centres to work with industrial partners include gaining access to materials and industrial knowledge and protecting their intellectual property rights. The motivations related to research collaboration
between the research centres and industrial firms in this study are identified and presented in Table 7.4.

Table 7.4 Main motivations for research collaboration of researchers and firms

<table>
<thead>
<tr>
<th></th>
<th>Researchers’ motivation</th>
<th>Firms’ motivations</th>
</tr>
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<tbody>
<tr>
<td><strong>Technological</strong></td>
<td>• Practical implementation of research results (12)</td>
<td>• Access to knowledge and technology (19)</td>
</tr>
<tr>
<td></td>
<td>• Development of new technological knowledge (3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Technology adaptation for problem solving (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Explore industrial applicability of research results (2)</td>
<td></td>
</tr>
<tr>
<td><strong>Strategic</strong></td>
<td>• Access to materials and industrial knowledge (6)</td>
<td>• Access to facilities and resources (9)</td>
</tr>
<tr>
<td></td>
<td>• Maintain and protect IPR (4)</td>
<td>• New/improved products/processes (16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• New technological knowledge (3)</td>
</tr>
<tr>
<td><strong>Financial</strong></td>
<td>• Additional financial sources (4)</td>
<td>• Additional financial sources (2)</td>
</tr>
<tr>
<td><strong>Political</strong></td>
<td>• Adapt to government initiative (4)</td>
<td></td>
</tr>
</tbody>
</table>

Note: The number shown in brackets are recurrent motivations found from the nineteen projects studied.

7.3.1.1 Technological motivation

Although firms and research centres have different research rationales, the findings indicate that technological motivation is the most important motivation for research cooperation for both research partners. On the firms’ side, technological motives are merely associated with access to knowledge and technology of the research centres. This is in consensus amongst the nineteen cases in this study. On the researchers’ side, the interviews reveal that their technological motivations have a broader scope concerning realisation of research results into industrial uses and gain relevant practical inspiration for research projects. Specifically, the technological motivations of the researchers are: (i) to exploit research results in practical implementation; (ii) to develop new technology and knowledge; (iii) to adapt existing knowledge for specific problem solving; and (iv) to explore industrial applicability of research results. Additionally, it is noticed that the different dimensions of the technological motivation of the researchers were found to be
associated with the project outcome and underlie characteristics of the collaborative projects.

7.3.1.2 Strategic motivation

It could be inferred from the interviews that strategic motivations for firms are related to their competitive advantage; i.e. access to resources of the research centres, develop new/improved products and/or processes, and build up new knowledge. On the other hand, one of the important strategic motivations for researchers is access to materials of the partner firms and benefit from industrial knowledge. Additionally, it appears that when the researchers are interested in acquiring materials and industrial knowledge that are accessible through the partner firms, their motivation is driven by the ambition to gain insights into their research agendas in order to test practical application of their research results.

The other significant strategic motivation for the researchers to collaborate with the firm is protection of intellectual property rights. In this aspect, when research collaboration is motivated by the researcher’s motive to protect IPR, the project is often continuing collaborative efforts of the research partners in which the research results exhibit commercially viable benefits. The researchers are therefore interested to maintain the rights to use developed technologies and knowledge for further research activities, not for commercial purposes.

7.3.1.3 Financial motivation

The interviews reveal that financial motivations for research collaboration between firms and the research centres are similar in that both partners expect that engaging in research collaboration provide financial support in terms of additional and alternative financial resources to their organisation.

Interestingly, it appears that none of the researchers from BIOTEC expressed that their motivation of R&D collaboration is driven by finding additional research funding. On
the contrary, all of NECTEC researchers interviewed indicated that one of the primary motives to work with industry is to gain external research funding. One explanation is based on the fact that the two research centres are different in the norm and culture of the organisation which shape the different behaviour of their researchers.

In addition, in the case of MTEC, there is one collaborative project in which MTEC researcher expressed that one of the primary motives of working with firms is to gain external funding. This is the project with large international firms. Most of MTEC’s collaborative projects are with SMEs, thus gaining external research funding is not likely to be the case.

7.3.1.4 Policy-related motivation

Regarding policy-related motivation, findings indicate that adaptation to government initiatives is one of the motivations for research cooperation only from the viewpoint of the researchers. This is because since 2004 when NSTDA changed their R&D management strategy from technology-based management to programme-based management, it stressed the importance of practical uses of research results. Accordingly, the researchers have increasingly considered collaborating with industry to align their research plans with industrial needs. Moreover, conducting collaborative R&D with industry is increasingly being recognised as one of significant key performance indicator (KPI) for researcher performance evaluation. In addition, it is also evident that the projects that the researchers participated in order to adapt to NSTDA’s initiatives in fostering public-private R&D collaboration are mostly those in which the researchers and the partner firms did not have previous collaborative research contact. In this context, although driven by R&D policy, it is somewhat contradictory that the researchers have a tendency to perceive the importance of research collaboration relatively less than their in-house research projects.

Considering firms’ policy-related motivation, it is not mentioned from the interviews that the partner firms collaborate with research centres because of the policy-related motives. This is possibly the case because in Thailand there is scarce concrete industrial
collaboration policy that provides incentives for firms to collaborate with research centres. One existing government measure to encourage private sector to invest more in research activities is the tax incentive in which firms operating in the country, in any zone and industrial sector regardless of size of firm, can benefit from a 200% deduction for R&D expenses on hiring qualified researchers and doing research and development projects. This policy measure aims to promote R&D activities in the private sector and to help stimulate science and technology development for the future of Thailand. Nevertheless, firms’ investment in research activities in Thailand remains limited.

7.3.2 Interactions strategies: active vs. passive

In order to find out how researchers work with firms in the collaborative projects, the researchers were asked to specify how they interacted with firms in connection with R&D collaborative projects. The open-ended and closed questions were asked enquiring about participation and contribution of the firm and researcher in the project, working with the firm’s scientists and engineers, and communicating with members of the firm.

Interactions between firms and research organisations participating in collaborative research refer to a bi-directional exchange of knowledge between the two parties that have different research orientations (basic and applied vs. industrial research). The findings show that there are firms that take a somewhat passive role in the collaboration by adopting a wait-and-see approach, and firms that actively participate in the projects have frequent feedbacks and discussion with the researchers. The active partner firms are those that have a special team who are responsible for collaboration activities, such as collecting data from the field, providing feedback from an industrial perspective in relation to commercial application of the technology involved in the projects, and sourcing appropriate materials or equipment. While the passive partner firms have a propensity to set out corresponding persons to keep up with the progress of the project without getting involved in main research activities, they are likely to leave the research tasks to the researchers.
Moreover, it appears that the projects that have passive partner firms are short-term projects that last less than a year, and in most cases are projects with SMEs directed at imperative problem solving. On the contrary, for the projects with active partner firms, it was found that to some extent there was also mobility of personnel involved during the period of R&D collaboration. Particularly in Case 12, which is the project of MTEC with a Japanese partner firm, the MTEC researcher was dispatched to work within the firm during the collaboration period. Likewise in Case 9, which is one of BIOTEC’s collaborative projects about the study of microbial from Thai natural product BIOTEC for pharmaceutical purposes, a team of BIOTEC researchers were sent to learn specific technique used in industrial laboratory from its partner. It could be argued that the interaction strategy that firms adopt in the process of R&D collaboration with research organisations is motivated by their own research orientation, and knowledge gap between the research partners.

Furthermore, it could be argued that characteristic of the collaboration within the nineteen projects studied by some means relates to interaction strategies adopted by the partners firms during the projects. However, the characteristic of collaboration in this context is considered in terms of active or passive manner of the partner firms in participating in collaborative projects. For instance, as evidenced in Case 9 and 12, the active partner firms tended to have closer interaction and stronger research partnerships with the research centres than the passive partners do. Also when there is high intensity of collaboration, it is likely that there could be opportunity for subsequent research collaboration between firm and research centre.

7.3.3 Attitudes of researchers towards working with industry

Unlike university researchers who teach and conduct research projects, for the researchers working at public research centres their emphasis is merely on conducting research activities. However, the research activities of NSTDA research centres are at different stages of technological development. Some researchers concentrate on upstream research, focusing on technology which is still in the early stage of the
innovation process. Other researchers centre their work on close-to-market research, focusing on technological adaptation, as well as integration and verification of technology for industrial applications.

The attitudes of researchers leading the collaborative projects are a significant aspect underlying how R&D collaborative projects are structured and organised. To find out how the researchers recognise the importance of research collaboration with firms, the researchers were asked to indicate how they justified the collaborative projects in connection with their main research agendas. They were asked whether research collaboration with industry is considered as core to their research activities, as technology transfer activities from public laboratory to industry, or as activities to link with firms and secondary to in-house research.

From the interviews, some researchers indicated that working with firms in collaborative projects is considered as a core activity to their research work. They elaborated that collaborative projects with industry helped them to complete the research life-cycle, bring research results from laboratory to market, recognise new applications of technology, and identify further research directions. These researchers tend to benefit from industrial knowledge absorbed during the collaborative projects in order to enhance their understanding about industrial world and increase their technological competency. The researchers who stated that collaborating with the firm is considered as part of their research strategy indicated that more than 70-80% of their work was associated with industrial firms, while the rest of their work were in-house research activities or joint projects with other research institutes and universities.

In addition, there were researchers who indicated that collaborating with firms was regarded as secondary research activities. It was found that the researchers themselves have had little experience working with industry and concentrated their research work primarily in-house. The stage of their research activities were to a certain extent considered as upstream research. They tended to get involved in the collaborative projects because the research problems of the projects appeared to be related to their
research tasks and relevant to their research fields. However, the relative important of the collaboration was considered minimal compared to their ongoing projects conducted in-house.

Moreover, the researchers who recognised that collaborating with firms was considered as technology transfer activities expressed that working with firms in collaborative projects enabled them to prove that the technology developed within the research centre was applicable and useful for industrial firms. They tended to focus on adaptation of technology for industrial uses, while primarily working on in-house research.

### 7.3.4 Time span of R&D collaborative projects

The findings indicated that the time span of the R&D collaborative projects varied, ranging from six months to three years. Fifteen of the collaborative projects studied spanned from one to three years, while only four projects lasted less than a year, spanning from six to nine months. In addition, it was evident that the time span of the collaborative project had a tendency to relate to firm size. Large firms tended to have a longer duration of collaborative projects with public research organisations than SMEs did. However, it should be noted here that not all SMEs in this sample had short-term collaborations with the research centres. One SME collaborating with BIOTEC had a one-year project, which was actually a continuing phase of their R&D collaboration. The other SME collaborating with NECTEC also had a one-year project, which was the first time that it worked with NECTEC. This project is likely to continue into the next project phase.

### 7.3.5 Physical distance between the research partners

The findings revealed that physical distance between the research centres and the partner firms was considered insignificant for their R&D collaboration. Physical distance here referred not only to the location of research partners, but also referred to the difficulty, time requirement, and expense of communicating and getting face-to-face contact. Among the nineteen cases studied, there was only one case (i.e. Case 5) in
which the partner firm was located in TSP. This project however did not demonstrate any exceptional aspect regarding the influence of geographical proximity on the interaction of research partners. Almost all of the researchers interviewed stated that they did not mind travelling to the firm’s site.

Generally, R&D activities in the collaborative projects were carried out both at the research centres and at the firms’ location. The research intensive activities were usually performed at the research centres, while application of knowledge and technology were typically implemented at the firm’s site. Nevertheless, the researchers who had worked extensively with industry stated that they preferred to work mostly at the firm’s site to easily access industrial knowledge and resources. In this case, facilities at the research centres were used only when complicated R&D activities were needed and they were not possible at the location of the partner firm. It was evident that there were several collaborative projects where all of the research activities were performed at the firm’s site. This implied that these projects possibly involved extensive knowledge transfer activities, specifically knowledge assimilation, in which the geographical proximity was an influencing factor on its success (Santoro and Gopalakrishnan, 2000)

7.3.6 Discussion

The findings about technological and strategic motivation of firms are consistent with the studies by Autio et al. (1996) and Montoro-Sanchez et al. (2006). While Autio et al. (1996) views different dimensions of research motivation from the industrial and scientific perspective, and partly from the public perspective. The findings from this study provide empirical evidence from the public perspective. However, the findings about motivation of research centres are somewhat different from previous studies. In that the literature presents technological motivation of research organisation in terms of access to teams, materials, and experience of the employees in the firms (Montoro-Sanchez et al., 2006), this study adds to the literature the specific technological motivations of researchers (e.g. practical implementation of research result), particularly from the perspective of those who work for public research organisations.
The other significant strategic motivation for the researchers to collaborate with firms is the protection of intellectual property rights. In this aspect, when research collaboration is motivated by the researcher’s motive to protect IPR, the project is often a continued collaborative effort between the research partners in which the research results exhibit commercially viable benefits. The researchers are therefore interested in maintaining the rights to use developed technologies and knowledge for further research activities, not for commercial purposes.

While other studies indicate that the main motivations of research organisation to collaborate with firms are finding additional and alternative resources (Autio et al., 1996; Fritsch and Schwirten, 1999; Montoro-Sanchez et al., 2006), the findings from this research are inconsistent with the literature. From the point of view of the researchers, financial reasons do not have priority over other reasons. The different results could be explained by the fact that the main R&D funding for the research centres is mainly from government funding, especially from NSTDA. Although the researchers have been urged to work with other organisations to benefit from networking and external research funding, financial benefits from collaborative projects with industry are considered marginal. Non-monetary benefits tend to have substantial advantages for the researchers and the research centres. For that reason, collaborative R&D projects in this study tend to be driven by technological and strategic reasons rather than for financial ones.

The study also showed that, although they had differing research orientations, the firms that took active roles in the collaborative project were those that had a knowledge base relevant to the technology involved in the project and the knowledge gap between the two partners was not too big or too small for distribution of knowledge. In such cases, the partners mutually benefited from the R&D collaboration. For the passive partner firms, the interviews pointed out that the knowledge distance between firms and the research centres with respect to technology involved in the project was relatively big. This inhibited the knowledge distribution and knowledge exchange between the two parties. Consequently, the passive partner firms were unable to interpret new
knowledge created during the collaborative projects. This knowledge only added to information overload for the firms. This finding is consistent with the study of Cummings and Teng (2003) in that the extent to which the research partners share similar knowledge bases and the extent of interactions between them are among the key factors effecting the knowledge transfer process.

Considering the profiles and backgrounds of the researchers interviewed, it was found that the individual characteristics of the researchers reflected how they perceived the importance of the R&D collaborative projects with industry. Additionally, the attitudes of researchers leading the collaborative projects were a significant aspect underlying how R&D collaborative projects were structured and organised.

In all such instances, it is oversimplistic to justify that the quality of the collaborative projects or the efficiency of interaction process is influenced by the relative importance of the project. However, it is possible to challenge that the variety of interactions with industry depend on the ‘integration skills’ of the researchers. It appears in this study that the researchers who extensively interacted with industry were more likely to develop the capability necessary to integrate the academic and industrial world, thus bringing research into practical use. Hence, they were more likely to value research collaboration with industry among their top priority work. This finding is consistent with the study by D’Este and Patel (2007) which found that individual characteristics of researchers have impact on linkage with industry.

Regarding the project duration, the findings from this study support the statement of Lee’s (2000) which stated that SMEs tend to have shorter project duration than large firms. In this study, most projects with SMEs spanned less than one year, while projects with large firms tended to last between one and three years. In addition, concerning time span of a project and the knowledge transfer process, the findings reveal that to some extent time span signified the orientation the collaborative project and the complication of the knowledge transfer process. As evident in the study, the shorter length of the project (i.e. less than one year) implied an orientation towards short-term
practical problem solving, whereas the projects with longer length usually involved long-term research partnerships for complex knowledge assimilation. The longer project implied better opportunity for the research partners to benefit from the project (Lee, 2000). Furthermore, the findings showed that some projects were carried out in phases. The researchers explained that this was preferable for both firms and research centres in that it allowed the partners to justify the research results and evaluate partner performance along the lines of their cooperation. Moreover, from the researcher’s perspective, it was practical in terms of administration and planning for other research activities during the fiscal year.

Lastly, from the viewpoint of the researchers interviewed, physical distance neither promoted nor hindered the likelihood of R&D collaboration with industry. However, geographical proximity may influence the knowledge transfer from the centres to firms, in that, closeness in distance may ease the exchange of ideas, experience and skills between research centres and partner firms as they encounter on daily basis. For example, the researchers in Case 1, Case 2, and Case 4 pointed out that they prefer working closely with firm’s researchers/technicians at firm’s site in order to gain practical knowledge from industry and to effectively transfer knowledge from the collaborative project to partner firm. They also indicated that being in close proximity with firm is less problematic in terms of dialogue regarding implementing research tasks and exploiting research results.

7.4 Operating R&D collaboration

In light of the analysis framework constructed to examine interaction between firms and research centres in relation to their R&D collaborations, this section discusses how R&D collaborative projects are implemented by introducing a typology of R&D collaborative projects developed from the empirical study. The typology is used to explain the nature of collaborative project with particular emphasis on the involvement and interactions of the research partner. The typology is classified with reference to two dimensions, i.e.
status of research activities and knowledge involved. As a consequence, four categories of research collaboration are explicated, which include interactive, exploitative, explorative and strategic R&D collaboration. Each of these will be discussed under four separate headings. The section concludes with an overall discussion of the different categories of research collaborations.

7.4.1 A typology of R&D collaborative projects

Each collaborative research project had unique characteristics and circumstances underpinning the way in which the project was carried out. This section exemplifies the specific types of R&D collaborative projects found in this study and examines factors relating to the idiosyncrasies of each type in order to find out how the research partners interacted in each particular setting. To present the categories of R&D collaborative projects, two dimensions underlying the characteristics of the research cooperation in this study is defined. The first dimension is the knowledge involved in the process of R&D collaboration, and the second dimension is the status of research activities.

The first dimension, the knowledge involved in the process of R&D collaboration, focuses on the stage of technological development at which the collaborative project operates. Based on the literature, two extreme forms of technological change concerning R&D projects are the development of knowledge from existing knowledge, and the creation of new knowledge with loose connections to exiting knowledge (Revilla et al., 2005). Following from Revilla’s concept, the first dimension considered in this study delineates R&D collaborative projects that use existing knowledge to derive applications and technologies for new/improved products and processes and those that require integration of expertise to construct new knowledge contributing to the development of new products and/or processes. However, as most R&D projects require both generation of some new knowledge and the application of some pre-exiting ideas. Therefore, this dimension is not viewed as dichotomous, but rather as a range with two extreme types of knowledge at either end.
The second dimension is the status of research activities, which focuses on the relatedness of the collaborative project with the internal research agendas of the research centres. It sketches out the extent to which the collaborative projects associate with the general research activities of the researchers and complement the research agendas of the research centres versus specific research support projects to solve problems or address particular needs of the industrial partners.

The combination of these two dimensions leads to a typology of R&D collaborative projects as shown in Fig 7.1. The typology includes four categories of R&D collaborative projects which are defined as interactive, exploitative, strategic, and explorative. Each of these four categories is further discussed with exemplary cases of collaborative R&D from this study.

<table>
<thead>
<tr>
<th>Knowledge involved</th>
<th>Existing Knowledge</th>
<th>New Knowledge</th>
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<tbody>
<tr>
<td>Category I</td>
<td>Exploitative R&amp;D Collaborations (3 cases)</td>
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<tr>
<td>Category II</td>
<td>Explorative R&amp;D Collaborations (2 cases)</td>
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<tr>
<td>Category III</td>
<td>Interactive R&amp;D Collaborations (11 cases)</td>
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<tr>
<td>Category IV</td>
<td>Strategic R&amp;D Collaborations (3 cases)</td>
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**Figure 7.1 A typology of R&D collaborative projects**

Source: Author, adapted from Revilla et al. (2005)
7.4.2 Category I: Exploitative R&D collaborations

Category I consists of three cases of R&D collaborative projects (Case 11, 13, and 14) that involve adaptation of existing knowledge developed within the research centres to solve problems for their industrial partners. Note that all of these cases are collaborative projects between MTEC and small-sized firms. The contents of the research project in this category are specific to the firms’ needs and to some extent related to the core research agendas of the research centre, although somewhat outside the research routine of the researchers. In this category, the collaborative projects are oriented towards short term practical problem-solving of firms. The collaborations often involve a narrow scope of work that is less likely to benefit the core research activities of the researchers. According to the researchers, these projects are viewed as something in addition to what they normally do.

The intensity of interaction between the research partners is relatively low in this context. A possible explanation of this finding is that partner firms involved in these projects do not have their own R&D labs. They are a somewhat dependent partner of the research centre, leaving most of the research tasks to the researchers. The projects are rather contractual-like collaborative R&D. A possible reason underlining the findings is that the industrial partners are SMEs with limited ‘absorptive capabilities’. Their knowledge bases are relatively limited. They can only benefit from the collaboration on a short-term basis, such as solving a firm’s specific problems. The partner firms are less likely to be able to fully internalise the knowledge and technologies generated during the projects, given the knowledge gap between the research centres and the firms. Long-term collaboration with the research centres is rare with partners in this project type. Knowledge developed in these projects is transferred by means of improved products and/or processes. Time span of the project is moderately short (not more than one year). Box 7.1 illustrates an example of exploitative R&D collaboration.
Box 7.1 Developing of large packaging for overseas transportation of rubber resin (Case 14)

This project, between MTEC and an SME in the rubber industry, is to develop large plastic tanks for the overseas transport of latex rubber. Typically, aluminium tanks are widely used for transporting latex rubber overseas. However, using plastic tanks is much more economic. Considering the lower transporting cost, the firm used to have a contract research with a university to develop the desired product. Unfortunately, the property of the plastic tank developed was not fully achieved. Accordingly, the firm approached MTEC, via MTEC Industry Liaison unit, to develop the desired product.

Learning from previous research experience of the firm with a university, the Plastic Technology Laboratory of MTEC proposed the research activities for this project to begin with material development in order to ensure property of the end product, followed by the development of the production process and manufacturing of the end product. Since the main business of the firm was not about plastics processing, most of the research activities were performed by the researcher. The firm provided information regarding requirements and uses of the end product, as well as conducted the testing of the product models.

In actual fact, the firm could have established contract research with MTEC. Nevertheless, this was not the case because they could not afford another contract research. A collaborative project was therefore preferred, given that the research cost is shared between firm and MTEC. The collaboration stopped shortly after the end product was successfully produced as required and the production process was transferred to the firm. Even though the researcher suggested that the property of the end product and efficiency of the production process could be improved, the firm had no interest because its main business was rubber latex, not plastic manufacturing.

7.4.3 Category II: Explorative R&D collaborations

There are two cases of explorative R&D collaboration in this study (Case 3 and 5, from BIOTEC). This type of collaboration focuses on new applications of research results, rather than the development or improvement of industrial technologies or innovative products/processes. Although the projects are built upon some existing knowledge, in most cases they involve knowledge that do not pre-exist in both the research centre and the firms. The difference between Category I and II is the relevance of the research content of the collaborative projects with the core research agendas or the research routine of researchers. The contents of the research project in this category are specific to the firms’ needs but considered relatively less complementary to the core research agendas of the research centre, thus regarded as positioned outside the research agendas and routine of the researchers. The collaborations provided are viewed as something additional to what the researchers normally do. Moreover, the stage of the projects in the research life cycle is considered premature for practical implications.
The similarity of the exploitative and explorative and R&D collaborative projects lie in that most of the research tasks are left to the researchers in both cases. The firms provide their requirements and expected research results, industrial knowledge and specifications, and feedback with modest indication that they intend to take an active role in the research itself. In the case of the exploitative R&D collaborative projects, the passive participation of firms is because they lack the knowledge based and R&D resources. In this context, although the firms have R&D labs and are large firms, the level of technological overlap between the firms and the research centres is marginal. Although the collaboration creates new knowledge which can become crucial to the performance of the partner firms, the level of technological relatedness of the research projects and their core business hinder knowledge assimilation of the partner firms. Moreover, the fact that creating new knowledge is always a risky activity, the partner firms are reluctant to carry on the next phase of research collaboration to materialise the new knowledge created, even when the research partners shared the cost. The firms perceive the importance of the explorative research activities as auxiliary work merely keeping them up to date with technology trends. Box 7.2 presents an example of explorative R&D collaboration.

**Box 7.2  Biotechnology application of digestive enzymes on pulp and paper (Case 3)**

This collaborative project was between BIOTEC and a large pulp and paper manufacturer. In this context, the firm desired to study utilisation of enzymes for paper production. The technology involved in this project as based on the use of enzymes for paper production. This application of enzymes technology was increasingly fashionable in the paper industry, because it had strong contributions to the reduction of environmental problems such as industrial pollution and disposing of agricultural waste.

This project required new knowledge to accomplish the research objectives, because neither partners were familiar with the application of knowledge involved in this project. Even though the partner firm had an internal R&D unit, its research activities focused on product improvement and efficiency of production process. Enzyme technology and its applications were considered new to the firm. Therefore, it was better to involve BIOTEC rather than developing all the knowledge that would be needed in-house. For BIOTEC, although the centre was competence on enzyme technology, the application of enzymes for paper production was a new research area for the researchers. Working in this project, the researchers had to gain knowledge of paper production in order to know how to use the enzymes in the production process. Likewise, the firm needed to get familiar with new techniques of using enzymes in the manufacturing process.
7.4.4 Category III: Interactive R&D collaborations

The findings indicate that the majority of the collaborative R&D projects in this study fit within the category of interactive R&D collaboration. These were the projects from eleven cases, in which five cases were from BIOTEC (i.e. Case 1, 2, 4, 6, and 10), three cases were from MTEC (i.e. Case 12, 15, and 16), and three cases were from NECTEC (i.e. Case 17, 18 and 19). The knowledge and technology involved in these projects are from existing knowledge, which had been developed and was available within the research centres. The development stage of knowledge of research centres in this category is considered to be at a mature stage, i.e. very close to market. By working with industrial firms, research results from collaborative projects could be materialised in industry. The research content of the projects complement the research agendas carried out at the research centres. The research collaborations in this category are oriented towards integration of research results and technologies for industrial purposes. The projects are said to help increase the scope and depth of the existing knowledge of the research centres and enhance industrial research skills of the researchers.

Knowledge developed from these collaborative projects are transferred to and applied by the partner firms through interactions during the projects. The relationships of the research partner show intense interaction, including frequent personal informal communication, information exchange, and mobility of personnel. The research partners are interdependent in terms of academic and practical knowledge, scientific and industrial facilities, and resources. Moreover, the projects in this category are less likely to suffer from a knowledge gap between research partners, given that the partner firms have invested in internal research activities and accumulated technological capabilities necessary for knowledge transfer from the research centres.

Three examples of the projects in this category are illustrated in Box 7.3, 7.4, and 7.5
Box 7.3 Bioremediation of salinity land using salt tolerant tree (Case 2)

An interactive R&D collaboration was the project between a large edible and industrial salt producer and BIOTEC. In this context, a research group at BIOTEC, who had been researching bioremediation for over a decade, had recently successfully applied and adapted the knowledge and technologies to several agricultural industries. During 1998-2003, the firm itself attempted to recover its 20 acres salinity land using organic fertiliser to increase soil fertility and tried to cultivate trees on the treated land. However, the research effort was not quite successful.

With the publicity of BIOTEC in research on bioremediation, in late 2003 the firm approached BIOTEC to establish a formal research relationship in order to assimilate the developed knowledge and technologies from BIOTEC. During 2003-2005, a team of BIOTEC researchers worked as technology consultants in the firm. Subsequently, a three-year collaborative project was organised during 2005-2008 following on from the successful consultancy project. This collaborative project included bioremediation of the salinity land and the development of specific rice strains and its cultivation on the recovery land. The research on plant biotechnology focused on the development of economic plant such as rice strain has long been one of the significant research agendas of BIOTEC.

For BIOTEC, the project was considered to increase the scope and depth of existing knowledge of the research team. Following on from the accomplishment of this project, BIOTEC received a research grant from a large-sized firm to conduct a similar project on a land coving 40 acres. Based on the developed knowledge and technologies, the new project will collect geological data, and perform a cost analysis as well as screening for appropriate salt-tolerant crops such as rice and eucalyptus for local farmers to cultivate.

Box 7.4 Development of production process for commercially pure titanium and titanium alloy Ti-6Al-4V for automotive industry (Case 12)

This project was an R&D collaboration between MTEC and a Japanese manufacturer of metal parts for various industries. The firm had headquarters and manufacturing plants both in Japan and Thailand.

In 2004, the Metal Injection Moulding (MIM) Laboratory of MTEC received technology transfer from the Japanese MIM Association. This technology transfer project included both transfer of MIM equipments and technology, which have made the MTEC MIM laboratory the first and still the only laboratory with pilot plant facilities specialising in MIM technology in Thailand. The research activities of this laboratory focused extensively on new process development using MIM application.

With the referral from Japanese MIM Association, in 2006 a collaborative project between the MTEC MIM laboratory and a Japanese MIM part producer operating in Thailand was organised to optimise MIM process for pure titanium and titanium alloy Ti-6Al-4V. In early 2007, the firm became the second company in Asia that could manufacture commercially pure titanium parts using MIM. The first project was followed by two collaborative projects; one during 2007-2008 to develop the production process of titanium alloy Ti-6Al-4V, and the other during 2008-2009 to commercially manufacture it. The continuing collaborations enabled the researchers to work closely with industry. Specially, there was mobility of MTEC researcher to work in the production plant of the firm in Thailand for two years during the second collaborative project.

The continuous collaborations with this firm have become one of the core research activities of the MTEC MIM lab. Moreover, the knowledge from these projects help the research team of MTEC to apply MIM technology to other industries, such as manufacturing medical implants, jewellery, and golf putter heads.
Box 7.5 Development of electronic nose for food industry (Case 18)

This was a project between Nanoelectronics and MEMS Laboratory of NECTEC and a local small vineyard.

In this context, a research team from the three research centres (NECTEC, MTEC, and NANOTEC) and a university developed a joint research project on e-nose, a technology that imitates the abilities of the human nose to detect and recognise odours, for application in the agro-food business. In extension of the joint research project, NECTEC introduced a prototype of e-nose and discussed with the vineyard for the collaborative R&D project to test the prototype and develop a commercial e-nose to check the quality of wine. After the prototype had been successfully developed and implemented with the vineyard, NECTEC subsequently applied the e-nose technology to other pre-harvest and post-harvest purposes, for instance, food such as meat, vegetable, fish, rice grains and coffee beans.

The collaboration with the vineyard was viewed as a channel for industrial implementation of the research results, testing commercial applicability of prototypes, and completing the innovation chain. Following from the e-nose project, NECTEC and the vineyard have started a pilot project for applications of precision farming concept, which uses technology including sensors, information, communications technology to help run farms better. The precision farming project is one of the flagship projects of NECTEC to develop precision agriculture and the ability to forecast agricultural planning in order to increase the competency of the Thai agricultural sector.

7.4.5 Category IV: Strategic R&D collaborations

Three cases of R&D collaboration (Case 7, 8, and 9 from BIOTEC) from this study fit into the category of strategic R&D collaborations. In this situation, firms and the research centres tend to work closely together to develop new knowledge and technologies that increase the competitive advantage of the firms and enhance industrial research capabilities of the research centre. These collaborative projects incorporate research that support the core research agendas of the research centres, with a focus on creating new knowledge. The strategic R&D collaborative projects differ from the other collaboration categories in that they focus on applied research for innovations that support the development of new products or processes rather than the direct application of technologies in immediate products or processes of the partner firms. The projects in this category are the most complicated type of project among the four project categories.

It involves research-intensive work, rather than industrial implementation of developed knowledge and technology. Therefore, the nature and outcome of the projects are less tangible when compared with the projects that fit in the integrative R&D collaboration. The development stage of knowledge involved is to some extent at the developing
stage. The results of these projects require future research before commercialisation of
the new products can emerge. The projects in this category are large and long-term
R&D collaborations. The researchers see that although working together with firms in
strategic R&D collaborative project is an extension of their daily work, the project
complements their research agendas.

From the interviews, the researchers participating in these projects indicated that they
considered firms as equal partner in terms of division of labour and knowledge
exchange. Thus, it could be said that the knowledge gap between the partners is low,
allowing the bilateral transfer of new knowledge generated from the collaboration. This
is because the firms collaborating in these projects are large international firms that
have extensive internal R&D knowledge capability related to the research activities in
the collaborative projects. The mutual benefits from the projects lie in scientific
discovery and innovation development. In addition, the researchers also indicated that
by working with large international firms, they can benefit from knowledge spillover,
trainings and exchanges of research personnel. Working with leading international
firms helps enhance the technological capabilities and industrial skills of the
researchers.

Furthermore, it is evident that the three projects in this category are part of activities
under the joint research agreement between the research centres and the large
international firms established at organisational level. Top management of the research
centres play an important role in the formulation of R&D collaborative projects and in
facilitating regular contact at both organisational and inter-personnel levels. The
organisational tie between the partners is the strongest one amongst the four categories
of collaboration. However, inter-personnel ties between the researchers are
considerably less than in interactive R&D collaborations. Moreover, the strategic R&D
collaboration relationships often involve co-ownership of patents. Box 7.6 illustrates
and example of strategic R&D collaboration.
**Box 7.6 Extraction of Thai plant derived for cosmetics products (Case 7)**

This project was a three-year collaborative project, organised under a joint research agreement between BIOTEC and a leading Japanese cosmetics manufacturer. The joint research agreement commenced in 2004 and their first collaborative project was established in 2005.

The aim of this project was to conduct an in-depth study of plant extracts that could potentially be used as cosmetic ingredients. Specifically, the partner firm was interested in developing one herb for skin care formulations, particularly those with whitening and anti-ageing properties. The research activities were carried out by leveraging respective chemical techniques of the research partners to seek possibilities to develop innovative cosmetics. BIOTEC specialised particularly on a broad technological range of biotechnology, but possessed inadequate knowledge and information in industrial applications and development of biotechnology. Even though the partner firm was very active in the cosmetic industry, its knowledge relating to biotechnological applications for their products was limited. The research partners benefitted from sharing methodologies and technology spillover during the project.

The collaborative efforts identified potential activities in in-vitro tests in six plant species. Accordingly, in June 2008, the research partners jointly applied for a patent in Japan and Thailand on potential activities of certain plant extracts. The success of the first collaborative project and the joint patent acted as a catalyst for further research development of cosmetic ingredients and skin care products in the second collaborative project.

### 7.4.6 Discussion

Findings suggest that three categories of R&D collaboration (i.e. interactive, exploitative, and explorative) to some extent represent a linear view of knowledge transfer. In this regard, the knowledge generated from a collaborative project is disseminated from research centre to firm, assimilated into a firm’s new or improved products and/or processes. In other words, this is the case where partner firms absorb knowledge from the collaborative projects and then apply it. This form of innovation is rather the ‘one-way bridge’ from public research to industrial research (Meyer-Krahmer and Schmoch, 1998), and represents the linear view of innovation which consists of research being transferred from public organisations to firms for further development (Phillimore, 1999).

The findings also put forward that the strategic R&D collaboration shows a dynamic knowledge transfer, in which the research centre and firm mutually disseminate and assimilate the new generated knowledge into their research practices. In this aspect,
there is non-unidirectional flow of knowledge between firms and research centres during their collaborative projects. Knowledge transfer between research partners requires collective learning based on close interactions between knowledge generation and knowledge application (Wang and Lu, 2007). Knowledge transfer is also considered as a multi-staged process, consisting of knowledge creation, knowledge acquisition, and knowledge integration (Santoro and Gopalakrishnan, 2000). These activities are not sequential; rather they occur simultaneously. Nevertheless, firms may or may not require further collaboration with research centre to commercially exploit the new generated knowledge, whilst research centres can employ the new generated knowledge for further applications and advanced research agendas.

Furthermore, findings highlight the important role of knowledge gap, technological capability and technological relatedness as important factors that influence the implementation of R&D collaborative projects between firms and research centres. These factors are discussed in the following section.

### 7.5 Factors influencing R&D collaboration

The three previous sections (section 7.2, 7.3, and 7.4) have presented the findings and analysis based on an analysis framework constructed to examine interactions between firms and research centres in relation to their R&D collaboration with an attempt to provide thorough understandings about R&D collaborations between the research centres and partner firms in the Thai context. In this section, we analyse factors influencing interaction in R&D collaborations between the research centres and firms in this study. Based on the fact that inter-organisation relationships involve partners from different organisations who are bounded by different culture and practices, these differing settings contribute to factors influencing public-private interaction. In this aspect, four groups of influencing factor are discussed in this section: technological factors, cultural factors, organisational factors, and institutional factors. The section discusses these influencing factors in light of the empirical findings and interpretation.
7.5.1 Technological factors

7.5.1.1 Knowledge gap

The findings clearly indicate that the level of knowledge gap between the research partners affects the way in which R&D collaborative projects are structured and processed. In the interactive and strategic R&D collaborations, it is evident that the research partners are interdependent. The interdependency is in the sense that firms have extensive industrial knowledge, while the research centres are competent in technological knowledge related to the collaborative project. Their collaboration is driven by the fact that the level of knowledge gap between the research partners allows the knowledge generated during the project to be disseminated and exploited. In the interactive R&D collaboration, firms are able to commercially use the applications of technology developed, while the research centres are able to confirm industrial applicability of their research results and adapt the industrial knowledge gained for further research. In the strategic R&D collaboration, firms and the research centres are at the frontier of industrial and academic knowledge. The flow of new knowledge generated enables them to act as mutual research partners in further research partnerships.

On the contrary, it is apparent in the cases of exploitative and explorative R&D collaborations that the level of knowledge gap between the research centres and firms are rather large. Knowledge transfer in these two categories of R&D collaboration therefore is considerably limited. These findings support the study of Wang and Lu (2005) in that the transfer of knowledge is associated with the knowledge gap. The knowledge gaps determine the structure and process of their R&D collaboration and influence the success of the project. Recognising the knowledge gap between the research partners helps to understand the knowledge required during the collaborative project and the roles played by each research partners (Lockett et al., 2005).
7.5.1.2 Technological capability

Findings from the four categories of R&D collaboration also suggest that firms’ technological capability enable firms to assimilate new knowledge generated from the collaborative project more effectively. Comparing firms in the interactive R&D collaboration with the ones in the exploitative R&D collaboration, it is evident that the firms in the former collaborative type are able to better understand and use the knowledge transferred from the R&D collaborative project to develop or refine the products or processes than the firms in the latter collaborative category. This is explained by the fact that firms have accumulated technological capability through their internal R&D efforts, while firms in the latter collaborative category have not. The extent of the firm’s internal R&D activities is an indication of technological capability. The findings about the significance of technological capability on the effectiveness of R&D collaboration concur with Santoro and Bierly (2006) in that technological capability is a significant facilitator of knowledge transfer.

7.5.1.3 Technological relatedness

The findings also suggest that technological relatedness of the research partners determine the structure and process of the R&D collaboration. The evidence indicates that the partner firms in the case of explorative R&D collaboration are less competent in incorporating new knowledge from the collaborative project into practice. A possible explanation is that the level of technological overlap between firms and research centres in relation to R&D collaborative project is marginal. As a result, it hinders firm from applying external knowledge to develop or refine their products and processes. The finding about the effects of technological relatedness is consistent with the study by Bierly et al. (2009) which concludes that technological relatedness has a strong association with a firm’s external knowledge application. In this respect, technological overlap between the research partners influences knowledge transfer and application in the R&D collaborative projects.
7.5.2 Operational factors

7.5.2.1 Project management

From the interview data, the influencing factors relating to project management are evident in a different way with respect to perspectives of firms and that of research centres. With regards to firms, especially the small firms, the common issue concerning project management are inefficient planning, organising research tasks, and managing resources. One of the researchers who worked with a small mould-making firm to improve manufacturing process of automotive parts indicated that research activities were interrupted because of unplanned orders from customers during the period of the R&D project. In effect, this slowed down performance of the project.

“We wanted to test efficiency of the production line that use the mould produced by 3D scanning technology. But due to the fact that the firm did not set a separate section in production line for the R&D project to experiment the new manufacturing process. They simply implemented it in the production line that they mainly use to produce the parts for their customers. When ad-hoc order emerged, ongoing experiments to collect technical information had to stop. The production line was switched back to use the conventional technique in order to produce the parts in time. The technical data collected was inadequate for research purposes and we had to start the experimental procedure again from the beginning.” 44

In addition, it appears that the factors associated with project management with large firms differ from SMEs to some extent. While SMEs seem to be more flexible to deal with and less bureaucratic, large firms require more protocols for the negotiation process and approval which sometimes make it difficult to start the project and get work done during the project implementation. However, the researchers indicated that working with medium and large firm was better than small firms in terms of more organised and structured work in the former.

In relation to the research centres, researchers revealed that coordination of supportive activities relating to initiating and administering collaborative projects with industry were somewhat inadequate and inefficient. Starting from the initial negotiation for R&D

44 Interview with MTEC researcher, Near-net-shape Metal Forming Technology Laboratory, 4 August 2008
collaboration, in many cases the researchers had to get involved in detailed negotiation about intellectual property rights (IPRs) of the results of the collaborative project. They pointed out that particular issues regarding IPRs and related concerns were beyond their knowledge and expertise. The researchers considered that it would be much more helpful if they could concentrate on the aspects of research activities and have a team of liaison people and patent engineers who can get involved at the beginning of the project.

Furthermore, the researchers cited that the approval process for R&D collaborative projects with industry often takes too long, especially in considering contract details. In many projects, research activities have to start before the project is officially approved. As the researchers and firms are ready to begin their work, waiting further for the paperwork may affect their timetable as well as work plan and other planned schedule. Additionally, it was revealed that researchers wished to have more support from the liaison person to help them find the right collaborative partners and match the needs of industry with the expertise of researchers. This is because sometimes industry is not aware of what the researchers do and their expertise is in, while the researchers themselves, especially young researchers, are not so experienced in looking out for collaborative projects with firms.

7.5.2.2 Commitment and contribution

Another issue that was raised when working with small-sized firms is firm commitment. Evidence showed that the factors related to firm commitment experienced by the researchers is discontinuity of personnel. This raises concerns in the progress of the project and possible further collaboration, as well as dedicated personnel of the firm to responsible for research work and coordinate with the researchers. The following quotes expressed the experience of the researchers in these two aspects.
“We worked closely with the firm owner himself at the beginning of the project. We met on a weekly basis to keep up with the work plan. But later on he was less motivated about the research project due to internal problems within the firm. We had to keep following him up to finish the project as planned.”  

“The plant manager was the key person coordinating with us. After the project was finished, we discussed possibility of the second phase of the collaboration with the firm. But it was not realised as the plant manager resigned, we lost our coordinating person who can communicate and defend the research idea within the firm. The firm owner was already happy that they are able to implement the results of the first project in its manufacturing lines, and need no further R&D project”.  

Considering contribution of the partners, in most case it is evident that firms tend to play supporting roles in providing material support, industrial specifications, and industrial knowledge. Field experiment and data collection are conducted by firms with supervision of the researchers. The researchers play an active role in the research projects. Regarding the division of labour, some researchers indicated that they covered about 70-80% of the research work and firms were responsible for the rest. In one case, the researcher revealed that the partner firm only provided matching funds for the project with little indication that they intended to take an active role in the research itself. This firm got involved in the project to benefit from the research findings.

The evidence concerning firm contribution coincides with the findings of Barnes et al. (2002) that firms tend to rely on the researchers to do the majority of the work in collaborative R&D projects as they perceive their counterpart as the experts. Generally, the R&D collaborative projects are financed by matching funds from the researcher centres and participating firms. In most cases, the project cost is shared equally between the two partners. However, the centres and firms may absorb some research expenses in kind (such as operating cost of researchers, materials and testing) and contribute the rest of their proportions in cash. The participating firm transfers fund to the research centre at the beginning of the project. The total research fund for the project is managed by the R&D administrative unit within the research centre.

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45 Interview with MTEC researcher, Plastic Technology Laboratory, 4 August 2008  
46 Interview with MTEC researcher, Automotive and Alternative Fuel Laboratory, 15 August 2008
7.5.3 Institutional factors

In this section, institutional factors has been analysed into four detailed issues: R&D management and financing system; strategic direction for R&D collaboration; intellectual property management; and incentive and performance evaluation for the researchers working with industry. These issues are discussed as follows.

7.5.3.1 R&D management and financing system

Generally, R&D collaborative projects are financed by matching funds from the researcher centres and participating firms. In most cases, the project cost is shared equally between the two partners. However, the centres and firms may absorb some research expenses in kind (such as operating cost of researchers, materials and testing) and contribute the rest of their proportion in cash. The participating firm transfers fund to the research centre at the beginning of the project. The total research fund for the project is managed by the R&D administrative unit within the research centre.

Additionally, the interviews revealed that the researchers contended that policies and regulation for R&D management and financing system were designed more for in-house R&D projects and R&D collaborative projects with academic institutes than for the ones with industry. They also expressed that dedicated policy and administration that differed for the ones for in-house projects and those for collaborative projects with academic institutes would help facilitate research collaborative projects between the research centre and industry.

Furthermore, it was remarked by many researchers that the process of R&D administration, particularly drafting research contract or agreement and project approval, is fairly time-consuming and does not quite correspond to the pace of working with industry. It is often that the project implementation has to start before the paperwork has been officially approved. Additionally, the researchers expressed that the official procedure to get funding for collaborative project after the SPA policy had changed NSTDA R&D management from project-based to programme-based management is neither easy nor supportive. Owing to SPA policy, each R&D project has
to fit into a one of the research programmes. At the end of the fiscal year, each research programme will call for project proposals for the next year. The R&D projects will then be allocated its research budget from the programme accordingly. This is somewhat a constraint for researchers working with industry. A researcher stated:

“For us to have collaborative project with industry, it is not always possible to develop a proposal and submit it to related research programme within the timeline set by the R&D management office in each fiscal year. In general, most of the collaborative projects with industry occur randomly during the year. Therefore, it is somewhat problematic for us to meet the deadlines of call for proposal of the research programme. Even though it is always possible to submit the proposal for R&D collaboration at any time during the year, the projects that come after the research budget have been allocated would experience some complexities in the administrative procedure. These impede the R&D collaborative projects.”

Another researcher also asserted in similar vein that:

“I think somehow our R&D management system for collaborative project with industry, particularly in terms of budgeting and timing, are problematic. Projects emerge during the fiscal year experience intricacies of submitting the projects to be part of research programme and to arrange for funding management of the project. The research programme management needs to re-allocate resource of the programme and sort out their research budget to fund these emerging projects. This adds extra procedure to the approval steps … R&D management system needs to be more flexible to deal with industry. We should be able to move faster when working with industry. So, I believe that quick and effective responses to the need of industry are really necessary.”

7.5.3.2 Strategies for R&D collaboration

The SPA initiative has set clear targets regarding industry focus of each research programme (as described in Chapter 2). From the perspective of the researchers, while this initiative provides better direction for in-house research projects, the direction for R&D collaboration with industry is to some extent still ambiguous. In short, they view the policies and practices as somewhat contradictory. A researcher commented that the way in which R&D collaboration with industry is organised is predominantly on a case-by-case basis and depends largely upon the enquiries of industry. In addition, he stated that in most of the cases the research centres and researchers take a rather passive role

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47 Interview with MTEC researcher, Near-net-shape Metal Forming Technology Laboratory, 4 August 2008
48 Interview with NECTEC researcher, Human Language Technology Laboratory, 7 August 2008
in looking out for industrial research partners. As a consequence, the collaborative projects with firms can only provide trivial benefits and impacts to target industry of the research programme. He further elaborated that:

**Collaborative projects with industry are technically different from in-house projects. We have to be more proactive in working with them (the industry). We can’t just wait for the projects to come to us. We need to find the right partner firms and build up research network with them. However, to proficiently doing that we need to be more specific in terms of the area of collaborative projects. We need some sort of strategic approach for R&D collaborative projects.**

In addition, another researcher commented that the R&D collaboration with industry at the research centres is carried out in a linear process approach, that is, technology is developed primarily by research centre and then transferred to the private sector. He stated that R&D collaboration with industry can be facilitated by increasing the involvement of firms at an early stage of technological development. In doing so, it is believed to increase the efficiency of the research work and public-private cooperation.

Moreover, a researcher illustrated that the combination of bottom-up and top-down approaches would help to set specific courses of the R&D collaboration with industry and drive researchers to eagerly collaborate with industry. In this respect, “the bottom-up approach” is collaborative strategy in which research collaboration is initiated from the ideas of researchers/research laboratories or even from individual firms. In contrast, the “top-down approach” is a collaborative strategy in which research collaboration originates from holistically consideration of the needs of industry and internal capability and subsequently formulates research collaboration between the research centre and industry. An illustrative comment by a researcher was:

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49 Interview with MTEC researcher, Automatic System and Mechatronics Laboratory, 17 September 2008
I believe that it is less effective if the R&D collaboration is taken case by case by the researchers. The research collaboration that combine top-down and bottom-up approach is needed. As sometimes researchers are not capable to make decision to involve in the deal concerning taking both bottom-up and top-down approach to consider key expertise of lab and main objective of the research programme and match this with industry need by including industry into research plan at the earlier stage than what we are now doing.\textsuperscript{50}

This researcher also stated that research programmes should have a technology roadmap of R&D collaborative project with industry. In this aspect, integrating the expertise of researchers and key research areas of the laboratory with the objectives of research programme and the needs of industry is believed to facilitate public-private research cooperation. In this way, the research centre can effectively exploit their research results and technology in full.

7.5.3.3 Intellectual property rights management

According to the interviews, intellectual property rights is one of the considering issues during the arrangement for R&D collaboration with industry. The factors that influence collaboration with industry regarding intellectual property rights include disagreement between the potential partners in some aspects, e.g. ownership of the research results, secrecy of the knowledge, and benefit sharing. A researcher elaborated that in general firms want exclusive rights on the results of the collaborative research, whereas the research centres prefer non-exclusive rights over the research results, so that they can be further exploited in other research activities and with other industries\textsuperscript{51}. In this regard, another researcher pointed out that it is possible to give exclusive rights to the partner firms for certain period of time and the researcher centres should agree not to disclose or license the technology to their competitors\textsuperscript{52}. However, the researchers view that there should be no limitation for them to exploit the results for research purposes.

\textsuperscript{50} Interview with NECTEC researcher, Human Language Technology Laboratory, 7 August 2008
\textsuperscript{51} Ibid.
\textsuperscript{52} Interview with MTEC researcher, Near-net-shape Metal Forming Technology Laboratory, 4 August 2008
There was also a concern that although NSTDA has set specific regulations for IPR management, this is not a one-size-fits-all policy\textsuperscript{53}. According to NSTDA IPR Regulation, the filing of patent applications has to be processed through NSTDA, via the Technology Licensing Office (TLO). The application will be under the name of NSTDA. In the patent application, the researchers are referred to as inventors, while NSTDA and the partner firm are patent co-holders. The cost for filing the application will be agreed between NSTDA and the partner firm on a case–by-case basis. With respect to profit sharing of the granted patent, it is stated in the regulation that inventors receive between 40 to 80 per cent of the profit, while the rest is allocated to NSTDA and firms. These details stated in the regulation sometimes diminish the establishment of research collaboration with industry. In some cases the firm want to hold the exclusive rights over the patent and is reluctant to collaborate knowing that they are not the sole patent holder.

7.5.3.4 Performance evaluation and incentive

Performance evaluation and incentives for the researcher being involved in research collaboration with industry is a controversial issue among the researchers. In this regard, interviews revealed three main concerns. Firstly using Key Performance Index (KPI) as a performance evaluation tool; secondly, the reward system for collaborating with industry; and lastly, the researcher’s career path and development.

(a) Using Key Performance Index (KPI) as performance evaluation tool

Following implementation of the SPA initiative in 2004, NSTDA and its national research centres restructured their organisation management and applied the Balance Scorecard (BSC) Model to translate strategy into measurable action. In this regard, the Key Performance Index (KPI) is set up to align with NSTDA’s vision and mission (Wonglimpiyarat, 2006). These attempts are planned to promote research cooperation between national research centres, academic institutes, and industries to overcome the inflexibility of NSTDA’s innovation management system.

\textsuperscript{53} Ibid
However, implementation of the policy does not encourage R&D collaboration between the research centres and firms to a certain extent. A researcher revealed that having KPI agreed beforehand at the beginning of each fiscal year in some way limited the contribution of researchers in the collaborative projects with industry\(^\text{54}\). This is because researchers may contribute only to meet their KPI. Going beyond what has been stated in their KPI, such as having additional work for collaborative projects with industry as they see would provide economic and/or non-economic benefits to research partners, may affect the overall performance of their laboratories and the Individual Action and Development Plan (IADP) of each researcher. In this aspect, it has been also mentioned that KPI are good in the sense that organisation goals are clear and measureable. On the other hand, it makes it less flexible for the researchers to work with industry\(^\text{55}\).

Moreover, regarding the SPA initiative although researchers agree that SPA allows flexibilities for laboratories to work together, a researcher quoted that collaboration between laboratories is problematic in terms of performance reporting\(^\text{56}\). It is typical to have one project carried out by one laboratory. But when two laboratories jointly work together in a project and have one deliverable, such as a research prototype for industry, the prototype is recorded as an output of one laboratory only. It is not likely the case that two laboratories report for the same deliverable in their KPI. They have to agree in advance what each partner will claim for their performance. This is one of the considering issues for researchers from different laboratories when they work together in a research project.

\textbf{(b) Reward system for collaborating with industry}

According to NSTDA’s regulation for staff promotion\(^\text{57}\), collaborative research with industry is given 40 points per one million Baht (approximately £ 16,500) of matching funds from industry, while having publication in international journal counts for 50 points per article. In addition, an innovation that is being commercialised or used as a

\(^{54}\) Interview with MTEC researcher, Plastic Technology Laboratory, 4 August 2008

\(^{55}\) Interview with NECTEC researcher, Human Language Technology Laboratory, 7 August 2008

\(^{56}\) Ibid.

\(^{57}\) NSTDA Handbook for Staff Performance Evaluation (2008)
public good is given 50 points for local exploitation, and 100 points internationally\(^{58}\). In this regard, it was mentioned that collaborative projects with industry are valued in terms of project investment from industry, not in terms of return on investment or economic impact of the project.

There is possibility that some projects with smaller investment from industry may contribute greater benefits than the larger ones. As such, it is said to be inequitable to justify the collaborative project in this way. Researchers who are keen on conducting collaborative research with industry revealed that the incentive and reward system for collaborative projects with industry by some means do not provide influential incentive over conducting in-house research and collaborative research with academic institutes\(^{59}\).

Furthermore, it has been cited that organising and conducting R&D collaborative projects with industry is considerably much more complicated than planning and conducting in-house research projects or collaborative projects with academic institutes\(^{60}\). For in-house research projects, researchers have more control over the project, more room to present the research results, less restriction on publication, and less time constraints. For these reasons, collaborative research with industry is to some extent less attractive to some researchers. This finding is in line with Howell (1998) in that inadequate incentives structure for researchers to work with industry puts pressure on researchers to consider publication-oriented activities and hence crowds out the time to develop industrial links.

\(c\) Career development of researcher

According to the interviews, it was mentioned that NSTDA and the research centres should consider different career development for researchers. That is, researchers specialising in downstream research and that prefer working closely with technology

\(^{58}\) Ibid.
\(^{59}\) Interview with MTEC researcher, Near-net-shape Metal Forming Technology Laboratory, 4 August 2008 and NECTEC researchers, Human Language Technology Laboratory, 7 August 2008
\(^{60}\) Interview with BIOTEC researcher, Animal Physiology Laboratory, 5 August 2008
users should be encouraged to progress as ‘industrial researchers’ or ‘technologists’61. Therefore, this argument supports the concern of having different performance evaluation for researcher working with industry as mentioned in previous sub-section (section 7.5.3.4(C)). In addition, a researcher supported that there should be specific career development plans for the researchers concentrating on collaborative research with industry.62 Apart from being excellent in their research arena, they should be able to understand the business sector and professionally communicate between the business and research arenas to work with industry. Typically, researchers and businessmen often speak in different languages. Therefore, to work effectively with industry researchers need to build up other skills apart from their research excellent.

7.5.4 Cultural factors

Fundamentally, the missions of research organisations and industry are different in that the former is knowledge-driven, while the latter is driven by profit. With reference to R&D collaborations, the two partners perceive research activities differently. Research organisations focus on producing scientific results that advance their knowledge and reputation. On the other hand, industry needs immediate products or process that can provide economic benefits in the most efficient time and cost. However, high-technology firms may behave in a different way contrasting to low-technology counterparts when collaborating with research organisations. According to the basis of divergent missions of research organisations and industry that underlies the cultural factors of the research partners in R&D collaborative projects. The study presents some findings regarding the cultural factors with respect to attitudes toward research activities, as well as time and pace in practices.

7.5.4.1 Attitudes towards research activities

The different attitudes towards research activities between firms and researchers are common issues found across the cases in this study, though the significance of the

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61 Interview with MTEC researcher, Near-net-shape Metal Forming Technology Laboratory, 4 August 2008
62 Interview with BIOTEC researcher, Plant Physiology and Biochemistry Laboratory, 6 August 2008
problems vary from case to case. The fundamental basis underlying the different attitudes towards research activities of public and private sector is the differing conditions and environments they are associated with. The evidence from the interviews suggests that researchers conduct research activities with the aim to achieve specific research objectives. For example, to publish research results in academic journals, to gain empirical data from industrial implementation of research results, to enhance industrial integration skills, and to build on further development in specific areas, and to meet performance evaluation criteria of the organisation.

On the contrary, firms engage in R&D collaborative project with a much narrower scope, e.g. imperative problem-solving, improvement of existing or new products and/or processes, and research on specific applications of technology. Firms tend to look for short-term benefits from the most efficient results with the lowest possible cost and in the shortest time, while researchers aim to build long-term competencies and seek the most efficient results for academic purpose and publications. Moreover, it is apparent in several cases that firms do not quite understand that a research project does not complete by itself; a series of development projects are needed to achieve successful process or marketable product. The following quotes demonstrate the concerns about diverge attitudes of the research partners.

“We are aware that when we work with industry we cannot set up negative treatments which result in lower productivity. There is still disagreement between our team and the firm in detailed project plans when we try to perform three treatments that we expect three different positive results, in order to confirm the best options. The firm considers it otherwise and say why you don’t just do what you think is the best one when you already have some ideas about the other two.” 63

“In the project that we worked with the firm to find optimum conditions for producing commercially pure titanium alloy, we tried to study several variables and factors in order to learn their significance and differences in order to gain knowledge for publication. But this was not what our partner looks for. They want the results that they can immediately use.” 64

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63 Interview with BIOTEC researcher, Animal Physiology Laboratory, 5 August 2008
64 Interview with MTEC researcher, Near-net-shape Metal Forming Technology Laboratory, 4 August 2008
“I think we are more interested in academic benefits from the research results. But firms want practical results that they can really use. This is always the conflict in the collaborative project. … Although working with industry is now being recognised as one of the KPI of the NSTDA researchers, but performance evaluation is only one thing. We have to keep up with the academic field. We can’t just work with industry and fulfil their requirement without considering about knowledge contribution.”  

7.5.4.2 Time orientations

From the interviews, one of the issues related to time in the R&D collaborative projects is the difference on how firms and researchers think about time in terms of meeting research objectives and other constraints. Firms expect results in the shortest time possible, while researchers have to manage time for collaborative projects with industry with other research projects they have in-house and projects with other research organisations. Because of the multidisciplinary work of the researchers, duration of collaborative projects with industry may take longer than expected. Consider an example, a researcher revealed that one of his projects could have been completed in three months if he was to work on the project full-time, but he inevitably had to spread it over six months time. Eventually, it took almost a year to complete the project due to interruption of ad-hoc tasks and time constraints from other projects. Another time-related issue is mismatch in time between firms and the researchers. This is crucial especially in situations where the partners are more dependence and building on each other to achieve research results. A researcher expressed her concern in this issue as follows:

“We screen specific enzymes from our collections and test whether they work as expected in lab-scale. Then, we handed them over to the firm to scale-up the experiment in their production plant. … Since this project is extra to us, we experienced problems with queuing for testing equipment in our lab. This is one of the problems on our side. When we asked the firm to test it in their plant, it took quite a while for them to give us feedback because they were working on their normal routine. We felt that it is difficult to manage the timeline in collaborative project when things are beyond our control.”

65 Interview with NECTEC researcher, Nano-electronic and MEMs Laboratory, 18 August 2008
66 Interview with BIOTEC researcher, Enzyme Technology Laboratory, 7 August 2008
7.5.5 Discussion

Findings highlight four groups of factors that influence the interaction of research centres and firms in this study and underline the importance of technological factors which include knowledge gap, technological capability, and technological relatedness, as determinant of the interaction and nature of R&D collaboration between research centre and firms. There are certainly different knowledge bases between the researcher centres and firms. It is firms’ technological capabilities that determine how the partners interact during the project. The findings also point out to the importance of the level of technological relatedness between research partners in the success implementation R&D collaboration.

In relation to institutional, operational, and cultural factors, it is rather complicated to identify which factor is the most important one for the research collaboration between the research centres and the partner firms in this study. This is because of these factors are linked and influence one another, especially the ones related to operational factors and institutional factors. However, the cultural factors are the common issues found in most public-private research partnerships. It is conspicuous that attitudes of researchers and firms toward R&D collaboration are different. These divergences stem from the fact that research organisations and firms have different points of departure (Kalpazidou Schmidt, 2008), i.e. research organisations are driven by curiosity while the bottom line for firms is economic benefits and returns. The findings about cultural factors impeding R&D collaboration between researchers and firms are in line with Schmidt (2008), which illustrate that the normative component of the research collaboration is considered as a significant factor to a more effective collaboration. As stated (in section 4.2.3.5), cultural differences are common influencing factors for research partnerships. Findings on the operational and institutional factors provide useful empirical evidence for the improvement of NSTDA R&D management, in particular how to manage research collaboration between the research centres and industrial partners.
7.6 Conclusion

This chapter has presented findings and analysis from the study of R&D collaborative projects between research centres and firms, in connection with an analysis framework constructed in Chapter 3. The analysis highlights a number of key findings.

Firstly, this study presents a typology of R&D collaborative projects developed to recognise the nature of R&D collaboration and the factors that influence the interactions of the research partners. The four categories of R&D collaborative projects (i.e. exploitative, explorative, integrative, and strategic) are drawn from two aspects – knowledge involved in the project and the coherence of collaborative projects with research focus of the research centres - constituting a typology of R&D collaborative project of the research centres. Exploitative R&D collaborative project is short-term and problem-solving project type in which research centres merely utilize existing knowledge to address specific problems of the partner firms. However, most of the research activities are performed by research centres due to firms’ limited absorptive capacity. Interactive R&D collaborative project involves industrial implementation of existing knowledge of research centres and requires feedback loop between research partners to develop and/or refine new products and processes. Most of the R&D collaboration studied is in this project type. Explorative R&D collaborative involves part of existing knowledge and the need of new knowledge to develop a successful collaboration. By project characteristic, this project type should promote knowledge production and innovation. However, this is not the case for the sampling projects being studied due to low level of technological overlap between research partners. Strategic R&D collaborative, on the other hand, involves long-term research partnership for the production of new knowledge through collaborative efforts of the research partners. This type is said to be the favourable R&D collaboration as it involves dynamic exchange of knowledge between research partners. This is because the project provides opportunity for firm and researcher to learn from each other and share their experience; while one is expert in industrial practice and the other is keen in academic frontier.
Secondly, the characteristics of R&D collaboration between research centres and firms indicate that the predominant research partners with BIOTEC, MTEC, and NECTECE are the agro-business firms, the automotive firms, and the IT firms respectively. However, the specific/clear direction regarding which particular technological applications the research centres intend to collaborate on with firms is absence. Most of the projects with firms are thus organised based on a case by case basis to apply technological knowledge already developed at the research centre to firms. Furthermore, it is evident that the partner firms, especially SMEs, have not paid much interest in developing long-term technological capability. As such, the effectiveness of R&D collaboration is hindered by firm’s absorptive capacity and their knowledge bases. Therefore, it could be contended that R&D collaboration between research centres and firms are in linear fashion rather feedback loop collaboration with interactive learning between partners.

The study also suggests that the significant antecedent of R&D collaborations between the research centres and firms is their partnership experience through consultancy work, contract and collaborative research, joint research agreement and previous R&D collaborative projects. The finding in terms of numbers indicates that about half of the collaborative projects studied originated from informal interaction (such as interpersonal contact). In these projects, firms had no past experience partnering with research centres. As a consequent, knowledge transfer process between the partners has been moderately complicated. On the other hand, the collaborative projects in which firms with past experience of partnering with research centres are more successful in their knowledge transfer process. These firms have established trust and social connectedness with research centres over time. Trust and social connectedness are important facilitators of tacit knowledge transfer. It is therefore could be argued that encouraging firms and research centres to associate in R&D-related activities helps promote their collaborative efforts and facilitate the transfer of tacit knowledge.

Thirdly, the motives of the research centres behind R&D collaboration with firms are primarily driven by technological reasons and strategic reasons. The finding reflects that
private sector is not considered as a significant financial resource for R&D funding for the research centres. This is because the number of in-house research projects in 2008 accounted for over 50% of the total projects carried out by the research centres. The collaborative projects with industry were a very small proportion of about 0.05%, ten times less than the in-house research. Although the government budget for public organisations has been increasing cut, there is modest financial constrain at the research centres. In addition, notwithstanding that NSTDA has recently started to use a strategic management performance tool (i.e. key performance indicator, KPI). Contract research and collaborative research with industry have increasing received greater attention from individual researchers and the research centres. However, there is significant improvement in terms of increasing numbers of contract research (as presented in Figure 2.6), but not yet for the collaborative projects.

By and large, most researchers put greater emphasis on in-house research than collaborative and contract research. The mind-set of researchers is worth considering; the attitude of researchers towards working with industry is a significant factor in influencing the likelihood of R&D collaboration and how researchers prioritise public-private research partnership in their research routine. This underlies the extent and intensity of interaction between firms and research centres as well as the characteristic of their interaction. The more researchers place emphasis on partnering with industry, the greater the dynamic of the collaboration is. Hence, a greater extent and intensity of their interaction is expected. The dynamics of an R&D collaborative project also depends on the behaviour of the firm in the project, i.e. as an active or passive partner. This characteristic of behaviour also reflects the level of the firm’s technological capability and relatedness as well as the firm’s knowledge bases.

Fourthly, the study also suggests several factors influencing R&D collaboration between research centres and firms. These include technological factors, operational factors, institutional factors, and cultural factors. The most significant one is technological factors which determine the nature of R&D collaboration. These factors include knowledge gap between partners, firms’ technological capability, and technological
relatedness. Each of these factors reflects on the behaviour of firms and their involvement in the project. The institutional and operational factors highlight a need for policies orchestra and effective management of public-private research partnership in NSTDA. The cultural factors suggest the encouragement of entrepreneurship culture among public researchers to shape their attitudes towards industrial research. The institution, organisation, and cultural factors are interrelated and should be taken into consideration in formulating policy and mechanisms to promote public-private research partnership.

In addition, it is worthwhile to note that the researchers do not consider that communicating to get face-to-face contact with firms hinders the likelihood of R&D collaboration. This points out that it is not necessary for research centres and firms to be close in physical distance to transfer technological knowledge. This is because of the tacit nature of knowledge which is embedded in human skill can be transferred through direct contact between source (i.e. researchers) and recipient (i.e. firms) as the researcher and firm have interact during the course of their collaborative project. Thus, in this case it could be contended that geographical proximity is thus not necessary to implement the R&D collaboration between research centres and firms.
CHAPTER 8
Conclusion

This research has taken Thailand as a case study. The setting of NSTDA - a prominent public research organisation, where the Thai government had planned the first science park, TSP, by placing large public research organisations in the park and use the image of S&T infrastructure and pool of resources to attract technology-based firms to the park, looks promising as a local innovation system. Interactions are central to innovation systems, and imply interactive learning and proximity of actors. However, mechanisms of interactions of actors within science parks are less known and depend to a great extent on local context of each locality they operate in. This study examines the situation in the Thai context.

By way of conclusion, this chapter reviews the research study and the way forward. It begins with a brief summary of the research study (section 8.1). The next section (section 8.2) highlights the findings from empirical evidence. Contributions of the research and policy implications in relation to the results of the research are suggested in section 8.3 and sections 8.4 respectively. Limitations of this study and suggestions for further research are described in section 8.5. Finally, the thesis ends with concluding remarks in section 8.6.

8.1 Review of the research study

This study started off on the questionable context in which the Thai government has co-located prominent research centres in Thailand Science Park (TSP) in an attempt to stimulate interaction between the public and private sector, especially research collaboration between industrial firms. The study thus probed into two research themes: co-location and collaboration.
8.1.1 Conceptual framework

Recognising that interactive learning is essential for an innovation system, the concept of system of innovation, localised innovation system in particular, was used as a point of departure to study the locality where public research organisations and firms are co-located. Central to an innovation system is interactive learning, which involves complex interaction of actors and implies their proximity. Taking the notion of proximity and interactive learning into consideration, this study examined the likelihood of interaction between local actors (i.e. research centres and firms) in a science park as a consequence of geographical proximity with particular emphasis on the extent and type of interaction of the local actors, as well as the factors influencing their interaction. Following from this investigation, formal interactions in the form of R&D collaboration between research centres and firms were further explored to deepen an understanding regarding the interactive learning process between the public and private sector. In this respect, R&D collaborations were studied based on the theoretical framework of inter-organisational (IOR) relationships to specify interactions between research centres and firms in relation to their collaborative efforts. The IOR framework was employed to develop an analysis framework to examine the nature of R&D collaboration between research centres and firms. The analysis framework comprised a three-stage analysis: i.e. the first stage analyses the initial conditions of R&D collaborations, the second stage examined the formulation of R&D collaborations, and the third stage explored the implementation of R&D collaborations. By this way, this study can provide an explanation for the extent to which co-location influences interactions between research centres and firms and in what ways these actors work together in relation to their research collaboration. In this way, it is possible to provide policy implication regarding public-private research partnership in the case of Thailand.

8.1.2 Methodology

This study employed a qualitative approach to examine the co-location and R&D collaboration in the case being studied. With reference to the two research themes and conceptual framework, two main research questions asked were (in Chapter 5):
1. To what extent does co-location (i.e. physical proximity) influence the likelihood of interaction between firms and research centres located in science parks in the case of Thailand?
   (1.1) What is the extent and type of interaction of local actors (i.e. firms and research centres)?
   (1.2) What are the factors influencing interaction of local actor?

2. What is the nature of R&D collaboration between research centres and firms in the case of Thailand?
   (2.1) What are the types of R&D collaboration that exist between research centres and firms?
   (2.2) How are R&D collaborative projects between research centres and firms operated?
   (2.3) What are the partners’ motivations for participating in R&D collaborations?
   (2.4) What are the determinants of and barriers to interactions between R&D collaboration partners?

For the first research question, data was collected from tenants in Thailand Science Park in order to explore their location choices, interaction experience with other actors in the TSP, and the influence of geographical proximity on their interactions with other actors in the park. For the second research question, R&D collaborative projects between firms and research centres were used as a tool to investigate the nature of public-private R&D collaboration. Phone interviews with the researchers who had undertaken R&D collaborative projects with firms were conducted in order to investigate how they partnered and worked together with firms in R&D collaborative projects.

The data was collected between March 2007 and September 2008 through in-depth and semi-structured face-to-face interviews with TSP tenants and phone interviews with researchers and top management of NSTDA, TSP, the research centres (i.e. BIOTEC, MTEC, NECTEC), and NSTDA policy personnel, and subsequently analysed. Secondary data was gathered from NSTDA’s internal documents, reports, and websites.
8.2 Key findings on co-location and R&D collaboration

8.2.1 Does co-location matter?

In this study, the extent to which co-location influenced the likelihood of interaction between firms and research centres located in TSP was examined. The main findings show that co-location (i.e. geographical proximity) to research centres in TSP does not influence the likelihood of formal interaction between local firms and research centres co-located in the park. Most of interactions between firms and research partner in TSP were found to be informal. It was recognised that spatial relation facilitated informal interactions (such as face-to-face communication and social meeting) among local actors, but did not yet lead to formal interaction, which requires trust and goodwill between partners. In other words, geographical proximity facilitates informal interaction between local actors in Thailand Science Park, but is insufficient for their collaboration.

This study also shows that, for TSP tenants, proximity to research centres is regarded as a good image to the company. The interviews to TSP tenants suggested that the benefits of locating in TSP to collaborate with the research centres were over-estimated, and the benefits in terms of getting access to expertise at the research frontier and collaborating in the innovation process within TSP had not been materialised to a great extent. However, subsequent benefits such as informal contact and goodwill and trust building were achieved to some extent. The study also suggests that factors underpinning the extent of interaction between the local actors in TSP are social proximity and technological proximity, which can help to activate the impact of geographical proximity on the interactive learning. These suggest that geographical proximity indirectly stimulates interaction between local actors rather than directly influences the likelihood of their interaction as it is often assumed.

In essence, research centres also interact with actors outside TSP. If geographical proximity is insufficient to trigger formal interaction between the local actors, what accounts for formal interaction between research centres and firms elsewhere? In this
relation, R&D collaborations between research centres and firms located outside TSP were employed as a means to explore interaction between research centres and firms, with particular emphasis on the nature of their R&D collaboration.

8.2.2 Nature of R&D collaboration between research centres and firms in the case of Thailand

The study employed the analysis framework proposed in Chapter 3 to explore R&D collaborative efforts between research centres and partner firms in three stages of interaction: genesis, formulation and operation in order to explain the nature of R&D collaboration between research centres and firms, and factors underpinning their interaction. The main findings are as follow.

Firstly, the study identified a typology of R&D collaboration between research centres and firms, which categorised their research partnerships into four types (i.e. exploitative, interactive, explorative, and strategic) based on knowledge involved and coherence of the project with research focus of the research centres. This typology helps understand the way in which R&D collaborations were initiated, organised, and implemented, particularly the involvement and interaction of research partners. The typology revealed that most R&D collaborations between research centres and firms were classified as interactive R&D collaborations, in which the collaborative project involved industrial application and utilisation of technological knowledge accumulated within the research centres in the firms’ products or processes development. Many of these projects resulted from collective projects or partnering experience between the research centre and firm, and were likely to follow with subsequent collaborations. It is noteworthy to highlight that in this study there are a small number of collaborative projects which involved extensive feedback loop between researcher centre and partner firm. Most of the projects are based on a restricted model, whereby the collaboration between firms and research centres involves merely specific projects to develop new/improved products or processes with the use of formal/existing knowledge in research centres.
Secondly, the study also finds that the nature of R&D collaborations between research centres and firms was determined by the interaction strategies, i.e. active vs. passive, taken by firms. With reference to the types of R&D collaborative projects in this study, the active partner firms were those that had interactive and strategic R&D collaboration with research centres, whereas the passive partner firms were those that had exploitative and explorative R&D collaboration. The strategies adopted by the partner firms depend on the firm’s characteristics, especially their absorptive capacity. In addition, not only did the firm’s characteristics determine nature of R&D collaboration, but also the attitudes of researchers toward working with industry. Some researchers were enthusiastic about working with industry and viewed it as part of their research routine, whereas some gave priority to their in-house research. These attitudes reflect how the researchers prioritised their collaborative efforts, which in turn accounted for the likelihood and extent of interaction between research centres and firms.

Thirdly, the study presented that R&D collaborations between research centres and firms are motivated by technological and strategic reasons, while financial motivation is not likely the case in this study, as from the perspective of the researchers’ non-monetary benefits outweighed the financial motivation. This finding is inconsistent with literature on motivation for R&D collaboration, which is explained by the fact that most of R&D funding for the research centres comes from the government. Researchers therefore are less likely to be aggressive or proactive in seeking research partnerships with industry. This could possibly hinder the likelihood of public-private research partnership.

Fourthly, the study highlights the important factors influencing interaction between research centres and firms in relation to R&D collaboration. First, the evidence from the typology of R&D collaborations emphasises the technological factors as determinants of interaction between research centres and firms. Second, the evidence presented in relation to organisational, institutional, and cultural factors point out significant barriers of interaction between research centres and firms. In the context being studied, evidence indicates that without necessary policies and mechanisms specific for R&D
collaboration with industry, the public-private research partnerships are inhibited by inappropriate institutional and organisational settings.

In addition to the findings on co-location and collaboration, it is also noteworthy to highlight that although the setting of NSTDA appears promising as a local innovation system. In that, the Thai government had planned the first science park (i.e. TSP) by placing large public research organisations as anchor tenants and using the image of S&T infrastructure as well as pool of resources to attract technology-based firms to the park. This locality is in fact in deficit of interactive learning between firms and research organisations, which is a necessary ingredient for a local system of innovation. However, there are some interactions between local actors, and between research centres and firms located elsewhere. For this reason, this setting in the Thai context can be called an ‘embryonic’ local innovation system, whereby key organisations and institutions are present but there is some inertia inside the system. Mechanisms to stimulate the dynamics of this setting are needed to build up the indigenous strength of this locality.

8.3 Contributions to academic knowledge

8.3.1 Science parks and geographical proximity of research partners

Science parks are different and diverse depending on their local context. Some science parks prosper, while many do not. The success stories have been told, but the less favourable cases have not been cited. Among the limited stories of science parks, the literature mainly covers the science park development in developed countries. There seems to be a lack of evidence about science parks in the less developed countries. This study therefore contributes to science park literature by partially filling the gap between the literature, by providing empirical evidence on science parks in Thailand, an Asian developing country which uses science park as a policy tool to encourage R&D in private sector and support public-private research partnerships. Several literature argue that science parks offer a potentially successful interaction between academia and
industry (Xue, 1997; Wallsten, 2004; Yang et al., 2009). However, the way in which this interaction works and underpins the development of science parks is to some extent considered as a black box. Unlike many studies on science parks, this study unveils the concept of science parks by presenting the mechanisms inside the black box and examining activities within.

The literature on science parks concerning the benefits of geographical proximity on relationships of science park actors, i.e. firms and academic as well as public research organisations, present a different view on the relatedness in distance between science park actors. Some studies argue that geographical proximity plays an importance role on promoting exchange of knowledge through formal and informal interactions between science park firms and research organisations located in close distance (Löfsten and Lindelöf, 2002; Lindelöf and Löfsten, 2004; Dettwiler et al., 2006). Other studies challenge the influence of geographical proximity, arguing that the existence or strength of relationships between firms and research organisations related to the research activities established between them is not influenced by their spatial distance (Vedovello, 1997; Romijn and Albu, 2002; Phillips and Yeung, 2003). Arguably, different contexts and models of science parks may influence the interaction between these two actors differently (Vedovello, 2000). In this respect, this study provides an empirical contribution to the science park literature, specifically regarding the knowledge on the early stage development of a science park which had placed strong emphasis on spatial relation and the influence of co-location on interaction of local actors. The findings from this study heighten the concern that geographical proximity to some extent is not an important influence on the establishment of relationships and interaction between firms and research organisations. By taking insight from research on prominent benefits of geographical proximity on interaction between science park actors, this research shows that relatedness of science park actors in other aspects apart from spatial dimension may influence their relationship.

In addition, there is no study that considers research relationships between the public and private sector in Thailand that has taken into account geographical proximity
context of firms and public research organisations. This study thus presents novel empirical evidence and knowledge for academics and policy makers regarding the nature of public-private R&D collaboration in a planned science park in Thailand where firms and research centres are collocated.

8.3.2 Interaction process of public-private research partnerships

Previous literature have long been studied public-private research partnerships in various perspectives, such as the impact of their relationships on innovation process (Agrawal, 2001), their performance (Link et al., 2002; Caloghirou et al., 2003), and factors influencing their relations (Santoro and Chakrabarti, 1999; Hagedoorn et al., 2000; Schartinger et al., 2002; Santoro and Bierly, 2006). Also, there have been literature on R&D collaborations that attempt to measure the relationships in terms of co-patent, co-authorship and co-publication between the research partners (Katz and Martin, 1997; Ponds et al., 2007). While previous literature accentuated the roles and importance of relations between firms and research organisations on the effectiveness of their relationships, the analysis focus of the research collaboration is mainly at inter-organisational level. Little attention has been given to the dynamic of their relationships at project-level, which would provide more details on the collaborative process between individual firms and researchers of public laboratories.

Methodologically, this study adds to existing literature in an alternative form of analysis of public-private research partnerships from the project-level perspective; focusing particularly on the interaction process of research partners (i.e. how firms and research centres really work together in their research collaboration). The focus of the analysis starts from the origin of the project, then moves on to recognise how the projects were formulated and implemented. This methodological perspective provides opportunity to thoroughly examine the interaction process of firms and research centres, who are the key actors in the system of innovation.
Additionally, this research combines different units of analysis in considering the public-private research partnerships. The relationships between local firms in the TSP and co-located research centres is examined (as presented in Chapter 6) together with investigation of research partnerships between research centres and firms located elsewhere. By this way, the nature of R&D collaboration of research centres can be justified.

Moreover, an additional empirical contribution of this study is that the findings on R&D collaboration reveal evidence regarding the interaction process occurring in a science park in the Thai context. Particularly, the research illustrates the way in which research centres and firms interact in the course of their R&D collaboration and highlights the factors involved in their collaboration. The understanding of the specific nature of R&D collaborations between research centres and firms, as well as the factors underpinning the way in which the partners interact, help explain the rationales beyond their R&D collaborative efforts, and consequently offer insightful analysis for appropriate policy design to promote research partnership between firms and public research organisations. In addition, the findings regarding the process of interaction between firms and research centres in relation to their R&D collaboration add to the literature on R&D collaboration which has focused primarily on co-patent, co-authorships, and co-publication.

Furthermore, another empirical contribution of this study is that it introduces a typology of R&D collaborative projects between firms and research centres, indicating four categories of research collaborations (as presented in Chapter 7, Figure 7.1). These categories point out those R&D collaborative projects are in actual fact different in the nature of project. Project nature varies depending on the knowledge involved and the coherence with research agenda of the research partners. Therefore, R&D collaboration between firms and research organisations should be dealt with caution, both in terms of project management and performance evaluation.
8.3.3 An alternative approach to study innovative process of actors

This study provides a theoretical contribution to the system of innovation literature, specifically regarding the need to combine the notion of proximity and the theoretical frameworks of inter-organisational relationships in order to exhaustively understand the interaction process of actors in an innovation system. By combining these two theoretical concepts to the concept of system of innovation, it enhances the explanatory power of the concept of system of innovation. The combined framework helps to better justify the importance of the interaction process of innovative actors in the innovation system being studied as well as to account for the key factors influencing interaction of the innovative actors.

Literature on system of innovation has strongly emphasised the importance of linkages between firms and public research organisations (Edquist, 2005). While the concept of system of innovation justifies the relevance of the interaction of actors in technological innovation, in part it does not fully explicate how the interaction process of innovative actors takes place. Thus there is a need to employ additional theoretical concepts to analyse the case being studied, i.e. the local innovation system of firms and research centres in the context of Thailand Science Park.

8.4 Implications for policy practice

8.4.1 Proximity and relationships of local actors

One possible policy implication of this study is on proximity, geographical proximity in particular, and its influences on relationships and interaction of the local actors, i.e. firms and public laboratories. It is often take for granted that the closeness in distance of these two actors is predominately considered to have an imperative role in promoting their relationships. For instance, technological innovation resulting from the research partnerships between public laboratories and co-located firms are often expected from the implementation of science parks, whereby research laboratories and firms are co-
located. In fact, geographical proximity of the local actors is not a necessary precondition of their interactions and interactive learning. This study shows that there were very modest formal interactions and research collaborations between firms co-located with public laboratories in Thailand Science Park. In this respect, geographical proximity of firms and public laboratories play a rather marginal role in encouraging their cooperation.

Hence, to stimulate and promote public-private research partnerships in a planned science park, the science park policy should not merely emphasise the influence of geographical proximity on relationships and interaction of the local actors. Links between actors in a science park do not happen automatically, or by design, but depend on various factors and different dimensions of proximity (e.g. technological proximity, and social proximity) which are equally important in influencing relationships between the local actors. Therefore, dimensions of proximity should be taken into account to activate the benefits of geographical proximity and facilitate localised learning. Implication for TSP and NSTDA as well as for Thai STI policy design is that one needs to focus more on factors influencing the likelihood and intensity of linkages between firms and research centres and to be more involved in catalysing and fostering interactions and spillover at local level.

This means that to encourage successful cooperation between firms and public laboratories co-located in a planned science park, it is necessary to assure that these local actors have adequate technological relatedness. This would call for the necessity to re-consider and revise the entry policy of science parks to narrow the scope of the target industry and firms. However, it does not imply that only firms that have similar knowledge with public laboratories in the science park will be recruited. On the other hand, prospective firms should be those who have abilities (i.e. absorptive capacity) to recognise the research opportunities that public laboratories provide. In this aspect, both partners can gain mutual benefit from their research relationships.
Also, policies on science park should attempt to create synergy among local firms and between firms and local organisations by promoting their social relations and facilitating their interaction and information exchange. This could be implemented by means of social networking (in person and/or online) or associations that tie the local actors together and actively spur the local environment for innovation and strategically support interaction between local actors. In this respect, the policy should place emphasis on creating local embeddedness of the actors to encourage their social connectedness, which would increase their willingness to cooperate.

In this regard, TSP needs to facilitate networking and stimulate knowledge exchange between local firms and research centres by taking into consideration the effects of different dimensions of proximity on interaction between firms and research centres. Direct policy tools can be used to encourage creation of a platform for dialogue between firms and research centres and formation of innovation cluster based on focused R&D schemes.

8.4.2 Facilitating research partnerships between firms and research centres

Another policy implication of this study is on the policy to structure local support to stimulate an active network between local actors. According to the analysis in this study, evidence indicates that research partnerships between firms and public laboratories happen unsystematically. In most cases, the collaborative projects occur erratically without strategic search and match processes between firms and the research centres. Impacts of the public-private research collaboration are thus rather limited. Besides that there were many cases in this study that the partnerships between firms and research centres were considered as one-off relationships. Also, in many cases firms were regarded as the user of research results, not as active partners in the innovation process. These firms passively participated in the collaborative projects as hands-off research partners; they provided requirements and left most of the research activities to research centres.
In order to promote dynamic technological cooperation between the public and private sectors, the implication is that related measures to support public-private R&D collaboration need to gradually move from collaborative efforts in solving specific problems in firms towards joint cooperation focusing on engineering and development works that involve dynamic process of innovation. This could be accomplished by incorporating firms in the research and innovation chain to formulate strategic industrial research projects. Policy should map the industrial needs with the strength and research focus of research centres in order to prioritise the specific areas of interest for R&D collaboration, not only problem-solving types of research projects. The collaborative projects should focus on industrial uses of the research results. This would allow a pool of expertise from different technological fields, where researchers from different research centres can jointly work in the collaborative project with industry.

Policy makers should also consider specific mechanisms that facilitate the development of local and trans-local pipelines which tie local actors together as well as connect them with external firms and other related public organisations. The local and trans-local pipelines would help increase interaction between local actors, strengthen their innovation process, and subsequently build up a potent local innovation system. One could envisage the formation of a research cluster or research consortium based on the matching between areas of expertise of research centres and business interest of industrial firms. The establishment of research consortium focusing specifically on technological development within industrial firms would help to strategically connect firms with public laboratories as well as universities and other public and private organisations involved. This form of organisational arrangement would help promote long-term relationships and interactions between the public and private sector. The research consortium can be employed to facilitate the development of technological innovation of firms participating in the research consortium and offer opportunities for academic researchers to recognise particular concerns of industry and gear their research towards industrial needs. By means of research consortium, research partnership considers not only geographical proximity of actors but also the proximity in terms of technological and social relations together with local interaction or ‘buzz’.
and interaction through ‘pipelines’ which could help create a dynamic process of learning and in turn could possibly move towards innovation clusters.

Furthermore, the policy should encourage the use of collective projects and consultancy services provided by researchers to create formal interactions and collaborations between firms and research centres. However, there is a need to take into account the institutional and organisational support that encourages researchers to integrate their work with industry more and more. In other words, R&D policy is not one for all; in-house research and collaborative research should be treated differently. This implies that R&D management systems, reward systems, and performance evaluation need to be cautiously planned to promote the involvement of researchers in public-private research partnerships.

8.4.3 Management of public-private research collaboration

One of the three policy implications of this study is on the way in which the research collaborative projects are managed. In relation to institutional shift at NSTDA whereby the SPA initiative and industrial cluster based R&D management have been implemented (section 2.3), the implication is that specific policy tools for managing collaborative research are needed to facilitate research partnerships between firms and research centres. In this regard, collaborative research needs to be treated in a different way from other types of research projects such as in-house research, contract research and funding research. New approaches or institutional and organisational arrangements may be needed to streamline funding and management of public-private research collaborative projects and remove (or reduce) barriers to co-operation and also motivate researchers to engage their works more with industrial firms.

For Thai STI policies which emphasise on national innovation systems and cluster approach (section 2.1), to foster collaboration between actors in innovation systems, the implication is that the Thai government should consider increasing financial support programmes to promote public-private research partnerships. Policies need to
encourage industrial firms to invest in research activities and increase their interaction with other firms and public research organisations.

8.5 Limitations of this study and suggestions for further research

It is important to recognise that the results of this study are of course subject to some of limitations. First, the study aimed to investigate the influence of co-location on the likelihood of interaction between local actors in the TSP during the period of early stage park development. The number of years of its existence, the small size of the park, and the number of firms in the park thus led to findings that are dependent on time-related issue. Science parks take several years to gradually develop to a well-established setting; the results presented in this study may be inapt as the TSP progresses. Second, the study explored R&D collaborations between firms and research centres mainly from the researchers’ perspective due to restriction in accessing the partner firms in many collaborative projects studied.

In addition, limitations are also the small sample of collaborative projects which is not large enough to derive generalisable results. Furthermore, the sample in this study is of firms that collaborate with research centres, however a lesser amount of information is known about firms that did not engage in R&D collaboration. Perhaps one implication from such small number of collaborative projects is that the barriers for not collaborating should be further examined and tackled to boost collaborative relation between firms and research centres.

Nevertheless, the results in this study highlight that geographical proximity may be a precondition for informal interaction between local actors, but it is not sufficient to promote formal interaction and interactive learning in the case of TSP. In that case, what are the necessary conditions for this particular setting to stimulate interaction between local actors? How can a science park in a less developed country, like Thailand, develop to an interactive learning locality? Further research which extensively explores in detail
the important roles and the influences of other dimensions of proximity (such as technological and organisational/institutional proximity) on the extent and intensity of the interaction of local actors would lead to a greater understanding about the necessary conditions for stimulating interactive and localized learning in science park and similar settings. Moreover, a study focuses on how firms interact with other external source of knowledge, such as universities and their customers and/or supplier, could help to understand how firms interact with their external links to acquire new knowledge.

It is evidenced in this study that firms and public research organisations do not simply cooperate with each other as a result of their physical closeness. This implies that collocating them in one place requires particular frameworks to foster their relations and partnership. In this respect, further research could also focus on cooperative network between public and private sector with particular emphasis on possible frameworks that could facilitate them to better work together.

Alternatively, as the science park concept is moving towards clusters and a learning region, policy research can focus on developing specific technology cluster (e.g. biotechnology) within TSP considering both endogenous resources of local organisations and exogenous links as a key strategy to shed some light on evolution of a science park towards a cluster or learning region.

Additionally, this study only focused on exploring R&D collaboration between firms and research centres. One or more case studies of public-private research collaboration in specific technology fields to evaluate industrial needs and examine why (or why not) firms collaborate with public research organisations would provide the basis for designing effective policies to foster public-private research partnerships. This will also provide fruitful information to support the research on developing specific technology clusters within the local innovation system of NSTDA.
8.6 Concluding remarks

In conclusion, co-location and collaboration between public research organisations and firms has been studied throughout this thesis. The context of a science park and national research centres in Thailand is used as a studied case. Geographical proximity alone cannot trigger interaction of actors, especially formal interaction such as research collaboration, bounded by spatial relation. Interaction between public research organisations and firms can take place without closeness in distance. Other dimensions of their relation are important factors influencing their interaction. By means of presenting the nature of R&D collaborative project between firms and research centres, this study could help both academics and policy-makers to understand the likelihood of interaction of local actors, the nature of public-private research partnerships, and the factors influencing their interaction and collaboration in order to improve mechanisms for promoting linkages between science and industry.
REFERENCES


## Appendix 1: Tenants in Thailand Science Park
(as of March 2007)

### Group I: R&D

<table>
<thead>
<tr>
<th>Company/Organisation</th>
<th>Activities</th>
<th>Country of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alltech Biotechnology Corp., Ltd. <a href="http://www.alltech.com">www.alltech.com</a></td>
<td>Asia-Pacific Bioscience Centre for R&amp;D in feed additives</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>2. Betagro Science Center Co., Ltd. <a href="http://www.betagro.com">www.betagro.com</a></td>
<td>Laboratory and testing services to control and monitor the quality of feed, animal health products and food products for Betagro Group</td>
<td>Thailand</td>
</tr>
<tr>
<td>3. Delphi Health Service Co., Ltd. <a href="http://www.delphihealthservices.com">www.delphihealthservices.com</a></td>
<td>R&amp;D, testing, early stages of product development, and contract laboratory research in human genotyping technology and bioinformatics</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>4. Concepts Foundation <a href="http://www.conceptfoundation.org">www.conceptfoundation.org</a></td>
<td>A non-profit organisation which helps improving the health of people around the world by turning intellectual property into competitive and cost effective products that could be distributed at lowest possible cost especially into the public sector health care channel of developing countries</td>
<td>International organisation</td>
</tr>
<tr>
<td>6. Hemotrans Co., Ltd. <a href="http://www.hemotrans.co.th">www.hemotrans.co.th</a></td>
<td>R&amp;D for artificial blood</td>
<td>Thailand</td>
</tr>
<tr>
<td>7. Shiseido (Thailand) Co., Ltd. <a href="http://www.shiseido.co.th">www.shiseido.co.th</a></td>
<td>Shiseido South East Asia Research Centre for cosmetic. It is set up as an office to collaborate with BIOTEC in microbiology studying and researching for new products from Thai plants.</td>
<td>Japan</td>
</tr>
<tr>
<td>8. Sipso Tropical Drink Co., Ltd.</td>
<td>Food products from jasmine rice</td>
<td>Thailand</td>
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</tbody>
</table>
## Group I: R&D

### Technology Sector: ICT & Electronic

<table>
<thead>
<tr>
<th>Company/Organisation</th>
<th>Activities</th>
<th>Country of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Embedded Technology Co., Ltd. <a href="http://www.embedded-th.com">www.embedded-th.com</a></td>
<td>Design and create prototype for electronic devices</td>
<td>Thailand</td>
</tr>
<tr>
<td>2. G Softbiz Co., Ltd. <a href="http://www.thai-g.com">www.thai-g.com</a></td>
<td>R&amp;D in Thai software for PDA and mobile phone</td>
<td>Thailand</td>
</tr>
<tr>
<td>3. Hard Disk Drive Institute</td>
<td>Implement the development plan for strengthening hard disk drive industry of the country</td>
<td>Thailand</td>
</tr>
<tr>
<td>4. Mobilis Automata Co., Ltd. <a href="http://www.thaimobilis.com">www.thaimobilis.com</a></td>
<td>R&amp;D in automation system, motion control system and industrial software</td>
<td>Thailand</td>
</tr>
<tr>
<td>5. NICT Asia Research Center <a href="http://www.nict-asia.org">www.nict-asia.org</a></td>
<td>A collaboration centre for R&amp;D in telecommunication among public and private sectors, as well as academic institutes</td>
<td>Japan</td>
</tr>
<tr>
<td>6. Office of Computer Clustering Program (CCP) <a href="http://www.ccp.or.th">www.ccp.or.th</a></td>
<td>Provide training and consultancy in IT, and system development</td>
<td>Thailand</td>
</tr>
<tr>
<td>7. Open Lab</td>
<td>Provide services and facilities for R&amp;D in ICT to promote collaboration between academics and industry.</td>
<td>Thailand</td>
</tr>
<tr>
<td>8. Sapphire Research and Development Co., Ltd. <a href="http://www.sapphire.co.th">www.sapphire.co.th</a></td>
<td>Software house to prepare software for manufacturing under CMM Standard</td>
<td>Thailand</td>
</tr>
<tr>
<td>9. Western Digital (Thailand) Co., Ltd. <a href="http://www.wdc.com">www.wdc.com</a></td>
<td>Provide trainings in cooperation with the Hard Disk Drive Institute (HDDI)</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>Company/Organisation</td>
<td>Activities</td>
<td>Country of Origin</td>
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</tr>
</tbody>
</table>
| 1. Advance Dental Technology Center (ADTEC)  
www.adtec.or.th | R&D in advance dental technology and dental services | Thailand |
| 2. Business System Service Co., Ltd.  
www.intriplex.com | Web-based RoHs Compliance Management System (RCMS) | Thailand |
| 3. Ceramics Institute | R&D in ceramics | Thailand |
| 4. Design & Engineering Consulting Service Center (DEEC) | Provide consultancy and training in engineering design and fine element | Thailand |
| 5. Golden Water Polymer Co., Ltd.  
www.polyplastics.com | R&D in printing and coating products | Thailand |
| 6. Intri-Plex (Thailand) Ltd.  
www.cementhaichemicals.com | Precision mechanical component design for data storage business, focusing on hard disk drive | U.S.A. |
| 7. Mouldmate Co., Ltd.  
www.mouldmate.co.th | R&D in rubber tire | Thailand |
| 8. Novatech Healthcare Co., Ltd.  
www.novatec.co.th | R&D in suture materials | Thailand |
| 9. Polyplastics Marketing (T) Ltd.  
www.polyplastics.com | R&D in engineering plastic | Japan |
| 10. SCG Chemical Co., Ltd.  
www.cementhaichemicals.com | R&D in petrochemical products | Thailand |
| 11. Siam Polymer Engineering and Consultation Co., Ltd. | R&D in natural latex glove and technology transfer in the area of rubber and latex | Thailand |
| 12. Thai Ceramics Co., Ltd.  
www.cottotiles.com | R&D in ceramics and ceramic tiles for construction industry | Thailand |
### Group II: R&D Support & Services

<table>
<thead>
<tr>
<th>Company/Organisation</th>
<th>Activities</th>
<th>Country of Origin</th>
</tr>
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<tbody>
<tr>
<td>1. Agrico (1995) - ADB-TA Program</td>
<td>ADB project to strengthen advanced agricultural science and technology in the Greater Mekong Sub Region</td>
<td>New Zealand</td>
</tr>
<tr>
<td><a href="http://www.adb-gms-agtech.org">www.adb-gms-agtech.org</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Asian Society for Environment Protection</td>
<td>An international non-profit association composed of professionals and institutions committed to the pursuit of sound environmental management and protection towards achieving sustainable development in the Asian Region.</td>
<td>International organisation</td>
</tr>
<tr>
<td><a href="http://www.asepinfo.org">www.asepinfo.org</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Bangkok Bank Public Company Limited</td>
<td>Provide banking services</td>
<td>Thailand</td>
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<tr>
<td><a href="http://www.bangkokbank.com">www.bangkokbank.com</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Full Advantage Co., Ltd.</td>
<td>Provide consultancy services in environmental management</td>
<td>Thailand</td>
</tr>
<tr>
<td>5. Rouse and Co International (Thailand) Ltd.</td>
<td>Provide patent and IP services, specialise in biotechnology and telecommunication areas</td>
<td>U.K.</td>
</tr>
<tr>
<td>6. SMC (THAILAND) Ltd.</td>
<td>A pneumatics technology transfer institute &amp; R&amp;D centre</td>
<td>Thailand</td>
</tr>
<tr>
<td><a href="http://www.smcthai.co.th">www.smcthai.co.th</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. T.H.NIC Co., Ltd.</td>
<td>Domain registration service (.th)</td>
<td>Thailand</td>
</tr>
<tr>
<td><a href="http://www.thnic.net">www.thnic.net</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Tokyo Tech Office (Thailand)</td>
<td>Collaborate distance learning projects between NSTDA, AIT, and Tokyo Technology Institute in distance education and tele-lecture via satellite system</td>
<td>Japan</td>
</tr>
<tr>
<td><a href="http://www.gsic.titech.ac.th">www.gsic.titech.ac.th</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. TUV SUD PSB (Thailand) Ltd</td>
<td>Provide testing services (food testing and EMC testing)</td>
<td>Singapore</td>
</tr>
<tr>
<td><a href="http://www.psbstest.com">www.psbstest.com</a></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Group III: Quality of Life

<table>
<thead>
<tr>
<th>Company/Organisation</th>
<th>Activities</th>
<th>Country of Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Bruchino Café</td>
<td>Coffee shop &amp; snacks</td>
<td>Thailand</td>
</tr>
<tr>
<td>2. Take a sit</td>
<td>Coffee shop &amp; snacks</td>
<td>Thailand</td>
</tr>
<tr>
<td>3. Travel Click</td>
<td>Traveling services</td>
<td>Thailand</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 2: Lists of Interviewees

#### 2.1 Tenants of Thailand Science Parks

<table>
<thead>
<tr>
<th>No.</th>
<th>Tenants</th>
<th>Founded</th>
<th>Locate in TSP since</th>
<th>No. of Employee</th>
<th>Origin</th>
<th>Industrial sector</th>
<th>Interviewees (Firms’ Executive)</th>
<th>Interview Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Betagro Science Centre Co., Ltd.</td>
<td>1967</td>
<td>2004</td>
<td>60</td>
<td>Thai</td>
<td>Biotechnology (Argo-Industry)</td>
<td>Mr. Rutjawate Taharnklaew General Manager</td>
<td>20 Mar 07</td>
<td>63 min.</td>
</tr>
<tr>
<td>3.</td>
<td>Dephi Health Services Co., Ltd.</td>
<td>1985</td>
<td>2007</td>
<td>4</td>
<td>U.S.</td>
<td>Biotechnology</td>
<td>Mr. Charles Runckel Director of Research</td>
<td>23 Mar 07</td>
<td>35 min.</td>
</tr>
<tr>
<td>4.</td>
<td>Stem Cells for Life Co., Ltd.</td>
<td>2006</td>
<td>2006</td>
<td>8</td>
<td>Thai</td>
<td>Biotechnology (Medical technology)</td>
<td>Dr. Kampon Sriwatanakul Managing Director</td>
<td>23 Mar 07</td>
<td>40 min.</td>
</tr>
<tr>
<td>6.</td>
<td>Embedded Technology Co., Ltd.</td>
<td>2004</td>
<td>2004</td>
<td>5</td>
<td>Thai</td>
<td>ICT &amp; Electronics and computer</td>
<td>Mr. Boonchai Kingrungpetch Manager</td>
<td>20 Mar 07</td>
<td>40 min.</td>
</tr>
<tr>
<td>8.</td>
<td>Advance Dental Technology Centre (ADTEC)</td>
<td>2005</td>
<td>2005</td>
<td>10</td>
<td>Thai</td>
<td>Advanced Materials (Dental technology)</td>
<td>Assoc. Prof. Wichit Tharanon</td>
<td>4 Apr 07</td>
<td>28 min.</td>
</tr>
<tr>
<td>9.</td>
<td>Intri-Plex Thailand Co., Ltd.</td>
<td>2005 (Mar)</td>
<td>2005 (Sep)</td>
<td>70</td>
<td>U.S.</td>
<td>Metal &amp; Advanced Materials</td>
<td>Mr. Dale F. Schudel Managing Director</td>
<td>26 Mar 07</td>
<td>45 min.</td>
</tr>
</tbody>
</table>
## 2.2 Executive and the Management of NSTDA, NRCs, and TSP

<table>
<thead>
<tr>
<th>No.</th>
<th>Organisations</th>
<th>Roles</th>
<th>Interviewees and Positions</th>
<th>Interview Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Thailand Science Park (TSP)</td>
<td>TSP management</td>
<td>Dr. Janekrishna Kanatarana Director of TSP</td>
<td>28 Mar 07</td>
<td>85 min.</td>
</tr>
<tr>
<td>2.</td>
<td>National Science and Technology Development Agency (NSTDA)</td>
<td>NSTDA and TSP Executive</td>
<td>Dr. Chachanat Thebtaranonth Vice President of NSTDA, and Director of Technology Management Centre (TMC)</td>
<td>5 Jun 07</td>
<td>60 min.</td>
</tr>
<tr>
<td>3.</td>
<td>National Science and Technology Development Agency (NSTDA)</td>
<td>NSTDA and TSP Executive</td>
<td>Dr. Supat Poopaka Assistant Director of Technology Management Centre (TMC)</td>
<td>25 Mar 08</td>
<td>54 min.</td>
</tr>
<tr>
<td>4.</td>
<td>National Centre for Genetics Engineering and Biotechnology (BIOTEC)</td>
<td>Stakeholder of NSTDA and TSP</td>
<td>Mrs. Darunee Edwards BIOTEC Deputy Director</td>
<td>11 Jun 07</td>
<td>50 min.</td>
</tr>
<tr>
<td>5.</td>
<td>National Metal and Materials Technology Centre (MTEC)</td>
<td>Stakeholder of NSTDA and TSP</td>
<td>Dr. Lerkiat Vongsampigoon MTEC Deputy Director</td>
<td>14 Jun 07</td>
<td>37 min.</td>
</tr>
<tr>
<td>6.</td>
<td>National Metal and Materials Technology Centre (MTEC)</td>
<td>Stakeholder of NSTDA and TSP</td>
<td>Dr. Natthaphon Wuttiphan Director of Infrastructure Development Division, MTEC</td>
<td>15 Jun 07</td>
<td>50 min.</td>
</tr>
<tr>
<td>7.</td>
<td>National Electronics and Computer Technology Centre (NECTEC)</td>
<td>Stakeholder of NSTDA and TSP</td>
<td>Dr. Pansak Siriruchatapong, NECTEC Director</td>
<td>12 Jun 07</td>
<td>22 min.</td>
</tr>
</tbody>
</table>
## 2.3 Researchers of the National Research Centres

### 2.3.1 National Centre for Genetic Engineering and Biotechnology (BIOTEC)

<table>
<thead>
<tr>
<th>No.</th>
<th>Project Description</th>
<th>Project Duration</th>
<th>Interviewees (Researchers)</th>
<th>Interview Date</th>
<th>Time</th>
</tr>
</thead>
</table>
| 1.  | (1) Artificial insemination of livestock  
     (2) Using sugarcane for animal feeds | 1 year each (1) Feb 07 - Jan 08  
(2) Aug 07 - Jul 08 | Dr. Siwat Sangsritavong | 5 Aug 08 | 78 min. |
| 2.  | (1) Rehabilitating saline soil  
     (2) Growing salt tolerant rice strains | 1 year each (1) Feb 07 - Jan 08  
(2) N/A | Dr. Chalermpol Kirdmanee | 6 Aug 08 | 77 min. |
| 3.  | Biotechnology application of digestive enzymes on pulp and paper | 1 year Jun 07 - May 08 | Dr. Lily Eurwilaichitr | 7 Aug 08 | 49 min. |
| 4.  | Optimisation of production process of ornamental plant | 1 year Jun 07 - May 08 | Dr. Tharathorn Teerakathiti | 8 Aug 08 | 47 min. |
| 5.  | Expression and characterization of enzymes for animal feed production | 1 year Jun 07 - May 08 | Dr. Sutipa Tanapongpipat | 8 Aug 08 | 50 min. |
| 6.  | Prawn bloodstocks nutrition feed development for Black Tiger Shrimp | 6 months May 07 - Oct 07 | Dr. Oraporn Meunpol | 11 Aug 08 | 45 min. |
| 7.  | Extraction of Thai Plant-derived for cosmetics | 3 years Jan 05 - Dec 07 | Dr. Thanit Changthavorn | 15 Sep 08 | 30 min. |
| 8.  | Micro Diversity of Thai Female Facial Skin | 1.5 years Oct 07 - Mar 09 | Dr. Vethachai Plengvidhya | 15 Sep 08 | 35 min. |
| 9.  | Isolation and categorisation of microorganism from Thai Natural Resources for pharmaceutical purposes | 2 years Jul 06 - Jun 08 | Dr. Somsak Sivichai | 18 Sep 08 | 40 min. |
| 10. | Prototype production of Umami, a food additive, from Soya Bean | 3 months Dec 06 - Feb 07 | Dr. Panit Kitsubun | 22 Sep 08 | 35 min. |
### 2.3.2 National Metal and Materials Technology Centre (MTEC)

<table>
<thead>
<tr>
<th>No.</th>
<th>Project</th>
<th>Project Duration</th>
<th>Interviewees (Researchers)</th>
<th>Interview Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.</td>
<td>Innovative production process of medical grade stainless steel for orthopaedic devices</td>
<td>6 months, Jun 05 - Dec 05</td>
<td>Dr. Wuttipong Rungseesantivanon</td>
<td>4 Aug 08</td>
<td>50 min.</td>
</tr>
<tr>
<td>12.</td>
<td>Innovative production process of titanium alloy for automotive industry (2-phase project)</td>
<td>7 months, Apr 06 - Oct 06 &amp; 1 year, Jan 07 - Dec 08</td>
<td>Dr. Anchalee Manonukul</td>
<td>4 Aug 08</td>
<td>198 min.</td>
</tr>
<tr>
<td>13.</td>
<td>Application of new production technology for automotive spare parts</td>
<td>9 months, Aug 04 - Apr 05</td>
<td>Dr. Chatchai Chandendueng</td>
<td>15 Aug 08</td>
<td>50 min.</td>
</tr>
<tr>
<td>14.</td>
<td>Development of new packaging for transporting rubber resin overseas</td>
<td>6 months, Sep 05 - Mar 06</td>
<td>Dr. Piyawit Koombhongse</td>
<td>12 Sep 08</td>
<td>43 min.</td>
</tr>
<tr>
<td>15.</td>
<td>Development of transmission systems of small tractor</td>
<td>2 years, Oct 05 - Sep 07</td>
<td>Mr. Dusit Thangphisosityothin</td>
<td>17 Sep 08</td>
<td>54 min.</td>
</tr>
<tr>
<td>16.</td>
<td>Development of innovative plastic films covering greenhouse for solar heat reduction</td>
<td>2 years, Sep 08 - Aug 10</td>
<td>Dr. Jittiporn Kruenate</td>
<td>19 Sep 08</td>
<td>27 min.</td>
</tr>
</tbody>
</table>

### 2.3.3 National Electronics and Computer Technology Centre (NECTEC)

<table>
<thead>
<tr>
<th>No.</th>
<th>Project</th>
<th>Project Duration</th>
<th>Interviewees (Researchers)</th>
<th>Interview Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>Speech technology synthesis engine (text-to-speech synthesis engine)</td>
<td>3 years, Oct 06 - Sep 09</td>
<td>Dr. Chai Wuttiwiwatchai</td>
<td>7 Aug 08</td>
<td>74 min.</td>
</tr>
<tr>
<td>18.</td>
<td>Development of electronic nose</td>
<td>1 year, May 06 - Apr 07</td>
<td>Dr. Adisorn Tuantranont</td>
<td>18 Aug 08</td>
<td>56 min.</td>
</tr>
<tr>
<td>19.</td>
<td>System development for telecommunication business</td>
<td>6 months, N/A</td>
<td>Mr. Seksun Sartsatit</td>
<td>19 Sep 08</td>
<td>34 min.</td>
</tr>
</tbody>
</table>
### 2.4 NSTDA Policy Officers

<table>
<thead>
<tr>
<th>No.</th>
<th>Organisations</th>
<th>Roles</th>
<th>Interviewees and Positions</th>
<th>Interview Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>National Science and Technology Development Agency (NSTDA)</td>
<td>Policy formulation</td>
<td>Dr. Ladawan Krasachol Director of Policy and Planning Department</td>
<td>(1) 27 Mar 08</td>
<td>90 min.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2) 3 Apr 08</td>
<td>108 min.</td>
</tr>
</tbody>
</table>
Appendix 3: Interview Guides for TSP Tenants

Part I  Location choices
1. Main concerns for choosing firm’s location
2. Initial reasons for locating in this Science Park
3. Subsequent benefits that drive the presence of firm in the Science Park
4. Drawbacks of locating in the Science Park

Part II  Interaction experience
5. How do you cooperate with other innovative actors?
   - Who do you link with during your innovative process?
   - Where do these actors locate, within or outside the TSP?
   - What are types of interaction? Whether it is formal or informal.
   - How significance of these interaction and linkages are to firm’s innovation?
6. Whether and how you have formulated collaboration with the NRCs
7. What obstacles you have experience while interacting with the NRCs and/or other actors in the TSP

Part III  Local settings of the Science Park
8. How and to what extent the local settings (i.e. location factors, physical infrastructure and facilities, and supports and services) in the TSP influence on the interactions between your firm and other organisations, especially the organisations in close proximity?
Appendix 4: Interview Guides for Executives and Management

4.1 Interview Guide for the TSP Management

1) Organisation
   - The organisation profile, facts and figures, etc.
   - Brief history of the TSP

2) TSP location
   - How do you attract potential tenants to the park?
   - How do you select the tenants?

3) Interactions between the actors in TSP
   - How do you promote linkages and interaction of the local actors? What roles do you play?
   - How do you facilitate the interaction between the tenants and the NRCs?
   - What are the barriers and difficulties in doing that? And how they have been overcome?

4) About local settings of the Science Park
   What would you say in terms of the extent to which local settings of the Science Park (i.e. location factors, physical infrastructure and facilities, and supports and services) influence interactions between tenants?
4.2 Interview Guide for NSTDA’s and NRC’s Executive and Management

1. What do you think are the benefits (and drawbacks) of the location of TSP?

2. From your experience, how do the settings of NSTDA and TSP affect the way in which NRCs interact with tenants, and with other private enterprises?

3. To what extent does this setting influence interaction, knowledge flow and technology transfer between the local firms and the laboratories, among the laboratories themselves, and between the laboratories and industry? Please elaborate

4. Could you comment on the framework of your organisation regarding interaction (both formal and informal ones) between NRCs and TSP tenants, as well as that of NRCs and industry?

   Note: *Formal interaction* is the relationships which include explicit agreement and codified type of knowledge transfer (e.g. contract research, collaborative project, and licensing, etc.)

   *Informal interaction* is daily functions which enable exchange of general information (e.g. informal contact, meeting and networking events, etc.)

5. What are supporting schemes available to encourage interactions, especially the formal interaction, between the NRCs and TSP tenants?

6. What do you think would encourage more interaction between the NRCs and firms, both local and external ones?

7. Your further comments regarding the development of TSP
Appendix 5: Interview Guides for Researchers

Part I  Project information
1. What the research project is about?
2. What do you do in this project?
3. How many research partners do you have in this project?
4. With whom do you work with?
5. Why do you choose this partner, and not the other one?
6. What are your reasons to collaborate?

Part II  Preconditions and arrangement
7. Is the project continued from your previous work?
8. How did you meet or find the research partner?
9. How the ideas have been originated?
10. How the project was constructed?
11. Why the collaborative mode is chosen, and not the other types of project, such as contract research, funding or in-house research?

Part III  Interaction experience
12. How would you describe the activities in the project? (Is it problem solving, exploitation of research results, development of new techniques/products/processes, technology licensing, or else?)
13. With whom in the firm do you work with?
14. How the project is facilitated?
15. How was the labour division in the project?
16. What are the kinds of cooperative activities in the project?
17. (Whether there are joint activities, training, facilities or people sharing, etc.)
18. Where is the research activities physically located? Does distance or geographical location of the project partners matter?
19. Apart from your lab and the firm, is there other organisation involve in the project?

Part IV  Opinion about R&D collaboration
20. What do you think are the difficulties in the courses of R&D collaborative projects?
21. Would you describe the collaborative projects as core of your research activities, or as transfer activities linking your main research activities with the firm?
22. What does the collaboration bring to you? How would you say the collaboration mean for you and your research activities?
23. Are there any continuations of the cooperation because of this project?

Part V  Opinion about organisation of R&D collaboration
24. From your experience, how would you comment on the framework of NSTDA and NRCs regarding R&D collaboration between public labs and firms?
25. Should there be any changes or improvement in the framework, so that research collaboration activities are better performed? If so, how should it be?
Appendix 6: Interview Topic List for Policy Officers

Key topic:
The emergence of two policy initiatives, i.e. ‘Strategic Planning Alliance (SPA)’ and ‘Cluster Programme Management Office (CMPO)’ and their implementation

Discussion points:
- Rationale of SPA and CPMO
- Their details concepts and implementation
- Their consequences on how research activities are organised
- Using SPA and CPMO as institutional framework to boost up R&D cooperation between NRCs and firm
Appendix 7: Synopsis of R&D Collaborative Projects

<table>
<thead>
<tr>
<th>Case</th>
<th>Synopsis</th>
</tr>
</thead>
</table>
| 1.   | (a) A study of conception rate and early pregnancy losses on the transfer of in vitro produce bovine embryos  
(b) Studies of nutritive value feeding, feeding value, and animal response of forage cane in cattle  
Two R&D collaborative projects between BIOTEC and a large dairy farm located in the northeast of the country. Interestingly, the two projects involved different products and processes, and the project duration was overlapped. The first project was about the study of conception rate and early pregnancy losses on the transfer of in vitro produce bovine embryos. The second one was relating to studies of nutritive value, feeding value, and animal response of forage cane in cattle. Origins of the two projects were different. In that, the research idea of the first project originated from motivation of the farm to improve efficiency of dairy cattle production, while the second project came about as the researcher persuaded the farm to involve in the project. The research idea of the second project was relatively new to the firm and not the area of its research interest before. However, appropriate use of home-grown forage cane as cattle feed was expected to provide direct economic benefits to the farm. |
| 2.   | (a) Bioremediation of salinity land using salt tolerant tree  
(b) Improving rice cultivation and developing rice specie for bio-remediated salinity land  
The case involved long-term research partnership between BIOTEC and a large edible and industrial salt manufacturer. The collaborations concerned two consecutive R&D collaborative projects about bioremediation of salinity land. The first project was about bioremediation on salinity land. The second project was built on the success of the previous project. It was about cultivating salt-tolerant fragrant rice on the restored salinity land. Although, the second project was indeed not directly related to the business sector of the partner firm, it actively participated and provided financial and technical support because of the anticipation in the indirect future benefits of the research results in terms of economic benefits as well as good image and publicity of the firm. In that, the result of this agricultural system helps farmers in saline soil areas to have more productive rice fields as well as to boost up their incomes. |
| 3.   | Biotechnology application of digestive enzymes for pulp and paper production process  
This case concerned the first formal interaction between BIOTEC and a large pulp and paper manufacturer. The project was about studying of utilisation of digestive enzymes in paper production process. BIOTEC researcher was responsible for almost all of research activities in the project. The partner firm took rather wait-and-see approach. After all, the firm did not take the research results into practice, nor continue research in industrial scale. In the viewpoint of firm, this project provided additional knowledge in order to keep up with latest trend in paper production process in which chemical ingredients have been increasing replaced by digestive enzymes. |
<table>
<thead>
<tr>
<th>Case</th>
<th>Synopsis</th>
</tr>
</thead>
</table>
| 4.   | **Optimisation of micro-propagation techniques of ornamental plants**  
A series of R&D collaboration consisted of two consecutive collaborative projects about the development of production process of micro tuber of ornamental plant for export market carried out with two related industrial firms. The R&D collaborative projects were followed by a licensing project. There were three firms involved in this case. They have business relationship as supplier, producer, and marketing arm. Interestingly, the ownership of products, production processes and techniques resulted from the collaborations are clearly planned from the very beginning of the collaboration. The final product, which is the particular strains of an ornamental plant, belongs to the first two partners involved in R&D collaborative projects. Production processes developed belongs to BIOTEC. BIOTEC licensed production technique to the third firm who commercially produce the micro tuber. Note that the licensee firm has been working with the two industrial partners and has received technology transfer from BIOTEC in a similar production process recently. The licensee is chosen at the beginning of the collaboration and it is included in the second research project at the later stage of the research activities when the work is near to commercialisation stage. |
| 5    | **Expression and characterisation of enzymes for animal feed production**  
The partner firm in this case is a tenant in Thailand Science Park. The firm is a subsidiary unit acting as the research arm of a large agricultural firm which has extensive range of animal food products and services. The R&D collaborative project was about identifying suitable fungal to be used as an ingredient in the production process of animal feed. It was considered as the first formal collaboration between BIOTEC and the firm following from a number of their meetings and discussions to initiate research partnership. Similar circumstances to Case 3 appeared in this R&D collaboration. Given that, the BIOTEC researcher was responsible for almost all laboratory work, while the firm tend to rely on the researcher to do the majority of the work. Somehow, the firm did not take the results further into practice. |
| 6    | **Development of feeds for Black Tiger Prawn**  
The case exhibits different feature from the other projects in terms of project initiator and origin of research ideas. The researcher, who has worked in shrimp industry for over a decade, played significant role in initiating the project by identifying the root caused of the problems in shrimp farming which mainly related to quality and nutrition of shrimp feed and feeding technique, then formulated research collaboration. Due to the nature of the research about industrial production and utilisation of shrimp feed, the research activities in the project incorporated several parties including suppliers of raw materials and users who are shrimp farm. Outcome of the collaborations includes licensing of the production technique to four shrimp feed producers. The technological innovation and transfer in this case is refer to linear process where by codified knowledge is developed then license to firms willing to exploit the research results under licensing contracts. |
<table>
<thead>
<tr>
<th>Case</th>
<th>Synopsis</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td><strong>Extraction of Thai-plant derived for cosmetics products</strong>&lt;br&gt;BIOTEC worked with the partner firm in this case under their joint research agreement. The case is about extraction of plant-derived for cosmetic ingredients. BIOTEC and the research partner in this case have been working together in the area of biodiversity research. They have jointed patent regarding identifying potential activities in in-vitro tests in six plant species. This is a catalyst for their further research and development of cosmetics ingredients and skin care products. The partner firm had set up their office in Thailand Science Park. However, it is only meant to be coordinating office.</td>
</tr>
<tr>
<td>8</td>
<td><strong>Study of microbial diversity on facial skin</strong>&lt;br&gt;This project was organised as a part of research activities under the joint research agreement with the partner firm, the same firm in the Case 7. The project was about the study of microbial diversity of Thai female facial skin was carried out with the same partner firm as the one in Case 7. In this case, the work between firm and the research centre were complemented in that the laboratory work will be carried out by BIOTEC and the firm collected data from the research volunteer. This collaboration was followed from the preliminary project that the partner firm worked with BIOTEC to confirm compatibility and possibility of technology before fully enter into collaborative project.</td>
</tr>
<tr>
<td>9</td>
<td><strong>Isolation and characterisation of microorganism from Thai natural resource for pharmaceutical uses</strong>&lt;br&gt;The collaboration in this case originated from long-time professional contacts and networking of BIOTEC’s senior researchers and the partner firm. They have signed a three-year partnership agreement aimed at developing new medicines based on natural products found in Thailand. The first phase of the partnership was from 2005 to 2008 with the emphasis on the isolation of fungi. The second phase also last three years, from 2008 to 2011, focuses on the isolation of bacteria.</td>
</tr>
<tr>
<td>10</td>
<td><strong>Prototype production of Umani, a food additive from Soya bean</strong>&lt;br&gt;This case was followed from previous contract research between BIOTEC and the partner firm in order to create new production process. However, the firms did not appear to make a substantial contribution beyond financial and occasional discussion related to the process developed. The project was relatively short. Time span was only three months. There is a patent resulted from this project. Also, after this project there was continuous relationship between the firm and BIOTEC. The firm will hire BIOTEC to produce the seasoning powder.</td>
</tr>
</tbody>
</table>
Case | Synopsis
---|---
11 | Development of production process of medical grade stainless steel for orthopaedic devices

The case involved sophisticated technique for the production of orthopedic implant device. The technique used was the metal injection moulding (MIM®) in which MTEC is renown in this area of expertise. The partner firm, who was technology-intensive SMEs, wanted to gain access to MTEC’s equipments and expertise in order to efficiently fabricating medical device by mixing engineering plastics and stainless steel using MIM technology. There was personal connection between the researcher and the partner firm resulting from prior contract work.

12 | Development of production process for commercially pure titanium and titanium alloy (Ti6-Al-4V) for automotive industry

This case is considered as one of the unique cases among the 19 studied cases, exhibiting intensive interactions and involvement of the research partners, as well as strong tie of relationships. The case involves two projects between MTEC and a Japanese firm operating in Thailand; the first one is one-year collaborative project to find optimum condition for fabricating Titanium Alloy using MIM technology and the second one is two-year collaborative project to fabricate Titanium Alloy for automotive parts using MIM process. In addition, these two projects also have a subsequent ongoing project.

The origin of this collaboration is based on referral from the Japanese MIM consortium. The Japanese partner firm initially prefers contract research. However, MTEC foresees that the collaborative projects benefit in a larger extent in terms of knowledge sharing between the partners, human resources, research facilities, and technological opportunities for local industry. Moreover, besides the strategic reasons in entering into the research collaboration, research motivations in this case include access to materials and external teams, gain financial resource, and most of all research challenges to MTEC research team.

13 | Application of 3D scanner technology for automotive spare part manufacturer

Application of 3D scanner in production process of automotive spare parts. Using 3D scanner in production line for automotive parts was considerably new to the local industry. The partner firm was a SME with limited resource and related knowledge-based regarding the MIM technology. In this case, collaborative research project was preferred by the firm rather than contract research to cover risk sharing and cost reduction for the partner firm. The research and the firm had informal interaction through consultancy project in which MTEC researcher acted as a third party to evaluate performance of a consultancy project between the firm and university.

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67 MIM is a manufacturing process that combines plastic injection moulding and powder metallurgy technologies.
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<td>14</td>
<td><em>Development of large packaging for overseas transportation of rubber resin</em>&lt;br&gt;Another case involving collaborating with SME having limited resource and technological knowledge-based. The case involved the development of plastics packaging for overseas transporting of rubber resin. Typically, aluminium container has been used to transport rubber resin. To export the resin, the cost of this aluminium container is considerably high. Thus, the idea of the project is to find alternative packaging for this purpose. The partner firm could have hire MTEC to do the research. On the contrary, the collaborative project was developed. Again, with the reason to help the firm funded the project.</td>
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<td>15</td>
<td><em>Development of transmission system for small form tractors</em>&lt;br&gt;The case involved development of transmission system of small form tractor. The partner firm was large local tractor manufacturer. The project initiated from the referral of university researchers who had worked with the firm as its consultant. Unlike some cases of MTEC collaborative projects which had modest involvement of the partner firm in the course of research activities during the project. This project required firm’s involvement not only the field test, but also the market information such as user preferences and requirements.</td>
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<td>16</td>
<td><em>Development of innovative plastics film for greenhouse to reduce solar heat</em>&lt;br&gt;Collaboration between MTEC and a large international firm in chemical industry. A two-year R&amp;D collaborative project started in 2008 to apply the firm’s pigments as additives to develop plastic films for greenhouse uses in tropical countries. Due to MTEC’s outstanding expertise in plastic processing technology, the firm collaborated with MTEC to access complementary knowledge. Unlike the other collaborative projects in which field tests are mostly carried out by the partner firms, this project involves a university as research partner responsible for field-testing of the greenhouse plastic films. This is because the firm itself does not have such testing facilities and experiences in the usage of the product.</td>
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| 17   | **Speech technology synthesis engine (text-to-speech synthesis engine)**  
      The case was about speech technology concerning Thai text-to-speech synthesis engine. This project is initiated in 2004 and continued until 2007. The project involved two firms (one large and one small), and one overseas public organisation. The content of collaboration efforts are primarily customisation of NECTEC’s existing technology for different purposes and uses of the partners. |
| 18   | **Development of electronics nose for food industry**  
      This collaborative project shows linear process type of research work. That is NECTEC researcher set up the project, developed technical contents in-house, evaluated technology trend and its applications, and finally looked for industrial partners to apply the research results by initiating research collaboration for further industrial development of the related technology. The firm is brought in to fulfil the research spectrum.  
      More precisely, at the early phase of this research, NECTEC proposed for ‘synergy fund’, the one-off initiative of NSTDA that made available in 2005 for collaborative projects between research centres or research centre and university as well as industry. The research idea of developing electronic nose is funded as the project incorporates four research partners that is; NECTEC develops electronic and hardware, MTEC develops sensor materials, NANOTEC syntheses new nano-materials, and Mahidol University studies software for scent detection and analysis. After the collaboration of these four partners, prototype of the electronic nose is developed. Then NECTEC carries on the work by looking for industrial partner for research collaborative project. |
| 19   | **System development for telecommunication business**  
      This project was about system development for a large telecommunication firm. It is the firm’s objective to lower licensing fee paid to foreign company for technology used in its system by developing its own applications. However, the firm does not have adequate technical and human resources to conduct in-house project. The origin of the collaboration is from recommendation and suggestion of one of NECTEC senior advisor who has good relationship with the firm |