

UNIVERSITY AND INDUSTRY COLLABORATION IN JAPAN AND
THAILAND: INFLUENCE OF KEY ACTORS' CHARACTERISTICS
AND MODES OF COLLABORATION

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Siriporn Pittayasophon

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Abstract

In university–industry collaboration (UIC), the influence of key actor characteristics on mode of collaboration and the influence of mode of collaboration on outcome have attracted researcher attention and influenced policy makers’ practices. Nonetheless, those two issues have not been well researched or extensively discussed. In that light, the present study aimed to investigate the influence of key actor characteristics on collaboration mode and the influence of collaboration mode on collaboration outcome.

The salient findings are summarized as follows. In Japan and Thailand, university type, firm size and industrial sector are determinants that influence collaboration mode. With regard to collaboration mode, university–industry collaboration in Japan is based on R&D activities, whereas university–industry collaboration in Thailand is based on cooperative education and consultation. Consultation mode seems to be important in the Thai case. More importantly, when consultation mode is used to complement to R&D mode, it seems to enhance collaboration outcomes. Type of collaboration mode is a determinant influencing collaboration outcome. Intellectual property is an important collaboration outcome in the Japanese case, whereas product and process innovation and product and process improvement seem to be important collaboration outcomes in the Thai case.

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Chapter 1

Introduction

1.1 Background

In University–Industry collaboration (UIC), two issues—the influence of key actors’ characteristics on collaboration mode and the influence of mode of collaboration on outcomes—have attracted research attention and influenced policy makers’ practice. To investigate these two issues, the existing literature is summarized to provide background for this study.

A system of innovation is defined as all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovations (Edquist, 1997). It consists of components and activities. Components are key actors (including firms, universities, and government agencies) and institutions (e.g., laws, values, and regulations), whereas activities affect the development and diffusion of innovation (Edquist, 1997). With regard to activities such as knowledge creation and diffusion, universities are key actors because they can create and disseminate knowledge in the forms of worker education and research and development (Etzkowitz & Leydesdorff, 2000; Van Looy et al., 2006). In that light, scholars from three schools of thought—national innovation system (NIS), triple helix, and technology management—have conducted extensive studies of the nature and effectiveness of university–industry collaboration.

The most specialized and well-known group is scholars in the so-called “triple helix” school of thought. The triple helix concept is based on the fact that bilateral

relations between government and university, university and industry, and government and industry have expanded into triadic relationships among the spheres. However, regarding collaboration between university and industry, Etzkowitz (1998), a triple helix scholar, concluded that each institutional sphere takes on the role of the other spheres to perform new roles beyond their traditional functions. While NIS researchers basically claim that sources of knowledge and innovation are generated by various actors in a system of innovation, triple helix research defines the university as the primary collaboration source of human resources, knowledge, and technology that embraces a mission of economic and social development.

Similarly, Wissema (2009) also stated that the university plays a crucial societal role as a source of fundamental knowledge. In knowledge-based economies, the needs of society pressure the university to gear its activities to be relevant to industry. Wissema also claimed, for example, that government policies or programs (science parks, business incubators, public seed capital funds, Bayh-Dole Act, etc.) have been initiated to pressure the university, which has led to a shift from the university's traditional mission (teaching and research) to commercialization. Due to both societal needs and government pressures, Wissema (2009) and Kyrö (1997) found that entrepreneurship emerges and promotes change in the university toward knowledge-based economies. In contrast, Martin and Etzkowitz (2001) concluded that interaction among institutional spheres influences the structures and functions of universities. Consequently, different "species" of universities have emerged over time, such as the national university, technical university, regional university, private university, and corporate university. Kondo (2008a, 2009) found that in Japan, university types are

related to R&D collaboration due to government control. National universities were found to be dominant in joint R&D activity, whereas commissioned R&D was a frequent mode for the private universities. Likewise, national universities had the highest share of technology licensing fees, as well as the highest number of spin-offs and start-ups. Reflecting those findings, this study follows the Japanese university classification presented in Kondo's studies to examine why certain universities are dominant in some specific modes (not only R&D and technology licensing mode), whether types of universities are related to the size of collaborating firms, and whether local or national contexts have impacts on collaboration.

However, the flow of collaboration does not depend on only the university. The firms' specific nature, such as firm size, industrial sector, and technological capability, is also a main factor. Nonetheless, the influence of firm characteristics (e.g., firm size, industrial sector, and technological capability) on the collaboration has been debated among scholars. For example, some scholars agree that larger firms tend to collaborate more than small firms (Arundel & Geuna, 2004; Cohen et al., 2002; Laursen & Salter, 2003; Mohnen & Hoareau, 2003), but Best (2001) argued that this conclusion may not be true because of the emergence of small high-tech firms in the United States and Taiwan. In term of the industrial sector, Rasiah and Chandran (2009) mentioned that the intensity of R&D collaboration varies by industry. Scharfetter et al. (2002) identified similar results in the case of Austria, in that high-technology sectors have high levels of interactions whereas low-technology sectors have weak interactions. However, scholars have debated these issues.

Various modes are used to transfer knowledge, such as collaborative R&D, consultancy, technology licensing, and human mobility. Despite providing a comprehensive framework, triple helix scholars have not paid much attention to this issue, unlike those of innovation studies (Agrawal & Henderson, 2002; Cohen et al., 1998; Cohen et al., 2002; Shane, 2002). They attempted to analyze the importance of the modes through which knowledge flows from university to industry. Nonetheless, these studies did not clearly identify the most effective mode that may be evaluated by assessing outcomes (Bekkers & Freitas, 2008). Interestingly, several studies have reported the importance of a combination of various collaboration modes (D'Este & Patel, 2007; Meyer-Krahmer & Schmoch, 1998), but the studies did not clearly explain how a combination of various modes or complementary mode is important.

In that light, this study is an investigation of three issues: the influence of university type on collaboration mode, the influence of firm characteristic on collaboration mode, and the influence of collaboration mode on collaboration outcome. To understand the differences among national systems, the influence of national system on those three issues is also examined.

1.2 Objective and Scope of the Study

The main purpose of this study is to investigate how key actors' characteristics affect the collaboration modes, the extent to which a combination of various modes affect outcomes, how the national systems influence the relationship between key actor characteristics and collaboration modes, and the influence of a combination of various collaboration modes on outcomes.

A combination of quantitative and qualitative research approaches was used in this study. First, econometric analysis was used as the quantitative approach. Second, the qualitative approach was used to modify existing theory. In-depth and semi-structured interviews of universities' executives responsible for university and industry collaboration, such as technology licensing offices, incubators, academic service centers, and others, were conducted. This is complemented with interviews of policy makers and existing documents.

This study was guided by the following key research questions:

Research question 1: Influence of university type (qualitative approach: modification of theory)

- Do university types relate to modes of collaboration? If so, why? If not, why not?
- Do university types relate to firm size? If so, why? If not, why not?
- In a certain local area, do different types of universities play different roles in supporting industry? If so, why? If not, why not?
- Do country contexts matter? Specifically, do the same types of universities in different countries use same distinctive collaboration modes?

Research question 2: Influence of firm characteristics (quantitative approach: hypothesis testing)

- Do firm characteristics (firm size and industrial sector) affect modes of collaboration?

Research question 3: Influence of mode of collaboration on outcome

(quantitative approach: hypothesis testing)

- Do the modes relate to each other? And how do these relationships between modes affect outcomes?

In this study, the units of analysis consist of two levels (macro and micro level). At the macro level (country), Japan and Thailand are selected for a comparative analysis because Japan is the top foreign investor in Thailand and foreign direct investment (FDI) is important for technology transfer. At the micro level (university), three types of universities—namely *national university*, *local public university*, and *private university*—are analyzed. Finally, at the micro level (firm), this study uses two large sources of data: the National Survey of R&D and Innovation Activity and the National Graduate Institute for Policy Studies (GRIPS) Firm Survey.

1.3 Structure of the Study

Chapter 1 is an introduction to the background of this study. Chapter 2 is a review of the existing literature on university and industry collaboration. It starts from the national innovation system, which consists of three key actors: the government, university, and firm. Then, it describes the triple helix concept, which stresses the leading role of the university in the system of innovation; however, the university's role can be changed due to government policies and society's needs. In this study, the literature on the influence of university types on collaboration modes in Japan is reviewed. Different types of universities are supposed to have different functions, which affect the selection of collaboration modes. Besides, the influence of firm characteristics

on collaboration modes, types of collaboration modes, and possible collaboration outcomes are reviewed in this chapter.

Chapter 3 presents two research methodologies used in the study: (1) the use of quantitative method for firm-level analysis and (2) qualitative method to modify theory for university-level analysis.

Chapter 4 is a summary of the historical background on university and industry collaboration in Japan and Thailand. It summarizes the turning point and evolution of university and industry collaboration policies. In addition, the university systems and firm's technological capabilities are also reviewed.

Chapter 5 is a discussion of the results from the interviews with Japanese and Thai universities' executives who are responsible for university and industry collaboration, complemented by the interviews of policy makers and experts. The influence of university type on collaboration mode was examined. Japan and Thailand were comparatively analyzed to understand the influence of country context on university and industry collaboration.

Chapter 6 is a survey data analysis. In the case of Japan, this study applied data from the Teikoku Databank Survey of Business Trends. In the case of Thailand, the National Survey of R&D and Innovation was used to analyze the influence of firm characteristics on collaboration modes and the influence of collaboration modes on

collaboration outcomes. These issues were also comparatively analyzed between two countries.

Chapter 7 is a conclusion of the main findings, which are on the influence of key actors' characteristics on collaboration mode, the influence of collaboration mode on collaboration outcome, and the impact of national innovation systems on those findings. Finally, theoretical contributions are suggested to partially fill the gap of knowledge, as are policy recommendations to foster university and industry collaboration.

Chapter 2

Literature Review:

University Types, Firm Characteristics, Modes, and Results of Collaboration

2.1 Introduction

There are several schools of thought in studying university and industry collaborations, including the national innovation system, triple helix, and technology management schools, because collaboration has been considered as one of the main factors contributing to successful innovation in the past two decades (Leydesdorff & Fritsch, 2006; Majid & Ismail, 2009; Iqbal et al., 2011). The evidence to confirm the aforementioned statements is that some of the most prestigious universities in the United States (e.g., the Massachusetts Institute of Technology or MIT) were established more than one century ago and one of their main missions was to support close research relationships between the university and industry (Etzkowitz, 1997; Santoro, 2000).

University and industry collaboration has been studied extensively due to its importance. Nonetheless, scholars have been debating several issues. First, universities historically developed into various types with different specialties (Martin & Etzkowitz, 2001; Wissema, 2009). Based on the studies of Kondo (2008a, 2009), national universities were dominant in joint R&D activity, whereas commissioned R&D was a frequent mode for private universities. He concluded that government control affects the relationship between university type and R&D collaboration. This dissertation covers various kinds of collaboration and identifies other factors (excluding government control and source of revenue) to examine why universities are dominant in some

specific modes and whether local contexts and country contexts have impacts on the collaboration. Second, the existing literature indicates the influence of firm characteristics (firm size and industrial sector) on the intensity of collaboration, but these issues have been debated extensively. Third, most existing studies have investigated the importance of modes of collaboration, but they do not particularly examine the extent to which the use of various modes affects the results.

The structure of this chapter comprises six sections as follows. Section 2.2 reviews the existing concepts of university and industry collaboration. Section 2.3 discusses how the roles of universities in national innovation systems have evolved over time and which university types have emerged from those evolutions. Section 2.4 summarizes how firm characteristics affect university and industry collaboration. Section 2.5 explores which modes the universities use to collaborate with industry and how those modes are classified. Section 2.6 studies the possible results of university and industry collaboration. Section 2.7 draws conclusion from the literature review and identifies the direction and the theoretical contribution of this study.

2.2 Literature on the Concept of University–Industry Collaboration

As mentioned earlier, the ideas and concepts associated with university and industry collaborations are not new. Several scholars have attempted to study university and industry collaborations. This section compiles two main concepts that contribute to university and industry collaboration.

2.2.1 National Innovation System Concept. The contribution of the national innovation system (NIS) is immense. Indeed, the basic idea of the NIS constructed by several scholars is to show how institutional spheres, including university, industry, and government, interconnect to create, develop, and diffuse knowledge, technology, and information. This section describes the works of six scholars that have had a formative influence on the concept of NIS.

The starting point of the NIS concept can be traced back to Friedrich List's concept of the national system of political economy (1841). This idea is related to the broad policies involved with learning about new technology and applying it. In order to generate new discoveries and inventions, industry should be connected to the formal institutions of science and of education.

Chris Freeman was also a pioneer in the concept of innovation. To him, innovation is an interactive process and is not a linear process in which innovation automatically comes out of R&D efforts (Freeman, 1982). This idea led to the NIS concept, in which the initiation, importation, modification, and diffusion of new technologies are generated by interaction between the public and private sectors (Freeman, 1987). The concept is similar to List's idea, which assumes that firms need the relationships among institutional spheres and international factors to innovate. Formal and semi-formal, flexible networks of innovators were required to facilitate access to various sources of external knowledge (Freeman, 1991).

Bengt-Åke Lundvall's (1992) idea is similar to Freeman's idea, in stating that innovation is an interactive process. Lundvall stated that a system of innovation is constituted by elements and relationships that interact in the production, diffusion, and use of new and economically useful knowledge. A national innovation system encompasses elements and relationships, either located within or rooted inside the borders of a nation state. In 1995, Lundvall proceeded to establish a more detailed definition that included all aspects of the economic structure, institutional set-up, marketing system, and system of finance. In term of the relationship between the university and both innovation and economic development, Lundvall (2007) concluded that the university needs to give long-term contributions to knowledge creation. The important role of the university is not to be incubators for start-ups or for patents. To establish a closer interaction with the rest of society, educational reforms—including the introduction of problem-based learning as a teaching method (i.e., a closer interaction between theory and practice)—is needed.

Richard Nelson and Nathan Rosenberg (1993) treated innovation broadly. Innovation is a concept that covers the process by which firms master and practice product and manufacturing processes that are new to them, if not to the world or to the nation. The NIS, in their idea, is a set of institutions whose interactions determine the innovative performance of firms. The institutional actors involved work together smoothly and coherently; however, the public and academia can support—but may not substitute for—the technological efforts of firms (Nelson & Rosenberg, 1993, p. 20). The development of human capital via education and training is essential for fostering

absorptive capacity. In addition, they argued that the concept of NIS is too broad and proposed a sectoral approach to the concept of systems of innovation.

Charles Edquist (1997) provided a different point of view from those of other scholars on the impact of innovation. He argued that innovation is the most important source of productivity growth as well as a major cause of the destruction of old jobs and the creation of new employment. However, his idea is similar to the concept of Freeman and Lundvall (1995). He stated that innovation processes occur over time and are influenced by a variety of interdependent and interactive factors. Firms rarely innovate in isolation; rather, they interact with other organizations to exchange, develop, and gain knowledge, information, and other resources. These organizations can be firms, universities, research laboratories, financial institutions, and government institutions. Organizations are likely to differ across national systems. These organizations also shape the behavior of firms. In contrast to the concept of Nelson and Rosenberg, Edquist (1997) defined and extended the boundaries of the innovation system from national to supranational (integrated Europe), regional within country (Silicon Valley in California), and local at the same time. A system of innovation, in his sense, is all important factors (economic, social, political, organizational, and other factors) that influence the development, diffusion, and use of innovations. In addition, Edquist (1997) concluded that we can identify the boundaries of system of innovation in three ways: geographically, sectorally, and in terms of activities. With regard to activities, he lists ten activities: (a) R&D, (b) building competence (education and training), (c) forming new product markets, (d) articulating quality requirements emanating from the demand side with regard to new products, (e) creating and changing organizations (e.g.,

enhancing entrepreneurship), (f) networking through markets and other mechanisms, (g) creating and changing institutions (e.g., patent law, tax), (h) incubation, (i) financing innovation processes that can facilitate commercialization, and (j) providing consultancy services. As research gaps for further study, he asked “which activities of which actors are important for the development of innovation” and if it is “possible to distinguish between important activities and less important ones” (Edquist, 1997, p.123). However, some scholars stated that this list may be useful for managers and policy makers (Liu & White, 2001) but it is not obvious how it leads to more rigorous theory (Lundvall, 2007).

2.2.2 Triple helix concept. The triple helix concept originated from Sabato’s triangle, in Jorge Sabato’s (1960) study of Latin America called. His intention was to construct a vigorous science and technology infrastructure linked to the productive structure of society through the coordination of the main actors of society: the government, industry, and the university. This concept assumes that the government should have an active role in stimulating and facilitating the creation of innovation (Mello, 2011).

In contrast to Sabato’s triangle, the triple helix model posits multiple sources of initiative that arise from each sphere individually and in collaboration with one or two others (Ranga & Etzkowitz, 2013). The relationship among three spheres (government, university, and industry) has emerged from different starting points in various parts of the world, but for the common purpose of stimulating knowledge-based economic development. The university is primarily seen as a source of human resources,

knowledge, and technology. Furthermore, advocates of the “triple helix” concept claim that universities have embraced economic and social development as a new mission, apart from their traditional missions of teaching and research (Etzkowitz, 1998). To this point, the interaction between the university and industry is likely to shift to becoming entrepreneurial in order to get closer to and respond to industry needs. However, Eun (2009) discovered that firms do not always rank commercializing science and technology knowledge as an important function of universities like education and training. He stressed that maximizing the strength of the university and industry collaboration at the expense of the traditional functions of universities (education and training) may not be the right policy to implement.

Recently, the key features of triple helix interactions have been introduced into an “innovation system” format, defined according to the systems theory as a set of components, relationships and functions (Ranga and Etzkowitz, 2013). First, among the components or actors of a system, the triple helix theory distinguishes between actors.

R&D and non-R&D innovators. R&D innovators in triple helix system are academic research groups and research centers in universities, company R&D divisions and public research organizations. In contrast, non-R&D innovators do not engage in R&D activities such as marketing, sales, and personnel training.

Single-sphere and multi-sphere (hybrid) institutions. A single institutional sphere is described as a rigid institutional boundary that has a low level of interaction with another sphere. It has a high degree of specialization and centralization, and limited

staff mobilization. On the contrary, hybrid institutions have smaller-scale hierarchies, with fewer layers and less centralized decision-making, in order to increase flexibility and responsiveness to changing market demands, such as technology transfer offices, industrial liaison offices, business support institutions (science parks, incubators, start-ups), and financial support institutions (venture capital firms, seed capital funds).

Second, the relationships among those actors can be classified into five main types.

Technology transfer. In university structures, several organizations—including technology transfer offices, science parks, business incubators, start-ups, and venture capital capacities—have been created as intermediary elements to facilitate the capitalization of knowledge and ensure interfacing with the external partners.

Collaboration and conflict moderation. Task conflicts can sometimes occur within the university, when third-mission activities are against long-established academic norms, procedures, and reward systems. Relationship conflicts are sometimes found in collaboration between universities and industry because of cultural differences and diverging interests, which perhaps hamper knowledge exchange and transfer.

Collaborative leadership. Innovation organizers at both the individual and institutional levels play a key role in collaborative relationship. They can gather people associated with different points of views to discuss ideas, compromise conflicts, and generate consensus.

Substitution. When another sphere is weak, substitution arises to fill emerging gaps. Substitution between spheres is described as government agencies taking up other functions that are beyond their traditional functions.

Networking. Informal and formal networking at the regional, national, and international levels is not a unique activity; it is widely found in many cases, such as R&D collaboration.

Third, the triple helix system emphasizes its function on effective flow of knowledge and technology through interconnections among key actors. As a result, the recent perspective on the triple helix concept could provide an explicit framework for the systemic interaction between actors and clarify a view of knowledge flows and resources within and among the spaces.

The NIS and triple helix concepts are both associated with the same ideas on flow of knowledge and technology through interaction among institutional spheres. The NIS approach basically believes that sources of knowledge and innovation are generated by various actors in a system of innovation, whereas the triple helix concept states that the university plays a leading role (Etzkowitz & Leydesdorff, 2000). Triple helix scholars also believe that the institution can take the roles of the others to perform new roles as well as to fulfill their traditional functions. However, Nelson and Rosenberg (1993) explicitly stated that the public and academia should support firms in developing technology rather than substituting for the technological efforts of firms.

2.3 Emergence of University Type

2.3.1 Historical evolution of the university. Similar to the triple helix scholars' ideas, Wissema (2009) also agreed that the university plays a crucial role as a source of fundamental knowledge. In knowledge-based economies, the needs of society propel the university to gear its activity to be relevant to industry. Besides, the role of government influences the university's behavior. First, because of limited resources, the government may not be able to allocate funds for cutting-edge or frontier scientific research. Second, the government can pressure the university, leading to a shift from traditional mission (teaching and research) to the exploitation of their knowledge for society. The establishment of several initiatives is evidence to indicate the influence of the government's role on the university. Public seed capital funds and bridging institutions have been initiated since the 1970s. Besides, government efforts can be indicated from the Bayh–Dole Act of 1980 in the United States and the Bayh–Dole Act of 1990 in Japan, which are widely credited with improving university and industry collaboration and technology transfer in the United States and Japan.

Due to both societal needs and government pressures, Wissema (2009) as well as Kyrö (1997) found that the university has transitioned. Table 2-1 shows Wissema's university generation. The medieval universities—the first generation of university—had as their main functions to provide education and to comply with the doctrines of the church. These universities were based on the use of Latin language and academic freedom. The second-generation university enhanced the meaning of research based on the modern scientific method, including objective, systematic, and reproducible experimentation and transparent argumentation. Third-generation universities were

experimenting with models for commercialization or exploitation of know-how, as well as with new organizational structures, marketing activities, and ways of financing. In this transitional stage, entrepreneurship again emerged as a means of facilitating and carrying out the change as well as driving economic growth (Wissema, 2009). Notably, the definition of entrepreneurship has been varied (Paasio et al., 2006, p. 22, in Kyrö & Mattila, 2012). In the concept of Wissema, entrepreneurship is a tool to enhance technology transfer and to raise the competitiveness of universities, whereas in the entrepreneurial university concept, it has a proactive role in advancing the economy, welfare, and equality in societies.

Table 2-1: Evolution of the Universities

| Characteristic | 1st generation | 2nd generation | 3rd generation |
|-----------------------|----------------------------------|----------------------------------|--|
| Objective | Education | Education + Research | Education + research + know-how exploitation |
| Role | Defending the truth | Discovering nature | Creating value |
| Method | Scholastic | Modern science, monodisciplinary | Modern science, interdisciplinary |
| Creating | Professionals | Professionals + scientists | Professionals + scientists + entrepreneurs |
| Orientation | Universal | National | Global |
| Language | Latin | National languages | English |
| Organization | Nations, faculties, colleges | Faculties | University institutes |
| Management | Chancellor | Part-time academics | Professional management |

Source: Wissema (2009)

In contrast to Wissema's concept, Kyrö (1997) found that entrepreneurship emerges and promotes change, but for Wissema's university generations, entrepreneurship was only employed to enhance change in the latest transition (the third generation of universities). The main difference between Wissema's (2009) third-generation university (which harnessed entrepreneurship) and Kyrö's entrepreneurial

university (1997) is that the entrepreneurial university concept has the culture, mindset, and spirit of entrepreneurship stemming from education. On the other hand, the third-generation university has built-in entrepreneurial elements. Kyrö and Mattila (2012) stated that these characteristics of the third-generation university bring about technology transfer as the main channel of entrepreneurship, whereas entrepreneurial university takes entrepreneurship through an educational path. They also provide an example to compare between the third generation of universities and the entrepreneurial university. Whereas the third-generation university concept draws its premises from technological transfer, the entrepreneurial university focuses on the entrepreneurial process, which needs to change society and economy; therefore, further university practices relate to cultural change within institutions, as well as to curriculum development and instruction.

This comparison implies that the third-generation university concept neglects education as a crucial channel for the foundation of entrepreneurial spirit. Teachers can mentor students to start firms for only a short period, but if the entrepreneurship is not embedded in the ways of thinking among students, they cannot sustain their startup firms without mentors.

2.3.2 Emergence of different university types. In contrast to Wissema's (2009) concept, Martin and Etzkowitz (2001) found that interactions among key actors affect universities' structures and functions. Consequently, different species of universities have emerged. Examples of universities for each type were provided in their study. First, the national university or classical university gradually transformed over

time, depending on the national environment, such as the Ivy League universities in the United States and the imperial universities (which subsequently become the national universities) in Japan. Second, the technical college (or university) appeared in Europe and was then transferred to elsewhere, such as the Tokyo Institute of Technology in Japan. Third, regional universities were explicitly set up to meet local or regional needs, initially agricultural needs but more general industrial needs later on, such as the land grant universities in the United States. Fourth, hybrid universities were created in several forms, such as combinations of Ivy League and land grant universities (Cornell University in the United States) and hybrids of traditional universities with open universities (distance learning). Fifth, a networked university either involved the vertical integration of further education colleges with a university to form an integrated supply chain or the horizontal integration of similar departments across several institutions working together, such as the Fraunhofer Institutes in Germany. Sixth, company universities established by companies are new entrants that provide skills and training to their employees. Seventh, the entrepreneurial university species predicted by Etzkowitz (1997) emphasizes commercialization as well as teaching and research.

Although several scholars have made efforts to discover emerging types of universities and to reclassify the types of universities (perhaps reflecting the explicit roles and specializations of universities), their ideas have never been put into practice. Apart from Martin and Etzkowitz (2001), the Central Council for Education (CCE; Chukyoshin) in Japan proposed a classification of universities by type in 1971, but it met with strong hostility from universities (Osaki, 1999, cited in Kitagawa & Oba, 2010). More than 30 years later, the CCE suggested the following seven functions as

exemplars that individual universities might prioritize according to their policies: a world-class research and education center, the development of highly qualified professionals, the development of a wide spectrum of professionals, comprehensive liberal arts education, education and research in specific disciplinary areas (art, sport, etc.), a community-based lifelong learning center, and service to society (service to the local community, industry–academic collaboration, international exchanges, etc.). Similarly, for Thailand, Areekul (2000) and Suwan et al. (2003) proposed a university classification that consists of three types of universities. First, the *research university* has as its main missions to provide teaching for master’s- and doctor’s-level programs, as well as bachelor’s-level programs in needed fields, and to focus on basic and applied research in order to gain frontier knowledge and/or technology for economic and social development. Second, a *teaching university* has the missions of providing teaching for bachelor’s- and master’s-level programs in response to market and societal needs, and to provide academic service to society. Third, a *community college* has the mission of providing people with educational opportunities. It focuses on teaching and learning for lower-bachelor’s-level programs, in order to develop human resources in response to the local community.

2.3.3 Current university classifications in Japan and Thailand. In order to select appropriate cases for comparative analysis between Japan and Thailand, this section is a review of the current university classifications in both countries. When comparing the Japanese and Thai university classifications, Japanese national universities are similar to Thai public autonomous universities, in that both focus on research activities and largely receive their budgets from the central government

(National Education Act, 1999; National University Corporation Law, 2004). In addition, Thai autonomous universities receive significantly more financial support from the private sector than Thai public universities (Rungratsamee, 2004). This phenomenon is similar to Japanese national universities, as seen from the studies of Kondo (2008a and 2009). National universities are dominant in R&D collaboration. According to the MEXT document, Japanese public universities in Japan were established and managed by local public entities or public university corporations to provide higher education opportunities to local people and to serve as intellectual and cultural centers within the local community. In contrast, Thai local governments do not directly provide financial support to higher education institutes. Even with different budgetary sources, however, the missions of Japanese public universities are similar to those of Rajabhat University and Rajamangala University of Technology. They put great emphasis on local development (MEXT online document; Rajabhat University Act of 2004; Rajamangala University of Technology Act of 2005). Also local community has a substantial role in governing the universities. In case of Rajabhat University, local community participation is required in the selection process of a president and university council members must consist of an expert in the area of local administration. Similarly, council members of Rajamangala University of Technology consist of experts, local companies' executives, provincial public prosecutors, and local government officials. Private universities in Japan and Thailand, which are established by private individuals, also have high degrees of autonomy. Each private university can design academic curricula and has the autonomy to promote its own unique education and research activities, based on the spiritual legacy of its foundation (MEXT and Office of Higher Education Commission). To sum up, this study focuses on examining

the differences and similarities in university and industry collaboration across three main types of universities: national universities, local public universities, and private universities.

2.3.4 Relationship between university type and university–industry

collaboration. Kondo (2008a) concluded that the Japanese national universities were dominant in joint R&D activities. They conducted 7,774 joint R&D projects with companies, followed by private universities (743 projects) and public universities (347 projects). On the contrary, private universities were key actors in commissioned R&D. They carried out 4,175 projects, whereas the national universities conducted 1,563 commissioned R&D projects. Additionally, the national universities applied for a higher number of patents than the other two types of universities, and the amount of technology licensing revenues generated by the national universities is the highest. Likewise, the national universities emphasize creating new entrepreneurs, as seen from number of start-up consultation offices (Table 2-2).

Table 2-2: Relationship between University Type and University-Industry Collaboration

| University Type | R&D Collaboration | | | | Domestic Patent Application (item) | Licensing Income (thousand yen) | Start-up Consultation Office (%) |
|-------------------------|---------------------|--------------------------------|-----------------------------|--------------------------------|------------------------------------|---------------------------------|----------------------------------|
| | Joint R&D (project) | Collaborating firm (% of SMEs) | Commissioned R&D (contract) | Collaborating firm (% of SMEs) | | | |
| National University | 7,774 | 35.4 | 1,563 | 27.6 | 3,756 | 415,997 | 70.1 |
| Local Public University | 347 | 41.2 | 621 | 23.3 | 115 | 1,619 | 35.8 |
| Private University | 743 | 28.8 | 4,175 | 27.0 | 1,214 | 124,893 | 20.6 |
| Total | 8,864 | 35.1 | 6,359 | 26.8 | 5,085 | 542,509 | |

Source: Kondo (2008a).

2.4 Relationship Between Firm Characteristics and University–Industry Collaboration

Diversity among firms stems from factors such as historical development, the size of the firm, its structure of ownership, technological capabilities, culture, and values. Firms therefore embed their own specific nature, which affects their behavior, practices, and decision making.

Firm size. The existing literature indicates that size influences university and industry collaboration (Cohen et al., 2002; Laursen & Salter, 2003; Arundel & Geuna, 2004). A large number of empirical studies conclude that the intensity of collaboration among larger firms is higher than that of small firms, due to their resources for carrying out R&D activities. Large firms cooperate to a greater extent (e.g. Cassiman and Veugelers, 2002; Becker and Dietz, 2004; Miotti and Sachwald, 2003; Negassi, 2004), benefit more from cooperation (Veugelers, 1998 as cited in Badillo et al., 2014) and innovate more openly than SMEs (De Backer, 2008 as cited in Badillo et al., 2014). Universities prefer to work with large firms, as they have higher financial resources for R&D and higher technological capabilities, giving them more prestige and greater opportunities for new research initiatives (Shapira et al., 1995; Beise and Stahl, 1999 as cited in Badillo et al., 2014). Small firms hardly do basic research because research findings are difficult to patent and hence the flow of payoffs cannot be capitalized, then these payoffs must be appropriated through incorporating the knowledge in the form of improved goods or processes (Rosenberg, 1989). However, debate on this issue has spread because of the emergence of small high-tech firms in the United States and

Taiwan (Best, 2001). The arguments on this issue lead an ambiguous relationship between size and collaboration.

Industrial sector. Freeman (1995) stated that the specific nature of an industry affects the intensity, patterns, and drivers of innovation activity. Rasiah and Chandran (2009) mentioned that the intensity of R&D collaboration varies by industry. Scharfetter et al. (2002) identified similar results in the case of Austria. High-technology sectors have high levels of interactions, whereas low-technology sectors have weak interactions. Firms in high-technology sectors must keep up with cutting-edge research in high-technology industries; therefore, those firms exploit scientific knowledge that originated from public research more frequently (Cohen et al., 2003). Likewise, because universities are the main sources of scientific knowledge, firms in high-technology sectors utilize external scientific knowledge and intend to access university research, whereas firms in the low-technology industries may not have the need to access higher technologies (Suzuki et al., 2012).

Regarding technology classifications for the manufacturing sector, the Organisation for Economic Co-Operation and Development (OECD; 2011) categorizes industries into four groups—low-technology industry, low-medium-technology industry, medium-high-technology industry, and high-technology industry—while Pavitt (1984) proposed four categories of industry—supplier-dominated industries, specialized supplier industries, scale-intensive industries, and science-based industries. Supplier-dominated industries such as the textile and food industries acquire new technologies from suppliers of machinery and capital goods; therefore, their in-house

R&D is rather small. Specialized supplier industries include the machinery and instrument industries. Scale-intensive industries such as the automotive sector are likely to learn from improvements in their designs and processes. Technology seems to change incrementally. Science-based industries include the pharmaceutical, electronics, and chemical industries, for which in-house R&D and external collaboration are major sources of technological change (Table 2-3). Malerba (2002) further developed the concept of the sectoral innovation system, which consists of three building blocks;

- *Knowledge and technological domain*: Any sector may be characterized by a specific knowledge base, as well as specific technologies and inputs.
- *Actors and networks*: A sector is composed of heterogeneous agents that can be organizations or individuals (e.g., consumers, entrepreneurs, scientists). Organizations may be firms or non-firms (e.g., universities, financial institutions, government agencies, trade unions, or technical associations), subunits of larger organizations (e.g., R&D or production departments), and groups of organizations (e.g., industry associations).
- *Institutions*: Institutions may range from more binding to less binding and from formal to informal. Institutions can be national or specific to sectors.

Table 2-3: Characteristic of Industrial Sector

| Sector Characteristics | Technology Accumulation | Source of Technology |
|------------------------|--|----------------------|
| Supplier dominated | Import technology/Little R&D | Supplier |
| Specialized suppliers | Design & development | Client |
| Scale intensive | Design, Operation and learning by doing (process innovation) | Internal knowledge |

| Sector Characteristics | Technology Accumulation | Source of Technology |
|------------------------|--|---|
| Science based | Academic research; search for new technologies | In-house R&D, External collaboration |

Source: Pavitt (1984), Abinoraseth (2007) cited in Vishuphong (2007)

Technological capability. Technological capability may be regarded as comprising the indigenous accumulated knowledge acquired through firms' accustomed learning processes and absorptive capacity (Adeoti, 2002), which is defined as a firm's ability to identify, assimilate, and exploit knowledge from the environment (Cohen & Levinthal, 1990). It plays a key role in determining firms' capability to access and make use of external knowledge (Muscio, 2009). The firm's innovation success also depends on the extent to which it can use technological opportunities from outside for its own purposes (Cohen & Levinthal, 1990). Particularly in times of competitive pressure, firms are forced to open their innovation process and use external knowledge sources to increase their innovative potential. A key factor to enhancing a firm's ability to benefit from externally acquired knowledge is its absorptive capacity (Cohen & Levinthal, 1990; Ducheck, 2013; Muscio, 2009).

The process of absorbing technological capabilities in forerunner and latecomer countries is different. Based on the Utterback model, the sequence of technology development starts from creating knowledge through R&D activities, until finally reaching own-brand products. Unlike the Utterback model, Linsu Kim's (1997) imitation to innovation model is built on Korean case studies indicating that latecomer

countries develop technology through a catching-up process. This process explains that latecomer countries learn by imitating and doing.

To measure absorptive capacity, some scholars use levels of R&D investment and R&D personnel as proxies. They assume that firms that continuously engage in internal R&D efficiently can establish internal capabilities for adapting external knowledge (Becker & Peters, 2000). Likewise, Malerba and Torrisi (1992) concluded that firms that do not permanently invest in R&D have far less access to the technological opportunities that stem from scientific research.

2.5 Mode of University–Industry Collaboration

Triple helix scholars have not specifically paid attention to the mode of university and industry collaboration, despite their comprehensive framework. Rather, this issue has been investigated by innovation studies experts (Agrawal & Henderson, 2002; Cohen et al., 1998; Cohen et al., 2002; Shane, 2002). They attempted to analyze the modes through which knowledge flows from universities to industry. Nonetheless, there is no universally accepted classification of university and industry collaborations (Røed, 2000). Also, little consensus regarding the most effective mode of university–industry collaboration has been achieved (Bekkers & Freitas, 2008; Eun, 2009).

The collaboration modes include, but are not limited to, the use of scientific publications, technology licensing, human mobility (personnel exchange, etc.), joint or collaborative R&D, contracted out or commissioned R&D, consultancy or technical guidance, incubation of start-ups, and informal collaboration. The interaction can take

place between individual researchers in both a university and a company or between a company and a university (Agrawal & Henderson, 2002; Bekkers & Freitas, 2008; D’Este et al., 2007; Eun, 2009; Iqbal et al., 2011; Joseph, 2009; Landry et al., 2005; Meyer-Krahmer & Schmoch, 1998; Rast et al., 2012). The list of modes is shown in Table 2-4, and their definitions are described below.¹

Use of scientific publications. Scientific publications diffuse codified knowledge generated from universities. However, co-publication written by two partners is different, since knowledge is generated by two parties.

Technology licensing. Technologies are developed independently by universities and are transferred to firms through licenses. Similar to scientific publications, patents are a kind of mechanism through which to diffuse codified knowledge. Nonetheless, licensing technology co-developed by two parties is considered to be a result of collaborative R&D, which requires a closer relationship than technology developed independently by universities.

Human mobility. Human mobility can be both formal and informal, and include both researchers and students. Cooperative education is one approach to human mobility. The difference between cooperative education and student internships is that in a cooperative program, students are required to work in a workplace as full-time employees from 4 months to 12 months, and also receive training and supervision from

¹ Based on Böhringer (2006), Perkmann and Walsh (2007), Ponomariov and Boardman (2012), and Merchán-Hernández and Valmaseda-Andia (2013)

both workplace mentors and from academic supervisors. In contrast, internship programs are more flexible. They can be paid or unpaid, and are shorter and done in the summer when students are out of school as part-time jobs. Sometimes, the relationship between partners is connected with human mobility when firms provide scholarships. In many cases, graduates can be hired for collaborative projects such as joint R&D and cooperative education.

R&D collaboration. Joint or collaborative R&D is different from contract or commissioned research. Joint R&D activity requires two partners to contribute substantial resources, whereas contract or commissioned research is requested by a firm to solve a problem of interest to the firm.

Academic consultancy or technical guidance. Academic consulting may be an institutionalized activity in which academics and industry engage or individual academic researchers provide advisory services to industry clients. In particular, academic consultancy or technical guidance, as mentioned in this study, focuses on research activities and product innovation-driven consulting. These activities assist firms in implementing downstream research activities.

Incubation and start-ups. Incubation is a unit that accelerates the successful development of a start-up by providing resources and services. It is usually within the same building or in proximity to it. Usually, an incubator provides meeting opportunities, such as a cafeteria and joint lectures, which are interesting for all young firms in the incubator. These incubator characteristics build the basis for the

development of frequent and social interaction, and for the exchange of both explicit and tacit knowledge (Cavusgil et al., 2003).

Informal interaction. Informal interaction is the forming of social relationships and networks at meeting or conferences. Those interactions involve informal and frequent face-to-face contacts.

Also, Table 2-5 shows that the most important modes of collaboration vary across countries. Cohen et al. (2002) found that the modes of open science, especially publications, public meetings and conferences, and informal information exchange, are the most important in the United States. Cooperative ventures do not seem to have been as important as other channels for industrial R&D. These results correspond to the cases of India and Netherlands, but they are controversial in relation to European and some Asian contributions. For instance, based on a survey of firms and universities, D'Este and Patel (2007, Eom (2009), Eun (2009), and Meyer-Krahmer and Schmoch (1998) found that both formal and informal collaboration are important channels of communication in Europe (the U.K. and Germany) and Asia (China and South Korea). Similarly, collaborations between universities and industry in Austria are established through a formal approach. Remarkably, education and training are not ranked as an important channel in several countries aside from the U.K. and China. According to several studies, as mentioned above, the differentiation of channels for collaboration across countries is interesting for researchers to examine.

Interestingly, several studies have found the simultaneous use of various modes. Meyer-Krahmer and Schmoch (1998) reported the results of a survey among German academics on the importance of various types of links with industry, finding that collaborative research and informal contacts were valued most highly. Similarly, D’Este and Patel (2007) concluded that science and engineering researchers in the U.K. used a wide variety of channels, such as consultancy and contract research, joint research, training, meetings and conferences, and the creation of new physical facilities (e.g. spin-offs).

Table 2-4: Modes of University and Industry Collaboration

| Mode of Collaboration | Rast <i>et al.</i> (2012) | Eun (2009) | Joseph (2009) | Eom (2009) | Cohen <i>et al.</i> (2002) | Landry, <i>et al.</i> (2005) | Bekkers and Freitas (2008) | D'Este and Patel (2007) | Meyer- Kraemer and Schmoch (1998) | Schartinger, <i>et al.</i> (2001) |
|---|---------------------------------|---------------|------------------|---------------|----------------------------------|------------------------------------|-------------------------------------|----------------------------------|---|--------------------------------------|
| | Malaysia | China | India | Korea | US | Canada | Netherlands | UK | Germany | Austria |
| Joint or collaborative R&D | x | x | x | x | | | x | x | x | x |
| Contract or commissioned R&D | x | x | x | x | x | x | x | x | x | x |
| Incubators | | x | x | x | | | | | | |
| Consultancy or technical guidance | x | | x | | x | | | | | |
| Technology licensing | x | x | x | x | x | x | x | | | |
| Scientific publication | | x | x | x | x | x | x | | x | x |
| Human mobility | | | | | | | | | | |
| (hire of graduates, personnel exchange, cooperative education) | | x | x | x | x | x | x | x | x | x |
| Informal collaboration (informal contact, conferences and meetings) | | x | x | x | x | x | x | x | x | |
| Sharing of facilities | | | | | | x | x | x | | |
| Spin-off companies | x | | x | x | | | x | | x | x |

Source: Compiled by author.

Table 2-5: Modes of Collaborations (Three Most Important Modes)

| Country | Three Most Important Mode |
|---|--|
| China (Eun, 2009) | 1. Cooperative R&D 2. Education and Training 3. Informal contact |
| Korea (Eom, 2009) | 1. Informal contact (consulting) 2. Joint R&D 3. Contract R&D |
| India (Joseph, 2009) | 1. Publication and report 2. Public conference 3. Informal contact |
| US (Cohen <i>et al.</i> , 2002) | 1. Publication and report 2. Informal contact 3. Public conference |
| Netherlands (Bekkers and Freitas, 2008) | 1. Publication and report 2. Informal contacts 3. Conference |
| UK (D'Este and Patel, 2007) | 1. Public conference 2. Contract R&D 3. Cooperative R&D/Education |
| Germany (Meyer-Krahmer and Schmoch, 1998) | 1. Cooperative R&D 2. Informal contact 3. Public conference |
| Austria (Schartinger <i>et al.</i> , 2001) | 1. Cooperative R&D 2. Cooperative education 3. Contract R&D |

Source: Compiled by author

2.6 Results of University–Industry Collaborations

In the system of innovation and triple helix concepts, two entities (a university and industry) are supposed to jointly deliver some results generated by collaboration. These results are used to monitor progress or to indicate sluggish interaction. This indication is a guideline for two entities to build, further develop, and improve their relational involvement as well as basic information for planning and decision making. Nonetheless,

few studies have attempted to assess results of collaboration (Iqbal et al., 2011; Majid & Ismail, 2009).

The possible results of collaborations are based on sequences of effects. Similar to Galbraith's idea, performance measurement indicators can be divided into inputs, outputs, outcomes, and impacts (Table 2-6). The input indicators are foremost suitable for evaluating the intent of a desired output, but do not guarantee it (Langford et al., 2006). Although output, outcome, and impact indicators deal with the results of cooperation, they are different. Outputs are the direct results of the cooperation. The outcome is not immediately seen at the end of project and is obtained from the output. The impact is a kind of long-term outcome (Seppo & Lilles, 2012) that could refer to the direct or indirect effects of cooperation on the different parties (Benchmarking and Foresight for Regions of Europe, 2008).

Input. Seppo and Lilles (2012) compiled related studies from several scholars on the results of collaboration. Resources—especially finances given to universities and researchers—are very important indicators. The most direct indicator of university–industry cooperation is the level of industry sponsorship and financing of university research (Langford et al., 2006). The financial support and benefits are important for universities and make it possible to establish and also maintain relationships with industry (Davey et al., 2011).

The capability and motivation of both universities and industry were identified as proxies for the input of collaboration. Publications are a common indicator of researchers' capabilities, but some scholars debate that it is not a reliable way to assess a researcher's quality; rather, citation counts provide a better measure (Moed, 2005). However, a different standpoint between university and industry needs to be considered; for example, publications may not be an expected result of university and industry collaboration because universities are interested in basic science while industry is not. The absorptive capacity and technological competence of a firm depend on its prior related knowledge and experience (Cohen & Levinthal, 1990), and therefore show the capabilities of the company as an input in the university and industry collaboration. Additionally, indicators of firm capability can include quality certificates (ISO certificates), numbers of previous projects with universities, membership in some research group or collaborative network, education of employees, and the involvement of staff in university activities (Seppo & Lilles, 2012).

With regard to motivation, researchers generally focus on their own interests and career paths; therefore, researchers' motivations are difficult to measure (Lee et al., 2010). The stimulation system and career model within universities and also in academia, more generally, are also important for encouraging scientists to cooperate with enterprises (Seppo & Lilles, 2012). Based on Bercovitz and Feldman (2008) and Perkmann et al. (2011), previous research has indicated that the departmental climate is one predictor of involvement in industry activity. Davey et al. (2011) recommended the existence of documented strategies embracing university and industry collaboration as well as the

implementation of these strategies (e.g., dedicating resources to support collaboration, providing incentives for academics, considering collaborations with enterprises in the assessment of one's work performance) as measures of favor and the attitude of a university or department.

Output. Several indicators are available to operationalize outputs from university–industry alliances (Perkmann et al., 2011), such as patent applications or granted patents, publications, joint publications, staff skills and training, and the intensity of collaboration.

Patent is used as an indicator of output of university and industry collaboration; however, it might not be the best indicator because collaboration between these two entities needs the flow of knowledge without restrictions (Perkmann et al., 2011). Those scholars claimed that publications are a good indicator, as they are subject to a peer-review process. The number of joint publications by university and industry scientists is a very explicit indicator of university–industry collaboration that focuses on longer-term perspectives. Nonetheless, this indicator should not be used alone for defining university–industry cooperation, as there are many cases in which no co-authored papers are published (Lundberg et al., 2006).

The development of human resources is also an output or outcome indicator for university and industry collaboration. Various indicators are available for assessment, including the number of doctoral and postdoctoral positions offered within the alliance, the

number of co-supervision arrangements between industry and the university, and the number of secondments of research scientists to partner organizations (Seppo & Lilles, 2012). Additionally, the number of master and doctoral theses derived from the collaborative work or supervision is the result of cooperation (Iqbal et al., 2011).

Intensity, as estimated by frequent interaction between the partners, is also a crucial measure. It facilitates the transfer of know-how and tacit knowledge, as opposed to the formal exchange of codified research results. Iqbal et al. (2011) found that there are different meetings for educational versus contact-making purposes. Workshops, seminars, and meetings, in which the participants are from both universities and industry, can be defined as the outputs of university–industry collaboration. Having a high number of personal contacts also represents a higher intensity of collaboration and knowledge transfer between the partners.

Outcome/impact. To measure the impact of university and industry collaboration outputs, the indicators should show if the collaboration achieved its aim and what the consequences of the collaboration have been for the partners (Pertuzé et al., 2010). There are different indicators, such as GDP per capita, productivity, export growth or employment growth, and the success of spin-off companies (Langford et al., 2006).

Table 2-6: Possible Result for University and Industry Collaboration

| Category | Example of Indicator |
|--------------------|--|
| Input | <p>Resources: R&D expenditure; university's governmental income; non-government donations, grants and contracts; industry sponsorship of university research; scholarships; number of researchers.</p> <p>Researchers' capabilities: number of publications, citations, projects, reports or patents done in the past.</p> <p>Researchers' motivation: number of previous industry contracts in the university; number of strategies concerning university and industry collaboration; amount of resources dedicated to support collaboration; perception of researcher about the benefits from the collaboration with industry.</p> <p>Firms' capabilities: quality certificates or standard; previous collaboration with academia; membership of some association or research group; number of scientists; structure of employees by occupation and education.</p> <p>Firms' motivation: number of previous contracts with universities; involvement with university (e.g. alumni, lecturer); perception of the firm about the benefits from the collaboration with university.</p> |
| Output | Patent applications; patents; license revenues; publications; joint publications; postdoctoral or doctoral positions offered within alliance; joint supervision; master and/or doctoral theses; secondment of researchers; spin-offs; non-licensed product and process |
| Outcome/ Impact | <p><i>Outcome:</i> product innovation; process innovation; increase in sales</p> <p><i>Impact:</i> GDP per capita; total factor productivity; number and share of high growth enterprises; success of spin-off companies; productivity growth; the increase in exports created by new inventions; employment growth;</p> |

Source: Compiled by Seppo and Lilles (2012)

Barnes *et al.* (2002); Bercovitz and Feldman (2008); Perkmann *et al.* (2011); Langford *et al.* (2006); Iqbal *et al.* (2011); Tijssen *et al.* (2009); Luoma *et al.* (2011)

2.7 Concluding Remarks

This chapter has reviewed the roles of different types of universities in a system of innovation. The review has covered the related concepts on university and industry collaboration, the evolution of universities' roles, emergence of different university species,

influence of firm characteristics, modes of collaboration, and results of collaboration.

According to literature review, three research gaps are identified as follows.

Research gap 1: Influence of university type. Previous studies (Kondo, 2008a, 2009) that mainly focused on R&D activities found that university type relates to R&D mode due to the influence of Japanese government policy. Beyond R&D mode, this study aims to examine how various types of collaboration influence modes and size of collaborating firms, and how local and country contexts impact on the roles of universities.

Research gap 2: Influence of firm characteristic. Based on the literature review, debated issues were found about the influence of firm characteristics on R&D collaboration. Regarding firm size, the intensity of collaboration among larger firms is higher than that of small firms, due to their resources for carrying out R&D activities (Arundel & Geuna, 2004; Cohen et al., 2002; Laursen & Salter, 2003; Mohnen & Hoareau, 2003; Mothhashi, 2004). In addition, small firms hardly do basic research because research findings are difficult to patent and hence the flow of payoffs cannot be capitalized, then these payoffs must be appropriated through incorporating the knowledge in the form of improved goods or processes (Rosenberg, 1989). Nonetheless, debate on this issue has spread because of the emergence of small high-tech firms in the United States and Taiwan (Best, 2001). In term of industrial sector, firms in high-technology sectors must keep up with cutting-edge research in high-technology industries; therefore, those firms exploit scientific knowledge that originated from public research more frequently (Cohen et al.,

2003). However, firms in different countries may behave differently according to the study of Edquist (1997). This study examine whether firm size and industrial sector influence R&D collaboration with university and whether country context influence the influence of firm characteristic on R&D collaboration.

Research gap 3: Influence of mode of collaboration on outcome. Little consensus has been achieved regarding the most effective mode (Bekkers & Freitas, 2008; Eun, 2009), which may be evaluated by assessing outcomes (Iqbal et al., 2011; Majid & Ismail, 2009). Previous studies (Meyer-Krahmer & Schmoch, 1998) reported the results of a survey among German academics on the importance of various types of links with industry but those studies did not clearly describe how the simultaneous use of various modes was important. This study, therefore, investigates these neglected issues on whether simultaneous use of various modes influence outcomes.

The next chapter details the research questions and hypotheses drawn from the research gaps and describes the research methodology used in this study.

Chapter 3

Research Methodology

Chapter 3 is the explanation on how the research gaps identified in Chapter 2 were transformed into the research questions and hypotheses. In this chapter, two research methodologies used in the study will be presented.

Section 3.1 presents the research questions and hypotheses. In Section 3.2 identifies the conceptual issues, shows how the research problems were explored, and describes the relationship between the variables identified in the study. The major entities that are units of analysis in this study are illustrated in Section 3.3. The explanation of statistical data used to analyze, and the procedure used in designing interview issues and collecting data is described in Section 3.4.

3.1 Research Question and Hypothesis

After identifying the research gaps in Chapter 2, they were transformed into research questions and hypotheses.

Research gap 1: Influence of university type. Research question (a) and (b) were set to examine the influence of university type on both collaboration mode and firm size. Research question (c) and (d), on the other hand, aim to investigate the influence of local and country context on collaboration mode.

Research questions

- a) Do university types relate to modes of collaboration? If so, why? If not, why not?
- b) Do university types relate to firm size? If so, why? If not, why not?
- c) In a certain local area, do different types of universities play different roles in supporting industry? If so, why? If not, why not?
- d) Do the country contexts matter? Specifically, do the same types of universities in different countries have the same distinctive modes?

Research gap 2: Influence of firm characteristics. The following six hypotheses aim to examine two main issues: (1) relationship between firm size and R&D collaboration, and (2) the relationship between the industrial sector and R&D collaboration. The first issue was set based on the results of empirical studies; these studies have identified that large firms tend to engage in collaborative R&D activities because small firms hardly do basic research because research findings are difficult to patent and hence the flow of payoffs cannot be capitalized, then these payoffs must be appropriated through incorporating the knowledge in the form of improved goods or processes (Rosenberg, 1989). For the second issue, four industrial sectors were selected based on frequency of collaboration: food, electrical apparatus, chemical, and automobile. The technology classification for the manufacturing sector proposed by Pavitt (1984) was used to set the hypotheses. This study examine whether firm size and industrial sector influence R&D collaboration with university and whether country context influence the influence of firm characteristic on R&D collaboration.

Hypotheses

- a) Large firms tend to engage in collaborative R&D activities because they have plenty of resources to do R&D activities.
- b) The food sector uses a supplier as a source of technology; therefore, the food sector does not significantly relate to R&D collaboration.
- c) The electrical apparatus sector has both in-house R&D and external collaboration as sources of technology; therefore, this sector significantly relates to collaborative R&D activities.
- d) The chemical sector uses both in-house R&D and external collaboration as sources of technology; therefore, it significantly relates to collaborative R&D activities.
- e) The automotive sector uses internal knowledge for R&D activities; therefore, it does not significantly relate to collaborative R&D activities.
- f) To understand differences between two national systems, the following hypotheses were set. Rather than country contexts, firm size and industrial sector influence modes of collaboration.

Research gap 3: Influence of mode of collaboration on outcome. According to the previous studies, the evidence related to the most effective mode of collaboration and the influence of complementary modes (a combination of various modes) is inconclusive. These two hypotheses investigate whether the complementary mode positively influences outcome.

Hypotheses

- g) The complementary mode positively influences outcome and the degree of influence of the complementary mode is higher than a single mode.
- h) In both Japan and Thailand, the degree of influence of the complementary mode is positive and relatively high.

3.2 Research Framework

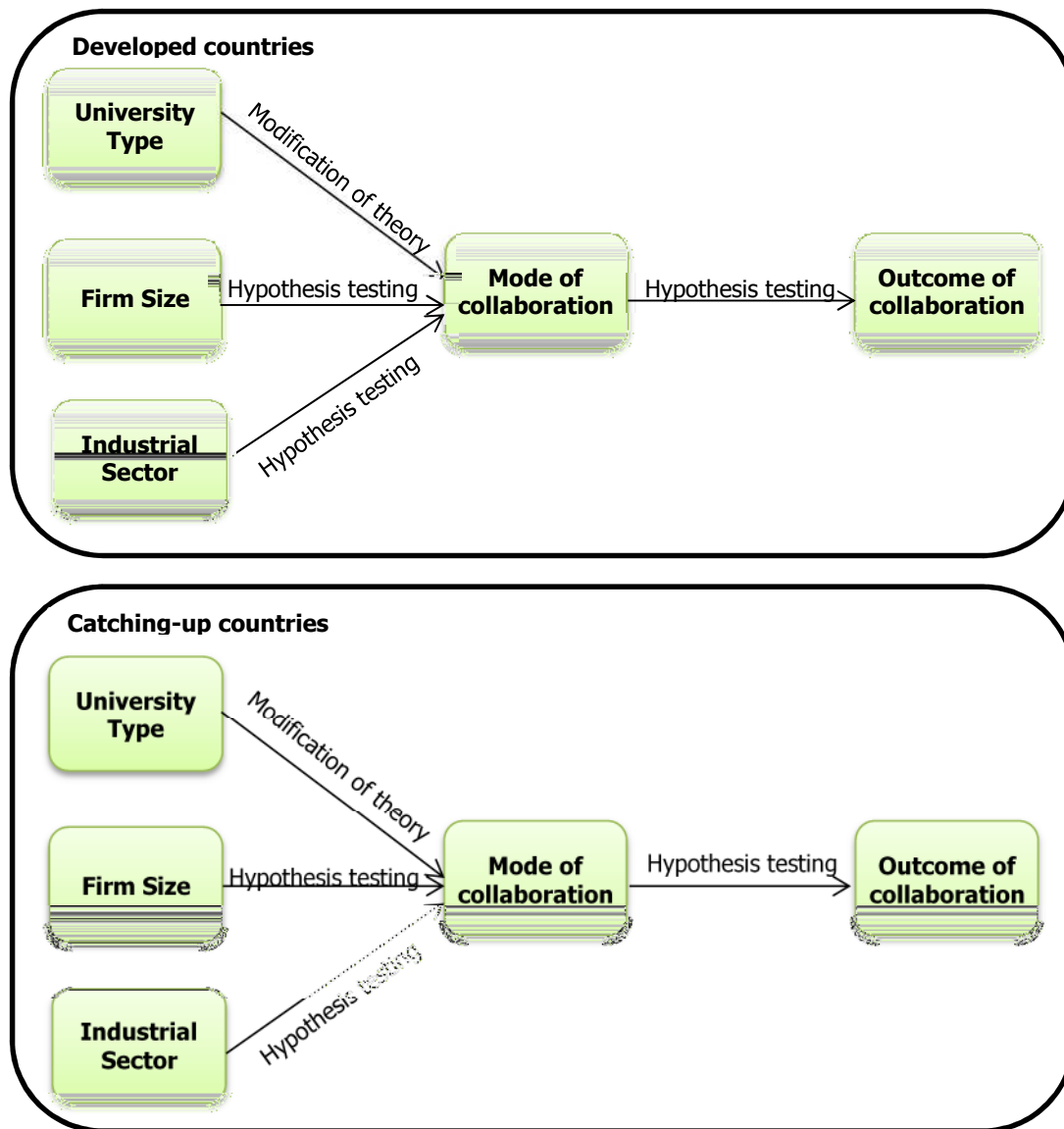
The concept of the system of innovation was used to study the three research gaps identified in Section 3.1. In the system of innovation, there are three key actors: government, industry, and university. This study focuses on bilateral relations between university and industry, which are (a) university and industry collaboration supported by government, and (b) collaboration built by university and industry themselves.

The frameworks for developed countries and catching-up countries are created separately (see Figure 3-1) because based on Edquist's study (1997), the actors are likely to differ across national systems (see Chapter 2). Nation innovation system in developing countries is different from the model proposed for developed nations: (a) the vast majority of firms in developing countries lack the minimum capabilities to engage in interactive learning and innovation (Chaminade and Vang, 2008), (b) in developing countries, the state plays a significant role in building successful innovation systems (Yusuf and Stiglitz, 2001), for example, basic investments in the innovation infrastructure have to be made by the public sector, and (c) universities in developing countries solely contribute to education,

rather than national economic upgrading and technological progress (Altbach & Salmi, 2011; Leifner & Schiller, 2008). With regard to university and industry collaboration, in developed countries, collaborative relationships have been considered at the best peripheral to the main higher education missions and formal collaboration such as joint R&D activities often occurs whereas developing countries are only beginning to explore these relationships and consultancies on informal basis between companies and university researchers are perhaps the most common approach of technology transfer (Parker, 1992).

To investigate the research questions, five variables are included in research framework. Three variables, namely university type, firm size, and industrial sector, are likely to influence collaboration mode while collaboration outcome seems to be influenced by collaboration mode. To investigate the relationship between those variables, two research approaches – (a) hypothesis testing for firm-level analysis and (b) qualitative approach to modify theory for university-level analysis– were used to analyze university data.

Figure 3-1: Conceptual framework



3.3 Research Design

The unit of analysis used in this study consists of (1) country level and (2) university and firm level.

3.3.1 Country level. Japan and Thailand were selected as case studies because Japan is the top foreign investor in Thailand, pouring \$5,273 million into local projects. The inflow of Japan's foreign direct investment (FDI) into Thailand accounts for 60.6%.² Previous studies have concluded that FDI is important for disseminating advanced knowledge into both local firms and local universities. For example, Kramer et al. (2009) conducted 40 in-depth interviews to senior managerial and technical staff of flagship MNEs in the automotive, life science, and information communication technology sectors in both Germany and the United Kingdom. They found that multinational enterprises (MNEs) contribute to the regional human capital by participating in local skills transfer programs and engaging in educational partnership with universities. On the other hand, MNEs benefit from inter-firm mobility in highly innovative regions and from the spatial and relational proximity to local universities, which gives them access to graduates and more senior personnel and to know-how (e.g., through contract research).

3.3.2 University and firm level.

University. This study modifies the existing theory proposed by Kondo (2008a, 2009). He concluded that three types of universities—a) national universities, b) local public universities, and c) private universities—influence R&D collaboration because institutional settings affect the mode and content of university–industry R&D collaboration through resource endowment, relations with central and local government, and financial incentives, etc. In order to create a comparison with Japanese universities, similar types of

² Board of Investment promoted projects

Thai universities were selected to investigate. As a counterpart to Japanese national universities, Thai public autonomous universities were selected because both of them largely receive budgets from the central government and are influenced by the central government. In addition, both of them engage more in collaborative R&D projects with industry than local public universities (Kondo, 2008a and 2009; Rungratsamee, 2004). Local public universities in Japan, on the other hand, are under the control of the local government. They aim to provide higher education opportunities to local people and to serve as intellectual and cultural centers within the local community. In the case of Thailand, Rajabhat University and Rajamangala University of Technology were selected to compare with Japanese local public universities. Even though Thai local governments do not directly provide financial support to higher education institutes, the missions of Japanese public universities are similar to those of Rajabhat University and Rajamangala University of Technology. They put great emphasis on local development (MEXT online document; Rajabhat University Act of 2004; Rajamangala University of Technology Act of 2005). Also, local community plays a substantial role in governing them (Rajabhat University Act of 2004; Rajamangala University of Technology). According to Rajabhat University Act, the local community must participate in selecting the president, and university council members must consist of experts in the area of local administration. In case of Rajamangala University of Technology, the university council members consist of local company executives, provincial public prosecutors, local government officials, and experts in various fields. In addition, central government agencies, for example, Ministry of Industry, Thailand Research Fund, Ministry of Science and Technology, Office of SMEs

Promotion, provides grants or funds for Rajabhat University and Rajamangala University of Technology to provide technical assistance to local businesses and local communities. Private universities, on the other hand, are established by private individuals and supported by private funds. Each private university can design academic curricula and has the autonomy to promote its own unique education and research activities, based on the spiritual legacy of its foundation (MEXT and Office of Higher Education Commission). However, they may be influenced by central government policy due to funding and other incentives (see Appendix Table A1-1).

For each type of university, universities in Japan and Thailand were selected based on course offering and data accessibilities (see Appendix Table A1-2). However, this study greatly emphasized the influence of university types; therefore, other aspects of each type of university, such as size, are disregarded.

Firm.

Japan.

The National Graduate Institute for Policy Studies (GRIPS) and the Office of Economic and Industrial Research in the House of Representatives cooperated with the research company Teikoku Databank (TDB) to conduct the GRIPS firm survey. The GRIPS Firm Survey was attached to a regular TDB survey called the TDB Survey of

Business Trends.³ The TDB survey, begun in May 2002, is a monthly survey conducted with over 20,000 nationwide corporations.

The target group was firms in all types of industries in Japan. The researchers sent questionnaires to 20,455 firms by e-mail. The number of returned questionnaires was about 10,731, which is a 52.5% response rate. The respondents were asked to give some basic information, for example, prefecture, size or number of employees, capital, and industry.

Apart from that, the researchers designed the following seven questions to examine university and industry collaboration. All firms were allowed to answer question 1, whereas only those firms that either currently or once conducted R&D activities (2,644 firms) were required to answer question 2 to question 7.

- Question 1: Whether firms currently or had once conducted R&D or did/had not conduct R&D.
- Question 2: Research result from collaboration classified by fields.
- Question 3: Utilization of research result.
- Question 4: Modes of collaboration.
- Question 5: Impact of collaboration on product innovation.
- Question 6: Difficulty in generating product innovation (without result of collaboration).

³ The TDB survey aims to report on businesses' overall activities, including their performance and business climate, and to make judgments regarding the current condition and future outlook of their respective industries.

- Question 7: Impact of collaboration on sales.

The researchers selected four questions to analyze university and industry collaboration, as follows:

- Question 1: Conducting/used to conduct or not conduct R&D activities.
- Question 4: Mode of collaboration (joint R&D, consignment of R&D, funding for university research, exchange of research sample, personnel exchange, technology licensing, and venture business).
- Question 5: Impact of collaboration on product innovation.
- Question 7: Impact of collaboration on sales.

Thailand. Thailand's Innovation Survey has been commissioned by the Ministry of Science and Technology since 1999.⁴ It is intended to offer a better understanding of the nature of R&D and innovation activities in Thai industry and to find ways to enhance and support them. The survey has been regularly conducted for more than 15 years. It follows two international guidelines (the Frascati manual and the Oslo manual) and adapts the Innovation Community Survey, which is a series of surveys executed by the National Statistical Offices throughout the European Union.

⁴ From 1999 to 2006, the survey was carried out by the National Science and Technology Development Agency. Since 2008, it has been carried out by the National Science Technology and Innovation Policy Office.

The results from the latest survey in 2011 indicated that 744 firms out of the 4,246 returned questionnaires were engaged in R&D and innovation activities. Both R&D and non-R&D firms were allowed to answer questions about collaboration with universities. Nonetheless, in order to compare this data with the Japanese data, collaborating firms that either conducted R&D activities or had once conduct R&D activities (452 firms) were selected as the target group for data analysis.

In the case of Thailand, the questions about R&D and innovation activities were put in the same questionnaire. The questionnaire comprised the following parts:

- Section 1: General information on companies, including year of establishment, number of employees, etc. (all firms were allowed to answer this section).
- Section 2: R&D activities, including definition of R&D, types of R&D activities, R&D expenditure and personnel, etc. (R&D firms were required to answer this section).
- Section 3: Innovation-related activities (innovating firms were required to answer this section).
- Section 4: External linkages for R&D and innovation-related activities (R&D/innovating firms were allowed to answer this section except for the question about modes of collaboration. All firms were required to answer this question).

The analysis of this study was based on the following questions:

- Section 1: Characteristics of firms (number of employees or firm size, industrial sector, total sales).
- Section 4: Modes of collaboration (joint R&D, contract out R&D, academic consultant, technology licensing, use of testing service, share of technical infrastructure, temporary personnel exchange, student internship, training for employees, co-publication, meeting or conference, personnel contact).
- Section 3: R&D and innovation results developed through collaboration with university (product innovation and process innovation).

The sampling frame of this survey was divided into two sets. The first set (repetitive) was gathered from a previous survey and R&D organizations such as the National Science and Technology Development Agency, the National Innovation Agency, the National Research Council of Thailand, and the Thailand Research Fund. All R&D firms are included in an annual survey in order to observe the behavior of these firms across time. The second set (non-repetitive) was obtained from the Business On-Line database, which holds comprehensive information on more than 300,000 establishments registered with the Commercial Registration Department in the Ministry of Commerce. Two techniques (stratified and systematic random sampling) were applied to this survey. All firms in this set were divided into three groups: Group 1: firms with the highest revenue (1% of total firms; all firms are samples); Group 2: excluding group 1, firms with the

highest revenue (10% of total firms; all firms are samples); and Group 3: the remainders (systematic random sampling technique based on revenue).

3.4 Research Method

In this study, the elements of qualitative and quantitative research approaches were combined. A mixed approach that includes a quantitative and a qualitative method provides greater breadth and depth of understanding and compensates for the weaknesses of one method with the strengths of another.

3.4.1 Qualitative approach. Qualitative approach was used to modify the existing theory about the relationship between university type and R&D collaboration proposed by Kondo (2008a and 2009). In line with Guest et al. (2013), qualitative method to this study due to the ability of this method to answer why and how questions. This method could provide a more detailed explanation of university and industry collaboration modes. To answer the research questions, a qualitative approach that modifies the theory was adopted.

The following interview issues were set to examine identified key explanatory variables, as shown in the research framework. The following interview issues were structured in accordance with the literature and the identified key variables.

1) *Background information about university.*

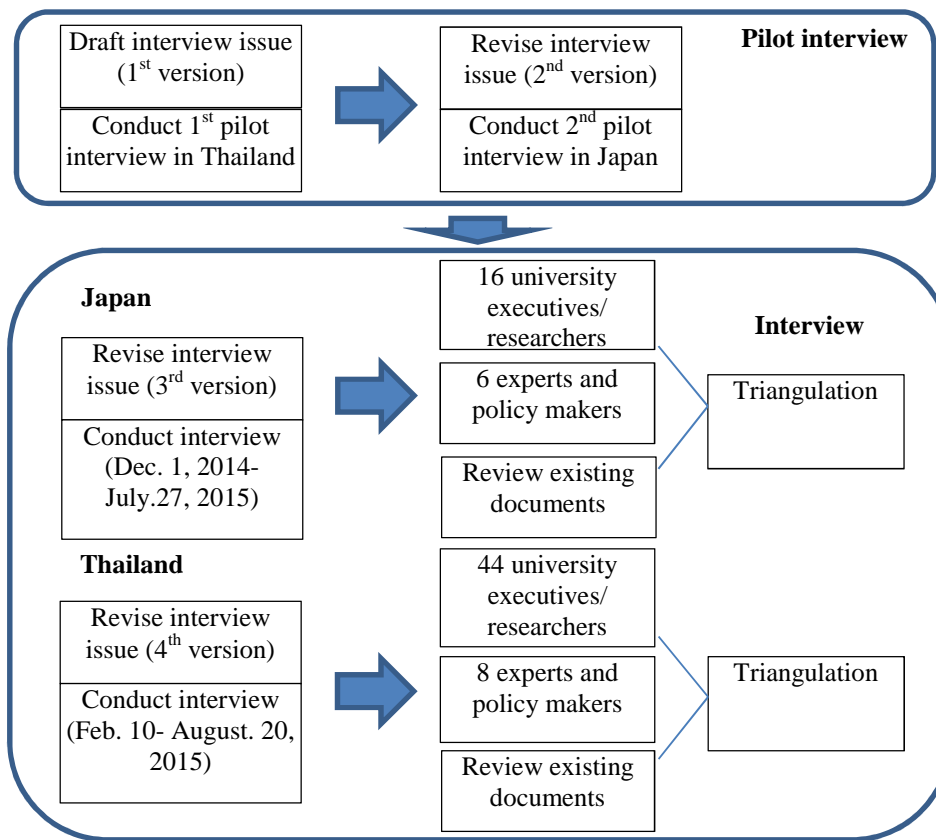
- Historical background and perception on collaborative activities
- Influence of government policies/initiatives on university's policies
- University policies related to supporting universities
 - Incentives for promoting collaboration with industry
 - Organizational structure/administrative system for supporting industry
(any central organization? Or faculty organization?)

2) *University and industry collaboration.*

- Characteristics of collaborating firm
- Collaboration mode (Frequent mode)
- Collaboration outcome developed through the most frequent mode

Two groups of people at the universities were interviewed; (1) executives of universities and/or central organizations overseeing collaborative activities, and (2) faculty members or researchers directly interacting with industry. The interviews with university and industry collaboration experts and policy makers in both countries were conducted. In total, the data was collected from 74 interviewees consisting of 22 Japanese interviewees and 52 Thai interviewees (see Appendix 1). Information gathered from the interviewees at the universities was cross-checked by against each other. Interviews of policy makers and secondary data consisting of government reports, university reports, and existing studies were also used to verify the data collected from the universities (Figure 3-2).

Figure 3-2: Qualitative Method



3.4.2 Quantitative approach. Two issues—the influence of a firm’s characteristics and the influence of the mode of collaboration—using a quantitative approach were analyzed (see Appendix equation). The details of the research method are described below.

Influence of firm characteristics. To examine the relationship between modes and firm characteristics, all the variables were classified as follows.

Mode. The coverage of sub-modes in both Japanese and Thai cases differed. Since there is no universally accepted classification (Røed, 2000), the classification and explanation of the modes were adapted from previous studies (see Appendix Table A1-3).

Firm size. This was classified into two groups: (a) large firm (> 200 employees), and (b) small and medium firm (≤ 200 employees).⁵

Industrial sector. The following four industrial sectors were selected according to technology classification for manufacturing (Pavitt, 1984), frequency of collaboration (based on Thai data), and the comparability of Japanese industrial classification and Thai industrial classification: (a) the food sector, (b) the chemical sector, (c) the electrical apparatus sector, and (d) the automotive sector.

Influence of mode of collaboration on outcome. To investigate the relationships between modes, the correlation coefficients were calculated. Then, three pairs of the strongest correlation coefficients were multiplied and included them as independent variables. These variables, which were obtained from multiplying the correlation coefficients, are complementary modes. Apart from the complementary modes, single modes (see Appendix Table A1-4) were also included as independent variables.

⁵ It is based on the classification of Office of Small and Medium Enterprises Promotion, Thailand (small and medium: ≤ 200 employees, large: > 200 employees).

Characteristics of firms, such as size and selected industrial sectors, were included as control variables.

In the case of Japan, the dependent variables were grouped into four levels according to the percentage of product innovation developed through collaboration and the percentage of the contribution of results developed through collaboration and translated into sales. Ordered probit regression was used to measure the results of dependent variables on an ordinal scale. In the case of Thailand, Poisson regression and linear regression were used to analyze the counting-number-dependent variables. Unlike Japan, all the results (product innovation, process innovation, and amount of total sales) are continuous numbers (see Appendix Table A1-5).

3.5 Concluding Remarks

This chapter presents the conceptual framework that was used to describe the relationship between the variables identified in the study. In Chapter 5, the influence of university type on the collaboration mode will be described. Chapter 6 is the data analysis on both the influence of a firm's characteristics on the collaboration mode and the influence of the collaboration mode on the collaboration outcome. The next chapter will include background information that will complement the data analysis of Chapters 5 and 6.

Chapter 4

University–Industry Collaboration in Japan and Thailand

In This chapter is a review of university and industry collaboration in Japan and Thailand. In order to understand the turning point and evolution of government policies, the historical background of policies related to university and industry collaboration was examined. This information was collected from the existing studies and the interviews with policy makers. This chapter consists of three sections: in Section 4.1 is a review of the situation in Japan as it relates to these issues; in Section 4.2 is an explanation of what has happened in Thailand; and Section 4.3 is a comparison of the situations in Japan and Thailand.

4.1 University-Industry Collaboration in Japan

4.1.1 The development of the Japanese higher education institution. Between the 1870s and the 1880s, the University of Tokyo was founded after the Westernized higher education institutions merged. At first, the university established four faculties: the Faculty of Law, the Faculty of Letters, the Faculty of Science, and the Faculty of Medicine. In the 1890s, the Faculty of Engineering and the Faculty of Agriculture were merged. After that, seven imperial universities were established in various parts of Japan. Meanwhile, a variety of universities, including public universities, private universities, non-degree granting technical and professional colleges, and separate women's colleges, were set up. In 1945, when the Allied Forces occupied Japan after World War II, the education system was

reformed based on the American model. All higher education institutions were classified as new universities while most of the non-degree granting technical and professional colleges were upgraded to universities or were merged into new universities. Importantly, in order to provide the opportunities for higher education to the younger generation, at least one national university was established in every prefecture (National Institute for Educational Research, n.d.).

Due to a special procurement arising from the Korean War (1950–1953), Japan wanted to train a highly qualified workforce for industrial development. The Japanese government focused on human resource development for the heavy chemical industry because this industry needed highly talented people for administration and management, middle-level technical specialists, and technicians. As a result, the government deregulated the procedure for establishing private universities to meet the growing demand for the initiative of the private sector, which did not receive financial support from the government. Also, colleges of technology were created as a new type of institution. In 1975, the government began supporting a public subsidy to cover some parts of the operational costs of private universities. At the same time, specialized training colleges of law were created to elevate the status of non-degree post-secondary education institutions, which meant that various kinds of vocational and technical training appeared in this period. In 1981, a law to establish the University of the Air (or Open University today) was enacted to provide lifelong learning opportunities to Japanese people through television and radio (National Institute for Educational Research, n.d.). Recently, there is a tendency for

Japanese universities to try to gain comprehensive status, which means establishing, and maintaining a full-set of courses rather than putting an emphasis on a particular specialty (Okamoto, 1997).

In total, there are 1,188 higher education institutions in Japan, which are officially classified into five groups: (1) national universities (86 universities), (2) local public universities (85 universities), (3) private universities (607 universities), (4) junior colleges (353 colleges), and (5) colleges of technology (57 colleges; UNESCO; MEXT). Japanese universities (national, public, and private) and junior colleges aim to provide a high level of education and expertise and to contribute to society by discovering and cultivating new theories and technologies. They offer and award academic degrees to students who successfully complete programs specified in Article 104 of the School Education Law. In contrast, colleges of technology and professional training colleges aim to provide a vocational education and work skills. These higher education institutions award degrees that are equivalent to a university undergraduate or graduate degree.

4.1.2 Japanese firms' technological capabilities.⁶ In Japan, industry R&D investment accounted for between 70% and 80% of the total national R&D expenditure in Japan over the last 20 years. The historical development of Japanese firms' technological capability is described below.

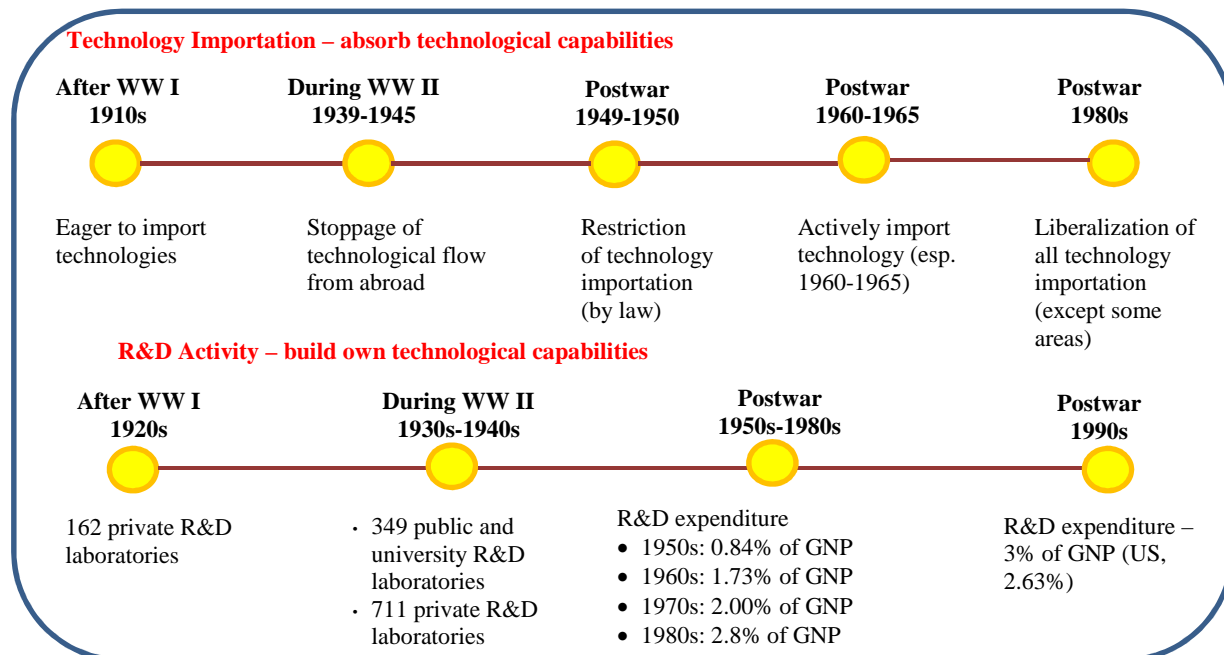
⁶ Summarized from a study by Goto and Odigari (1996).

After World War I, Japanese firms were still in an early stage of development and struggled to compete with the more advanced European and American firms. When the unprecedented economic boom ended in 1920, some Japanese firms began to create their own indigenous knowledge and technologies through R&D investment. At this point, 162 private R&D laboratories, consisting of 71 chemistry laboratories, 27 metal and machinery laboratories, and 24 food laboratories, were established.

During World War II, even though technological flow from abroad stopped, Japan continued to invest heavily in R&D activities to compensate for the lack of technology importation. This can be seen very clearly in the establishment of approximately 1,000 R&D laboratories in both the public and private sector. While investing in R&D activities, Japan developed advanced technologies by locating, assimilating, and adapting the advanced technologies imported from Europe and the United States. After World War II, the Japanese government encouraged firms to build their own technological capabilities through the enactment of the Foreign Exchange, Foreign Trade Control Law (1949) and the Foreign Investment Law (1950). Except for small payments, applications for technology importation had to be approved by the Foreign Investment Council. In 1968, technology importation that amounted to less than \$50,000 was automatically approved; however, some items were excluded, including cross-licensing agreements, contracts with foreign parent firms and their subsidiaries in Japan, and contracts in some technological areas. As a result, R&D investment increased from 0.84% of gross national product (GNP) in 1955 to 1.73% of GNP in 1961 and 2.00% of GNP in 1973. Then, in 1980, all technology

importations were liberalized except for some technology areas (in the case of less than 100 million yen, technology could be freely imported). In 1983, Japan's R&D expenditure increased to 2.8% of GNP and reached 3.0% of GNP in 1991. As mentioned earlier, technology importation was considered an important mechanism for upgrading Japan's technological capabilities. At that time, Japan used several channels for technology importation, including machinery and equipment importation, technological agreement, consultation, purchasing of blueprints, personnel exchange, and foreign direct investment (Goto & Odigari, 1996; Figure 4-1).

Figure 4-1: Technology Importation and Creation of Indigenous Knowledge



Source: Summarized by author. Data from Goto and Odigari (1996).

The case of the canned tomato sector clearly shows how Japan adapted foreign technologies and created indigenous technologies. At first, US technologies such as canning and plant breeding were imported. The Japanese used a trial-and-error method to

improve and adapt US technologies to conform to conditions in Japan. While imitating US technologies, the Japanese put effort into developing technology to achieve self-reliance. Over time, knowledge was accumulated through a learning process and was fully exploited in local areas. Consequently, skilled leaders in technology appeared throughout the nation, even in small research facilities. At this point, Japan's food industry had high technological capabilities. It has since applied gene technology in the food-processing industry (United University, 1994).

4.1.3 Japanese government policy on university and industry collaboration.

In the 1960s, Japan aimed to introduce advanced knowledge from overseas, and collaboration between universities and industry became a normal procedure. In several cases, university academicians played an active role in starting businesses, and technology transfers often involved the licensing of patents held by university faculty.

These cases include the establishment of Hakunetsu-sha (currently known as Toshiba) by Ichisuke Fujioka, an assistant professor at Kogakuryo, and the development of Ajinomoto by the entrepreneur Saburosuke Suzuki, who acquired exclusive rights to a patent on glutamic acid, the umami compound of a kombu seaweed broth, which Tokyo University professor Kikunae Ikeda had applied for (Goto & Baba, 2007, cited in Motohashi & Muramatsu, 2012). In addition, in the case of the petro-chemistry industry (H. Niiyama, personal communication, December 1, 2014), catalysis was an emerging technology in the 1960s. Pioneering Japanese professors accepted many research students

from various industries. They did not bring any specific research subjects of their own but joined the professors' research teams. As a result, they learned how catalysis research was conducted and returned to their companies to share their experiences with their fellow engineers. Also, their personal relations with the professors helped to develop further research collaboration projects when specific needs arose. In 1970, leading petro-chemistry companies; each quite small on a global scale, formed a group to collaborate with each other. Global competition was not very severe in this field. They were satisfied with the reasonably big domestic market where the competition was limited. In the 1980s, when bioengineering became attractive to many companies, the same story was repeated. This was commonly found in the new, emerging field of engineering. The university collaborated with industry through human resource development. At that time, it seemed that there was no systematic approach to collaboration.

The story told by Niiyama supports Branscomb et al.'s (1999) study. Although the law regarding R&D cooperation for national universities was enacted in the 1970s, university and industry collaboration arose from individual faculty members applying for scholarship funding and from companies sponsoring student employment. However, informal collaboration soon became formal collaboration. For example, one remarkable characteristic of Japanese universities in the field of engineering was the emphasis they placed on a graduate's thesis work. The first three years of a graduate degree represented the student's moratorium period. In the fourth year, students enrolled at a research laboratory where they were trained as researchers and were able to partake in face-to-face

discussions with seniors (senior students, advisors, and a supervising professor). As a result of this intimate supervision, students' graduation theses reached a level at which they were worth presenting to academic societies. These experiences became the backbone of the students' engineering careers. Also, the students' intimate relations with supervisors represented their entry into university–industry collaboration. When they faced some difficulty in their careers as engineers, they could visit their old supervisors at their universities and ask for advice. This personal relationship could sometimes lead to an official framework of cooperative research, including financial aid provided by the company (H. Niiyama, personal communication, December 1, 2014).

Furthermore, a joint research system was established in 1983 with the intention of creating joint research centers at national universities by 1987. These centers would act as a bridge between universities and industry through joint research, technology consultation, and information exchange, etc. (Watanabe, 2009). This policy increased the amount of joint research funding by six times during the period 1983–1991, and the number of projects and joint patent applications also increased (Yamamoto, 1997). However, the number of university and industry collaboration activities during this period was limited due to the fact that university professors were not very willing to work with industry. Firms, on the other hand, wanted to collaborate with universities because it allowed them to recruit excellent students (H. Nei, personal communication, November 27, 2014). Therefore, the Japanese government and academic societies had to play an intermediary role in stimulating university and industry collaboration. METI coordinated collaboration between university

and industry. Quite a large number of engineers participate in academic societies in Japan and play an important role in a variety of social activities. It may be just my impression, because I don't have any statistics of this kind worldwide. It will, however, be useful to consider how academic society works in terms of constructing university–industry links. Academic societies undoubtedly facilitate communication between university and industry (H. Niiyama, personal communication, December 1, 2014)

“During the late 1990s, industry was also aware of the importance of doing R&D with universities due to its experience of the economic crisis in 1993” (H. Nei, personal communication, November 27, 2014). At the same time, university and industry collaboration became a policy focus in Japan. The Japanese government primarily focused on creating new knowledge and then focused on transferring technology, commercializing research outputs, and creating business ventures (MEXT, 2014). At first, the Japanese government started promoting cooperative R&D activities through the contract research system and the system of joint research in the 1980s. Following this, the issue of intellectual property rights was promoted due to the influence of U.S. government policy; for example, the government encouraged universities to establish technology-licensing offices (TLO) and enacted the Japanese Bayh–Dole Act to transfer ownership of intellectual property rights to universities. However, national universities at that time were public organizations and could not own intellectual property rights. Due to this problem, the National University Corporation Law (2004) was enacted to make national universities autonomous and to allow them to own intellectual property rights. From 2000–2001, the

Japanese government encouraged universities to set up business ventures through the Industrial Technology Enhancement Act and the Hiranuma Plan (which targeted 1,000 university-originated ventures over three years). In 2002, the university-originated ventures were allowed to use national universities' technical facilities (H. Nei, personal communication, November 27, 2014; M. Nagura, personal communication, April 4, 2014). Recently, the Japanese government enacted the Industrial Competitiveness Enhancement Act. This act allowed national universities to set up venture funds to invest in spin-off firms (Kagami, 2014).

In 2011, the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) introduced a program at the regional level to support regional innovation strategies with inter-ministerial collaboration from another two ministries (METI and the Ministry of Agriculture, Forestry, and Fisheries [MAFF]). MEXT facilitates the formation of knowledge networks for universities and other research institutes, supports the research facilities and equipment of local universities and other research institutes, and develops human resources. METI, on the other hand, focuses on marketing-stage R&D (commercialization and sales), while MAFF supports R&D applications for agriculture, forestry, and fisheries. Recently, the government has also introduced tax incentives covering 30% of the gross special R&D cost (a rise from 12%) for joint R&D with university or public research institutions.

Apart from universities, Japan's public industrial technology research institutes or Kohsetsushi Centers also play an important role in improving the technological capabilities of local firms. These centers were established in 1902 and are operated by prefectural or local governments under the guidance of the METI. Kohsetsushi Centers hire more than 6,000 staff in 262 offices (or 182 Kohsetsushi Centers) and work with local SMEs (Stephen & Robert, 2011). The types of services provided depend on the regional center in question; for example, the Tokyo center provides technical assistance, support for product development, joint R&D, industrial human resource development, collaboration for industry, and support for technology management through collaboration with local government agencies and local universities. The Kohsetsushi Centers support both general and specific technologies; for example, the Tokyo center targets software, mechatronics, nanotechnology, and biotechnology. With regard to R&D activities, staffs at Kohsetsushi Centers spend half their time on R&D. Furthermore, small manufacturers often send one or two of their staff members to work on projects at the Kohsetsushi Centers, which provides opportunities for firms' research personnel to gain research experience, develop new technical skills, and transfer technology back to their firms.⁷ In addition, prefectural governments are actively making efforts to promote science and technology by, for example, establishing councils to design policies for the promotion of science and technology and adopting outlines and guidelines for science and technology policies individually.⁸ For example, members of the administration in the Sendai area (including the

⁷ <http://www.iri-tokyo.jp/english/index.html>

⁸ <http://www.mext.go.jp/english/whitepaper/1302746.htm>

president of Tohoku University, the governor of Miyagi prefecture, the mayor of Sendai city, and the chairman of Tohoku Economic Federation) have exchanged opinions about the direction of collaboration between industry, academia, and government. This attempt has achieved positive results, such as personnel exchanges between Tohoku University and Miyagi prefecture/Sendai city, the establishment of industry-academia-government collaboration funds, and the establishment of the MEMS Park Consortium.⁹ Interestingly, private universities also play an active role in creating innovation through collaboration with local government.

“Professor Masaru Tomita, a 42-year-old professor at Keio University, was assigned to be the head of this new research institute in Tsuruoka, Yamagata prefecture. All R&D facilities were provided by local government. This institute pioneered the new life science field of systems biology using both experimental and computational biology. At that time, no university was carrying out research in this area. To build up the institute, he hired young talent from around the world to be his researchers. As a result, it took him only one year to get one patent. However, this technology was very new so it was very difficult to find a firm to acquire a technology license. Therefore, Keio University asked a journalist in the biotechnology field for assistance and then, this journalist asked a venture capitalist firm established by a professor to acquire the technology. This venture capitalist firm agreed to acquire the technology and invested in the start-up firm. He also asked food-processing companies such as Ajinomoto to provide R&D funds and do

⁹ <http://www.city.sendai.jp/keizai/sangaku/english/industry/>

collaborative research. After that, this start-up asked Hiden to create a new device and opened analytical services at a cell level. Consequently, pharmaceutical firms and universities used their service. Ten years after the firm's establishment, this start-up could receive an initial public offering (IPO)” (A. Nishizawa, personal communication, December 11, 2014).

4.1.4 Situation of university–industry collaboration in Japan. The reform of national universities has changed their behavior to some extent in relation to R&D collaboration with industry and has dramatically changed their management of intellectual property. They intended to increase their revenues and gain a better external evaluation (Kondo, 2009). With regard to joint R&D, national universities share the highest proportions of joint research, whereas two other types of universities (local public universities and private universities) tend to do contract research projects with firms. Kondo (2008a) has studied not only the relationship between the type of university and the mode of collaboration but also the relationship between the type of university and the characteristics of the collaborating firm. He concluded that local public universities tend to collaborate with SMEs. In terms of the results of collaboration, the number of patent applications from Japanese universities in 2011 was about 9,124 items, consisting of 6,507 domestic patents and 2,617 foreign patents. National universities were the majority of applicants (74% of total domestic patent applications) followed by private universities

(24%; Kondo, 2008a). Of the total patents, 5,645 patent licenses¹⁰ were granted in 2011. These patent licenses generated \$8.7 million in revenues,¹¹ which mainly came from national universities (81%), whereas 15% of the total revenues belonged to private universities. With regard to start-ups, there were 2,143 start-ups from Japanese universities in total; 70% of the total start-up consultation offices for researchers and students were located in national universities rather than other types of universities (Kondo 2008a; Table 2-2).

4.2 University–Industry Collaboration in Thailand

4.2.1 Development of the Thai higher education institution. This section reviews the historical development of the higher education system in Thailand. The reign of King Rama V was the starting point in the development of higher education, as can be seen in the establishment of specialized higher education institutes such as a medical school, a teacher training school, and a law school. These specialized higher education institutes were made into faculties of Chulalongkorn University in 1917 with a special charter providing a certain degree of autonomy from the government's civil services. In 1934, after the revolution, Thammasat University was founded outside the civil service system with a special charter. Academicians and university administrators then had the idea of transforming these universities into autonomous bodies after 1969.

¹⁰ As of 2013, MEXT and METI have approved 39 technology-licensing offices (TLOs). In 2011, the number of patent licenses by TLOs was 3,123.

¹¹ The exchange rate on June 8, 2015, was 1 yen = 0.008 US dollar.

Between the 1970s and 2000s, the Thai government enacted the following laws to serve specific purposes and to establish higher education institutes. In 1971, three technical institutes¹² were founded based on the Technology Act. These technical institutes were intended to provide the training of technicians, technical instructors, and technologists. In 1986, these three institutes became autonomous and were upgraded to university status. Three years later, the Private Higher Educational Institution Act was enacted to allow for the establishing of private universities and colleges. These universities are autonomous in terms of financial and personnel management, whereas academic programs are regulated by the Office of the Higher Education Commission (OHEC). During the 1990s, Suranaree University of Technology was established as the first autonomous university. Autonomous universities receive financial support from the government's budget for basic works but have freedom in terms of financial, academic, and personnel management. Since then, 18 public universities have been transformed into autonomous universities. In order to support the development of the regions of Thailand, an act related to Rajabhat University was enforced in 2004. In addition, the Institute of Technology and Vocational Education or Rajamangala Institute of Technology was upgraded to the Rajamangala University of Technology in 2005. Its purpose is to offer educational programs, undertake research, and provide academic services to the community. A special kind of private university, mainly funded by one corporate, has also emerged to fulfill the specific needs of business corporations. In 1993, Dusit Thani College was the first college in Thailand established by

¹² King Mongkut University of Technology, Thonburi (KMUTT), King Mongkut University of Technology, Ladkrabang (KMUTL), and King Mongkut University of Technology, North Bangkok (KMUTNB).

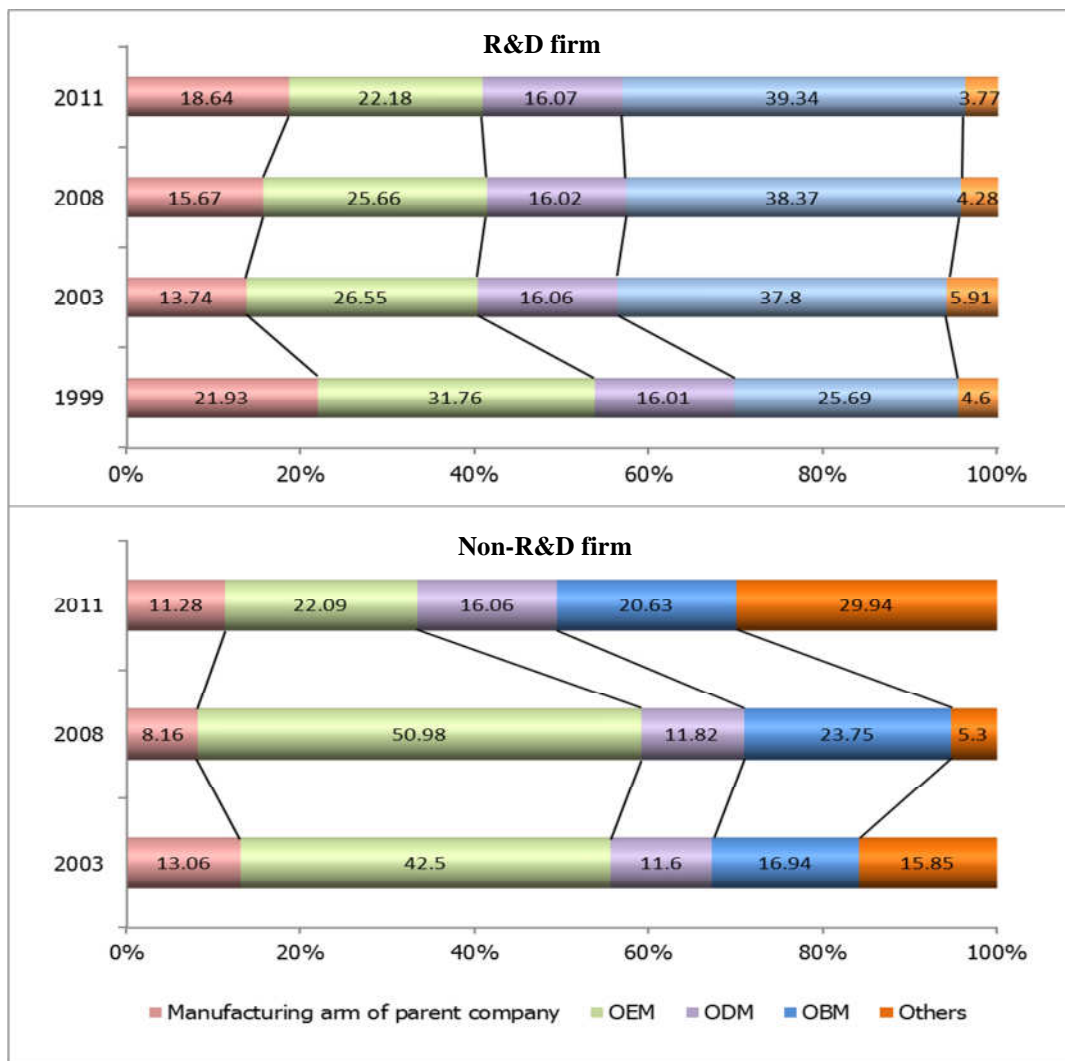
a private company, namely Dusit Thani Group, which owns and operates hotels and resorts. The college is located adjacent to one of the group's hotels. In 2007, Panyapiwat Institute of Management was founded based on funding from CP All Co., Ltd.

Currently, the Ministry of Defense and the Ministry of Public Health have their own educational institutes that specialize in fields related to their own specific needs. The Office of Higher Education Commission (OHEC), on the other hand, oversees altogether 171 higher education institutions. This includes 31 public higher education institutions, 71 private higher education institutions, 49 regional universities (40 Rajabhat Universities and 9 Rajamangala Universities of Technology; Office of Higher Education Commission, 2013).

4.2.2 Thai firms' technological capabilities. Thai firms' technological capabilities are relatively low compared to their Japanese counterparts. Only a small minority of large subsidiaries of TNCs, large domestic firms, and SMEs have strong R&D capabilities while the majority is still struggling to increase their design and engineering capability (Intarakumnerd & Leclerr, 2010). The results of the National Survey of R&D and Innovation Activities provide data at the macro level. The findings were similar to the conclusions of Intarakumnerd and Leclerr (2010). A majority of firms (90%) receive their largest share of company revenue from products manufactured by enterprises according to design specifications provided by external buyers (OEM), whereas only 10% of total firms receive their largest share from products developed and designed by enterprises and sold

under their own brand (OBM). Nonetheless, there is one sign suggesting an improvement in firms' technological capabilities. The share of OBM has increased significantly while the proportion of OEM has sharply declined (Figure 4-2).

Figure 4-2: Thai Firms' Capabilities



Source: National Science, Technology and Innovation Policy Office

Remark: Share of company's revenue according to types of products

- Manufacturing arm of parent company: Products manufactured by your enterprise according to design specifications of parent company or subsidiaries
- OEM: Products manufactured by your enterprise according to design specifications provided by external buyers
- ODM: Products developed and designed by your enterprise according to performance requirements of buyers
- OBM: Products developed and designed by your enterprise and sold under your own brand

At the micro level, Sadoi (2012) concluded that Thai automotive firms have achieved only production capability. Their technological capabilities cannot be developed to cover innovative capability. In the case of Japanese firms and joint ventures (Japanese and Thai), R&D and quality control activities are mostly carried out in Japan. These firms have relied on Japanese's technical assistance. Even in the case of joint ventures between large Thai firms and Japanese textile firms, the stages of development and planning are carried out in Japan. There is no plan to relocate high-engineering activities to Thailand. Regarding Thai firms, some have technical assistance agreements for each technology while others do not. They hire Japanese advisors and Thai staff who speak fluent Japanese (Sadoi, 2012).

4.2.3 Thai government policy on university and industry collaboration.

University and industry collaboration in Thailand initially paid most attention to engineering activities (problem solving) and cooperative education. By setting up the Industrial Technology Assistance Program (iTAP) in 1992, the Thai government, through the Ministry of Science and Technology (MOST), provided technical guidance to industry through consultation and R&D. This program is intended to strengthen the technological capabilities of Thai SMEs. It acts as an intermediary that locates and partially subsidizes university professors, allowing them to work for Thai SMEs as consultants to solve their technical problems (S. Chatratana, personal communication, October 21, 2014; T. Smitinont & N. Singhavilai, personal communication, February 18, 2015). In the meantime, Suranaree University of Technology initiated the concept of cooperative education in 1993.

Ten years later, the OHEC, under the Ministry of Education (MOE), explicitly embraced the cooperative education concept and encouraged its application to all universities (Ruksasuk, 2011). In the same year (1993), Thailand Research Fund (TRF) was established to provide R&D grants for basic research, scholarships for students and researchers, and community-based research. Some R&D schemes focus on collaboration with universities, industry, and communities (TRF). During the legislation of the National Education Act and the bureaucratic reform between 1999 and 2000, the government encouraged public universities to become autonomous in order to increase management efficiency. This indirectly affected the effectiveness of collaboration between the two parties. In 2004, OHEC also encouraged universities to set up TLOs and university business incubators (UBIs) to stimulate technology transfer to industry and provide intellectual property services for university researchers (MOE, 2014). Furthermore, between 2004 and 2007, MOST set up science parks in three regions outside Bangkok. The purpose of these measures is to transfer knowledge and technology, provide technical assistance to local businesses, and incubate technology startups (K. Promwong, personal communication, February 17, 2015). Also, MOST established a clinic technology program to provide consultancy services to universities and vocational educational institutes located mostly outside Bangkok¹³ (MOST). In 2012, TRF initiated Research and Researchers for Industry (RRI) to provide research funding to students pursuing their master's or doctoral degree. The research topics are based on industrial demand (TRF). In 2014, the Thai government started operating a talent mobility program with the intention of encouraging university

¹³ Clinic technology project, Ministry of Science and Technology, Thailand

researchers to work with industry as full-time or part-time staff. Researchers who receive scholarships from government are able to join this program. Time working in industry is considered to be compensation for these scholarships (K. Promwong, personal communication, February 17, 2015). Recently, the Thailand Board of Investment (BOI) has approved its new policy for promoted companies which carry out joint R&D with university and research institutes, and donations to Technology and Human Resources Development Funds, educational institutes, specialized training centers, research institutes or governmental agencies in the science and technology field in Thailand. The promoted companies, which already have an eight-year corporate income tax exemption, will receive an additional three-year corporate income tax exemption.¹⁴ Strategic sectors,¹⁵ on the other hand, will receive additional incentives in the form of a 50% reduction in corporate income tax on net profit derived from the promoted activity for 5 years (Thailand Board of Investment).

4.2.4 Situation of university–industry collaboration in Thailand. In Thailand, national universities have the highest intensity of university and industry collaboration. National universities tend to collaborate with industry whereas local public universities

¹⁴ One additional year: investments or expenditures are not less than 1% of the project's total revenue for the first 3 years combined, or not less than 200 million baht.

Two additional years: investments or expenditures are not less than 2% of the project's total revenue for the first 3 years combined, or not less than 400 million baht.

Three additional years: investments or expenditures are not less than 3% of the project's total revenue for the first 3 years combined, or not less than 600 million baht.

¹⁵ Strategic sectors are the automobile sector, the electrical apparatus sector, the petrochemical and chemical product sector, the digital sector, the agricultural processing sector, and the textile sector, etc.

focus on collaboration with communities. Private universities have the least number of university and industry collaboration activities (Table 4-1).

Table 4-1: University and Industry Collaboration in Thailand across University Types

| University Type | R&D collaboration (project) | | Consultation (project) | | Cooperative Education | | Granted Patent (item) ⁶ | Technology licensing (license) ⁷ |
|-------------------------|-----------------------------|------------------------|------------------------|------------------------|-----------------------|------------------------|------------------------------------|---|
| | Industry ¹ | Community ² | Industry ³ | Community ⁴ | Student ⁵ | Host firm ⁵ | | |
| National University | 244 | 0 | 125 | 72 | 9,787 | 5,330 | 45 | 106 |
| Local public University | 44 | 89 | 23 | 87 | 6,823 | 4,894 | 0 | 3 |
| Private University | 8 | 0 | 6 | 0 | 2,755 | 1,531 | 0 | 0 |
| Total | 296 | 89 | 155 | 159 | 19,365 | | 45 | 109 |

Remark: This table provides the data on Thai government projects

Source: 1: Master Research Grants (2012) and Research and Researchers for Industries (2013), TRF and iTAP (5-year average data from 2010-2014 per year), NSTDA

2: Area Based Collaborative Research for Undergraduate and Master Students (2009), TRF

3: iTAP (5-year average data from 2010-2014 per year), NSTDA

4: Clinic Technology (2015), MOST

5: Cooperative Education Network (2011), OHEC

6: Department of Intellectual Property (2011)

7: National Science Technology and Innovation Policy Office (2008-2011).

Data includes petty patent, trademark, copyright

Kondo (2008b) conducted a case study to investigate the development of university and industry collaboration. He selected the hard disk drive (HDD) industry as a case study because Thailand is one of the world's most important producers of HDDs.

“At present, there are four key HDD manufacturers: Seagate, Fujitsu, Hitachi, and Western Digital. All of them are multinational corporations. A branch of International Disk Equipment and Materials Association (IDEMA) was established

in 1999 to operate business networking and information sharing and to address key issues in the development of the industry.

At first, two parties—the private sector and universities—initiated the collaboration, and the role of the government was limited. Seagate and IDEMA Thailand collaborated with universities such as Asian Institute of Technology, Khon Kaen University (KKU), SUT, and King Mongkut's University of Technology Thonburi (KMUTT). The first collaboration was based on human resource development in the engineering area, and this was extended to R&D collaboration with the creation of a joint R&D center. Nonetheless, this center continued to focus on human resource development. Regarding the role of government at that time, only two public research institutes existed that related to the HDD industry: Thai Microelectronics Center and Electric and Electronics Institute. The turning point of the Triple Helix collaboration in this industry occurred when IDEMA Thailand offered recommendations on the necessity of human resource development and technology enhancement to the National Science and Technology Development Agency (NSTDA). The recommendations consisted of four main issues: (a) strong partnership among industry, university, and research institute/government, (b) human resource development, (c) automation infrastructure development, and (d) supplier development and innovative industry policy. After that, NSTDA operated seven pilot projects between September 2004 and May 2005 based on IDEMA's recommendations. To manage and handle projects, NSTDA appointed a cluster manager who was a staff of the National Electronics and Computer Technology

Center (NECTEC). At this stage, the board of investment provided incentives for human resource development and technology enhancement to the HDD industry. From September 2005, universities and firms jointly developed 49 curricula. There were 14 universities involved in the activities. HDD centers of excellence (COEs) were established at three universities: KMUTT, KKU, and King Mongkut's Institute of Technology Ladkrabang. To promote collaborative R&D activities, NSTDA provided 500 million baht. Over time, the collaboration developed and expanded to include many firms. As a result, joint R&D projects and contract R&D projects were conducted by firms themselves, which were not involved in the HDD cluster program.”

Regarding patents, the applications of Thai universities amount to 327 items. Of the total patent applications, 45% belong to approved TLOs. From 2008 to 2012, Thai TLOs generated \$6.7 million¹⁶ from licensing several types of intellectual property such as patents, copyright, trademarks, geographical indications, plant varieties, and animal varieties (Commission of Higher Education, 2014). In terms of entrepreneurship promotion, Thai universities created 500 start-ups and spin-offs between 2009 and 2013.

Kondo (2010) studied the case of Chulalongkorn University (CU), a pioneer in terms of university/industry collaboration and intellectual property management in

¹⁶ The exchange rate on June 8, 2015 was 1 baht = 0.029 US dollar.

Thailand. This case study describes how one Thai university collaborates with industry, handles intellectual property, and promotes entrepreneurs.

“As a large-size university in Thailand, CU conducts university and industry research collaboration at various levels. At the individual researcher level, some faculty members provide consulting services, and some work at company laboratories in order to earn extra money. At the organizational level, in cases when a project does not involve other faculties or research centers, the office of a given faculty or research center will handle and manage the contract work itself. In contrast, Chula Unisearch can manage contracts if a project involves various faculties and research centers. Chula Unisearch was established as an internal organization in 1986 to manage interdisciplinary contract projects. Chula Unisearch itself provides consulting services. In the case of IP, the Chulalongkorn University Intellectual Property Institute (CUIPI), an independent organization, becomes involved. In addition to IP management, CUIPI coordinates contract research, joint research between university faculties/research centers and companies, and IP research and training. Entrepreneurship training financed by CHE is also provided once or twice a year.

Also, Chulalongkorn University Intellectual Property Foundation (CUIPF) possesses a holding company, Jamjuree Innovations Co. Ltd., established in 2006, in addition to CUIPI. This holding company intends to commercialize

Chulalongkorn University technologies through spinning off companies. In term of educational collaboration, the internal organization, called “University-Industry Relation,” handles scholarships and internships. In former days, all aspects of university–industry relations were handled by this organization. The Continuous Education Center manages continuous education for working people.”

4.3 Comparison Between Japan and Thailand

4.3.1 Development of the higher education institution. The development of higher education in both Japan and Thailand started in the same period (the 1860s to the 1870s). The first university in Japan was the University of Tokyo, which was founded through the merger and restructuring of the Westernized higher education institutions (National Institute for Educational Research, n.d.). The King Guard School was then established to provide higher education for the public. Chulalongkorn University was established as the first university in Thailand by incorporating existing specialized higher education institutes, such as a medical school, a teacher training school, and a law school, as its own faculties (Nitungkorn, 2000; Suwanwela, 2008). In the 1950s, Japan considered a highly qualified workforce and research as the essential resources for industrial development; therefore, the government deregulated the procedure for establishing private universities and set up colleges of technology. In the 1970s, various kinds of vocational and technical training appeared in Japan (National Institute for Educational Research, n.d.). At the same time, the Thai government passed the Technology Act to provide for the training of technicians, technical instructors, and technologists. However, private education

development in Thailand lagged behind Japan, and hence, Thailand passed an act allowing for the establishing of private universities and colleges in the late 1980s. In the 2000s, the Thai government realized the importance of regional development and upgraded regional educational institutes (Rajabhat and Rajamangala University) to give them university status.

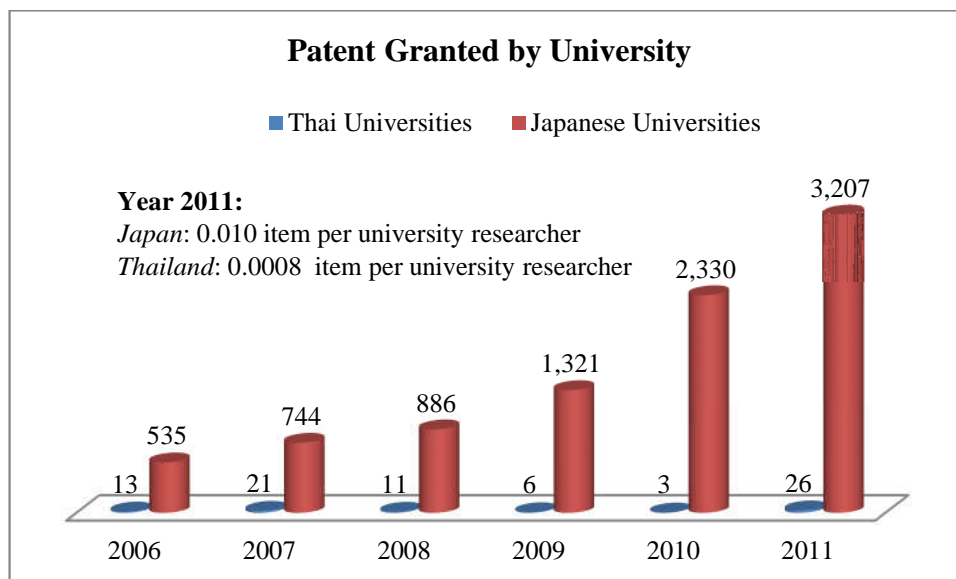
4.3.2 Firms' technological capability. Japanese firms became more innovative, invested in R&D, and relied less on the importation of foreign technologies (Odagiri & Goto, 1993). In contrast, in Thailand, only a small minority of large subsidiaries of TNCs, large domestic firms, and SMEs had capability in R&D, whereas a majority still struggled to increase their design and engineering capability (Intarakumnerd & Leclerc, 2010). This outcome was one result of the fact that, over the last 20 years, Japanese industry R&D investment has accounted for between 70% and 80% of the total national R&D expenditure, while Thailand's share during the same period was 30–50% (Sakakibara, 2007; STI Office, 2014).

4.3.3 Government policy on university-industry collaboration. With regard to key actors' roles in supporting industry, key actors MEXT and METI initiated several programs to facilitate the collaboration. These two ministries play complementary roles in supporting university and industry collaboration. To support regional innovation strategies, MEXT facilitates the formation of knowledge networks of universities and other research institutes, supports research facilities and equipment among local universities and other

research institutes, and develops human resources. METI, on the other hand, focuses on R&D at the marketing stage (commercialization and sales). In Thailand, MOST and MOE are the main key actors behind these policies, but the programs initiated by these two ministries partly overlap. Both MOST and MOE have implemented business incubator programs at universities. The difference between these programs is that MOST focuses on technology business incubators whereas MOE's university business incubators (UBI) may or may not relate to technology. Moreover, at the regional level, local Japanese government and local public research institutes also play an active role in assisting industry. Under METI's guidance, prefectural or local governments have operated Japan's local public industrial technology research institutes or Kosetsushi Centers, which were established in 1902 (Stephen & Robert, 2011). These centers partially take role of universities in transferring technology or knowledge to local SMEs. Nonetheless, Japanese local universities play a role in supporting industry through the government's facilitation, including providing research facilities. In contrast, in Thailand, there is no local research institute; to address this, the central government commissioned major universities located across regions to host and operate government initiatives. These initiatives include clinic technology programs and regional science parks located in the north (Chiang Mai University), northeast (Konkaen University), and south (Prince of Songkla University); the ability to provide consultancy services to local firms and communities has been established at universities and vocational educational institutes mostly located outside Bangkok (Ministry of Science and Technology).

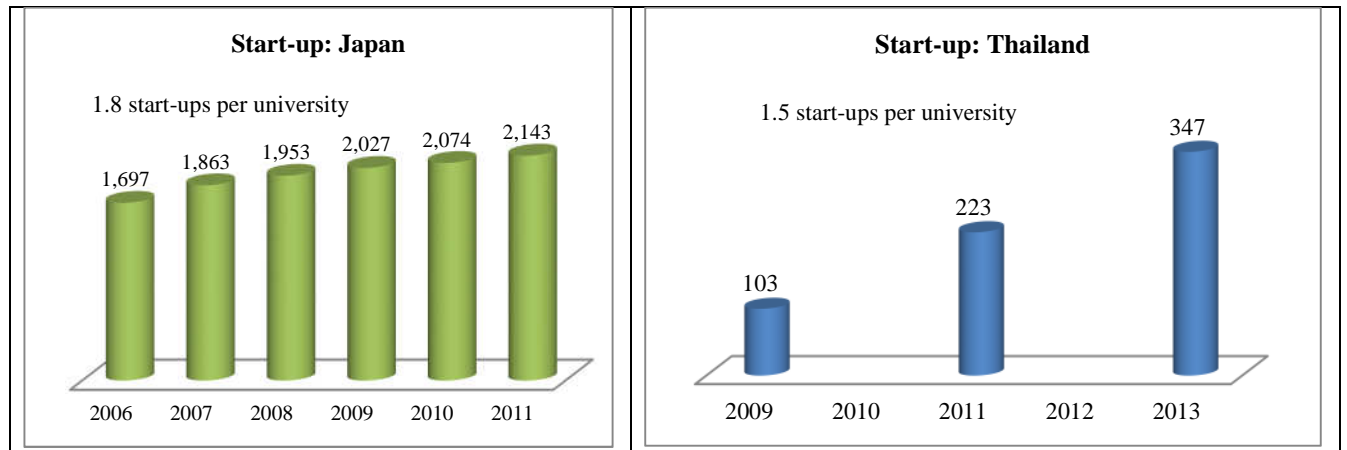
4.3.4 Situation of university–industry collaboration. Regarding the granting of patents, Thai universities lag behind their Japanese counterparts. The granted patents per researcher at Japanese universities are 12.5 times more than those at Thai universities. From 2008 to 2012, Japanese universities generated revenues of \$127 million from patent licensing (Japan Patent Office, 2014). During the same period, on the other hand, Thai universities generated \$6.7 million from licensing several types of intellectual properties such as patents, copyright, trademarks, geographical indications, plant varieties, and animal varieties (Office of Higher Education Commission, 2014). In terms of entrepreneurship promotion, the number of start-ups arising from Japanese universities is higher than the number arising from Thai universities (Figures 4-3 and 4-4).

Figure 4-3: Patent Granted by Universities in Japan and Thailand



Source: Patent: Japan Patent Office (2014) and Commission of Higher Education (2014), University researcher: OECD and NRCT

Figure 4-4: Number of Start-ups from Universities in Japan and Thailand
(accumulated number)



Source: Japan: MEXT (2014) and Thailand: MOE (2014)

4.4 Concluding Remarks

Although university and industry collaboration policies began at the same time in Japan and Thailand, they have had different results in each country. One of the main reasons for this may be the focus of the different policies that have been introduced to promote university and industry collaboration. While the Japanese government initially emphasized collaborative R&D and technology licensing activities, the Thai government primarily aimed to upgrade the engineering activities of Thai SMEs. Furthermore, Japanese firms are more innovative and have invested heavily in more R&D activities than Thai firms. Not only is the number of Japanese universities much higher than the number of Thai universities, but their technological capabilities are also much higher, as can be seen from the number of granted patents. The information that has been reviewed in this chapter will provide the background for the data analysis that can be found in Chapter 5 and Chapter 6.

Chapter 5

Results and Discussion:

Influence of University Type

Chapter 5 analyses the data at the university level from the personal communications of Japanese and Thai universities' executives responsible for university and industry interactions and also analyses personal communications of policy makers and experts.

This chapter aims to fill the research gap regarding the influence of university types. Three types of universities (21 universities) are examined: (1) national universities, (2) local public universities, and (3) private universities.¹⁷ It is comprised of four sections. Section 5.1 summarizes the historical background of the universities. Organizational structures in supporting industry of Japanese and Thai universities are concluded in Section 5.2. Key findings about the collaboration between university and industry across different

¹⁷ National university is established by the central government. It emphasizes research mission to gain frontier knowledge and/or technology.

Local public university is established by either the local government or the central government. Local government allocates budget to the university while the central government provides grant to the universities to assist local community. Main mission of local public university is to provide higher education opportunities to local people and to serve as intellectual and cultural centers within the local community.

Private university is established by private individuals and supported by private funds. It can design academic curricula and has the autonomy to promote its own unique education and research activities, based on the spiritual legacy of its foundation.

types of universities in both countries and about the influence of local and country contexts are discussed in Section 5.3. The conclusion regarding these issues is provided in Section 5.4.

5.1 Historical Backgrounds of Universities

This section investigates the universities' historical backgrounds and how they stem unique culture.

First, with regard to national universities, the University of Tokyo (Todai) was established in 1877 as the first university in Japan by merging the Tokyo Kaisei School (western study) with a medical school. Initially, there were four faculties; law, science, letters, and medicine, which were set up. It continued to merge with various schools, such as the Imperial College of Engineering and the Tokyo School of Agriculture and Forestry. Tohoku University (Tohoku) was founded on Aobayama Mountain in 1958 as a national university botanical garden for the preservation of flora. The three main principles of the university are that it is open door, research first, and a place for practice-oriented research and education. Explicitly, the open door policy began with the acceptance of students from technical high schools in 1911, and the first females at a Japanese university in 1913. In Thailand, Chulalongkorn University (CU) was the first higher educational institute, and it was originally set up with four faculties in 1917, which are medicine, engineering, arts, and science. However, this university was not formed by a merger of schools. It was based on a royal policy aimed at producing quality personnel in both the public and private sector.

Unlike CU, Mahidol University (MU), established in 1888, originated with a public medical school. At present, these four universities have become comprehensive universities that offer courses ranging from the field of S&T to social sciences at undergraduate and graduate education. Based on their long histories and unique establishment, these four universities seem to have excellent research cultures. In theory, all mentioned universities were transformed to be autonomous,¹⁸ but in fact, their cultures, including administration practices, have not been completely autonomous yet. In the case of Japan, the universities are strongly controlled by the central government (Kondo, 2008a), whereas in the Thai case, some scholars name the situation as a semi-autonomous culture in which the practices have not been changed from the previous situation yet (P. Lakpetch, personal communication, February, 24, 2015). Chiang Mai University (CMU) was established as the first institution of higher education in Northern Thailand. Since its establishment, CMU has been aiming at providing a broad range of academic programs as a comprehensive university. In terms of national universities mainly offering science and engineering course, Tokyo Institute of Technology (Tokodai) and King Mongkut's University of Technology Thonburi (KMUTT) were selected as case studies of Japan and Thailand. They were established in 1881 and 1957, respectively. Both of them used to be technical colleges. In the 2000s, Tokodai and KMUTT became autonomous higher education institutes. They offer courses in engineering and science for bachelor and doctoral degrees. In the case of Thailand, KMUTT is likely to have a more flexible administrative approach and its policies initiated by university council are relatively distinguished; for example, setting flexible

¹⁸ Japan: National University Corporation Law, Thailand: Autonomous University Law

criteria to promote career paths of academic staff and sending university researchers to be full-time staff at firms. As a result, in scholars' points of view, KMUTT has become more autonomous than other autonomous universities (W. Leelasiriwong, personal communication, February 16, 2015).

The second type of university examined was local public universities. Fukui Prefectural University (FPU) was originally set up in 1992 with bio-resource and nursing courses. Recently, it expanded to open an economic faculty. Interestingly, this university aims to collaborate with local businesses through the Research Institute for Regional Economics. This institute aims to share information among local businesses and to conduct research on Asian countries in order to provide this information to companies in Fukui Prefecture. Miyagi University (MYU) was founded in 1993 as a strategic project in the Miyagi Prefecture comprehensive plan. MYU initially offered degrees in the nursing and project design area. Then, in 2005, it merged with Miyagi Agricultural College, a junior college located in Taihaku-ku, Sendai, and the School of Food, Agricultural and Environmental Sciences was operated. In the Thai case, Phuket Rajabhat University (PKRU), established in 1971, used to be a teacher's college. PKRU has become a higher education institute offering both industrial technology and social sciences courses. In contrast, two institutes of Rajamangala University of Technology (RMUT), such as RMUT at Thanyaburi and RMUT at Lanna, were established in 1975 as technical colleges with specialization in hands-on training in technical education. RMUTs have become higher education institutes and currently open courses in both S&T and social sciences.

Nonetheless, the proportion of S&T students is much higher than social sciences students (RMUT had 19,185 S&T graduates and 4,940 social science graduates in 2013¹⁹). This kind of university has a relatively high focus on its educational mission. In the Thai case, the faculty members still have to focus on teaching (N. Moonpa, personal communication, February 10, 2015; C. Charoenchai, personal communication, February 19, 2015), whereas in Japan, although the university's executives strongly support collaborative activities, few faculty members are interested in working on this kind of activity (M. Shimotani & T. Utagawa, personal communication, December 18, 2015).

The third type of university includes Keio University (Keio), Toyo University (Toyo), Tohoku Institute of Technology (TIT), and Toyota Technological Institute (TTI), which are private universities in Japan, and Siam University (Siam), Rangsit University (RSU), North Chiang Mai University (NCMU), Dhurakij Pundit University (DPU), and Panyapiwat Institute of Management (PIM), which are private universities in Thailand. Keio, established in 1858, was initially a Dutch studies school and it then transformed into an English studies school. After that, it set up an elementary and secondary school, followed by a School of Medicine. It is currently a comprehensive university. Toyo was founded in 1887 as a private philosophy academy. Rather than training professional philosophers, Toyo emphasizes education that enables students to develop their own perspectives and insights and to act on the basis of their own philosophy. Its academic programs cover from natural science and history to literature and sports. TIT is a private

¹⁹ RMUTT Annual Report 2013

university that initially offered electronics and communication courses. Until now, TIT has emphasized an engineering education. In the Thai case, the root of Siam was a vocational college with an engineering education (established in 1965). On the contrary, RSU (established in 1965), DPU (established in 1968), and NCMU (established in 1999) were originally higher education institutes. The latter three institutions had the similarity of offering business administration courses at the beginning. The difference is that RSU opened nursing courses whereas NCMU offered engineering courses. In scholars' opinions, Keio accumulated a bureaucratic culture due to its long history in education and research (T. Ueyama, personal communication, January 30, 2015). In addition, Japanese private universities received financial aid from the government that could influence them (Kondo, 2008a; H. Nei, personal communication, November 27, 2014; T. Ueyama, personal communication, January 30, 2015). Thai private universities' administrative approaches seem to be flexible and they are slightly influenced by the government due to limited financial support from the government (N. Pantaratorn, personal communication, March 5, 2015).

In terms of special cases, TTI and PIM largely receive budget from one corporation. Toyota Corporation established TTI in 1981 as a part of its social contribution activities. It originally admitted only students with industrial experiences and then extended to admit high school students. This university used to offer vocational and bachelor's programs in engineering but it now also provides graduate education. Interestingly, Toyota's competitors also recruit TTI's graduates. In the Thai case, PIM was established in

2007 as a subsidiary of CP All Co., Ltd. It formerly offered bachelor's and master's degrees in retail management mainly to produce quality personnel for the parent company.

Recently, its courses were extended to cover fields of S&T and social sciences. Also, it offers a doctoral degree in business administration for its Chinese program. The uniqueness of this institute is that it provides a work-based learning program that requires the students to work with affiliated companies or other companies. More interestingly, PIM puts great emphasis on creating networks. The executives strongly encourage the faculty members to exchange ideas with various people, such as affiliated companies' staffs, suppliers, experts, and university people. Additionally, it hires many young lecturers who are in new generation. The environment of PIM is different from traditional universities.

5.2 Universities' Organizational Structures for Supporting Industry

Based on personal communication data and existing documents, Japanese universities, especially national universities and large private universities, set up central organizations to oversee collaborative activities regarding collaborative R&D, intellectual property, and business ventures. In contrast, Thai university organizational structures for supporting industry appear to be relatively decentralized but they still retain a centralized structure. In the past, academic service centers at the university level had a conventional structure for external collaboration. The purposes of establishment are basically to do commissioned R&D projects, to provide technical consultancy services, and to arrange training programs. However, the partners of this center are mostly the government agencies. As a result, most of the universities facilitate collaboration with industry at the

faculty level. The academic service centers at faculties are considered to be independent bodies. They have the authority to make decisions and operate projects. In Thai universities, there is no explicit policy to facilitate the cross-faculty collaboration; therefore, they hardly gain the advantages of multidisciplinary research. Nonetheless, King Mongkut's University of Technology, Thonburi (KMUTT) is different from other universities. It has been centralizing all collaborative activities to its Liaison Office (Appendix 2).

5.3 Key Findings and Discussion

This section is a summary and discussion of key findings.

5.3.1 Research Question (a): Do university types relate to modes of collaboration? If so, why, if not, why not?

National universities are dominant in joint R&D activities. The results of Japanese cases support this statement. Japanese universities prefer to conduct joint research, where university researchers and company researchers work together on equal footing. Those universities have put more efforts into attracting external R&D funds because the Japanese government has gradually reduced the budget of national universities (O. Mitsuhiro, personal communication, December 15, 2014; F. Hasegawa, & N.K. Das, personal communication, July 24, 2015). To learn new knowledge, firms want to closely work with them and they aim to jointly apply for patents. Sometimes, those patents have not yet been commercialized because they are future technologies. Firms need to file patents in order to protect their competitors (X. Gu, personal communication, July, 5, 2015). Interestingly, we

found interdisciplinary joint R&D projects, which require knowledge in various fields, such as art, science, humanity, sociology, engineering, and science. For example, the University of Tokyo explicitly encourages and takes advantage of its multidisciplinary knowledge across faculties or departments (University of Tokyo, 2011) when it has joint R&D projects with the industry. In the case of Tohoku University, it does not have a specific policy eliminating boundaries of faculties. Nonetheless, when collaborative projects are associated with various kinds of knowledge, the Office of Cooperative Research and Development coordinates researchers across faculties (F. Hasegawa, personal communication, July 24, 2015).

In contrast, the findings of Thai cases do not support results of previous studies. The collaborations are mostly based on commissioned R&D because there are rare cases in which Thai private firms contribute human resources to R&D projects. The results of those collaboration are mainly product and process improvement (Chulalongkorn University [CU]'s Faculty of Engineering database; Lakpetch, 2009; Mahidol University [MU] Annual Report, 2013; S. Assabumrungrat, personal communication, February 17, 2015; S. Chairoj, personal communication, February 16, 2015; S. Jomjunyong, personal communication, August 12, 2015; T. Anantana, personal communication,, August 20, 2015). In the case of the medical schools of those universities, many clinical research projects were found (P. Sampatanukul, personal communication, February 26, 2015). Unlike Japanese universities, Thai universities hardly work across faculties (B. Withyachumnarnkul, personal communication, February 14, 2015; S. Ekasit, personal communication, February 17,

2015). If it happens, it is a result of personal relationship of professors across faculty/department, rather than an official policy of the universities (S. Ekasit, personal communication, February 17, 2015). Remarkably, the collaborations of KMUTT and Chiang Mai University (CMU) are different from CU and MU. In KMUTT's case, the frequent mode is intensive cooperative education,²⁰ which emphasizes students' R&D activities under the joint supervision of firms and universities, because one of KMUTT's missions is to produce quality human resources with hands-on and practical experiences (M. Nopharatant, personal communication, February 10, 2015). In contrast, CMU is located in an area where most firms are SMEs that do not have high technological capabilities. CMU's activities are, therefore, based on both consultation and commissioned R&D to these local SMEs. CMU's Northern Science Park is an intermediary body enabling CMU to carry out these activities (S. Jomjunyong, personal communication, August 12, 2015; T. Anantana, personal communication, August 20, 2015).

Local public universities have the least collaborative R&D activities. Based on Kondo's study (2008a; 2009), local public universities in Japan have the least R&D activities compared to the other two types of universities. The findings of the Japanese cases confirm Kondo's studies. The universities, like Fukui Prefectural University (FPU) and Miyagi University (MYU) mostly provide consultation on product and process improvement because most collaborating firms are small local firms that do not have R&D capabilities and may not know how to access the universities. For example, to collaborate

²⁰ KMUTT called it a "work integrated learning" or "WIL" program.

with firms, FPU hires four faculty members who used to be companies' researchers. One of them holds a university's executive position and carries out several projects with the industry, whereas the remainders are also interested in doing so (T. Utagawa, personal communication, December 18, 2014). In addition, education and contribution to local communities are priority missions of these universities and external funds received by these universities do not specifically ask for R&D activities. For example, MYU has received grants under an Ippo Ippo Nippon project from local government and Japan Association of Corporate Executives to build demonstrated plants for local communities (I. Miyahara, & T. Furukawa, personal communication, July 23, 2015).

In Thailand, local public universities seem to have higher numbers of R&D and engineering activities than private universities (see Table 4-1 in Chapter 4), especially in the case of local universities focusing on engineering disciplines, because they receive financial support from the central government. Nonetheless, cooperative education²¹ is also a high priority because these local universities have the main mission of providing education-producing human resources with practical skills. These universities, therefore, send students to work as full-time employees at firms. In some cases, afterwards, joint curriculum development between universities and firms was initiated (C. Charoenchai,

²¹ Cooperative education: Students are required to work in a work place as full-time employees for 4 to 12 months. They also receive training and supervision from both workplace mentors and academic supervisors. In contrast, internship programs are more flexible. They can be paid or unpaid, shorter, and done in the summer when students are out of school. They can be part-time.

personal communication, February 19, 2015; H. Prasankarn & N. Chanrawang, personal communication, February 25, 2015; N. Moonpa, personal communication, February 10, 2015).

Private universities are key performers in commissioned R&D activities. Japanese cases present various kinds of collaboration, not only commissioned R&D. It depends on universities' specializations. Joint R&D is the most frequent mode for Keio and TTI, whereas Toyo often does commissioned R&D projects. Interestingly, consultation seems to be a distinctive mode of TIT. Those results partially support results of previous studies (Kondo, 2008a, 2009); a distinctive mode of Toyo is commissioned R&D. In contrast, in the Thai case, collaboration is mostly based on cooperative education.

In Japan, Keio University has similar interaction modes as national universities (K. Hatori, personal communication, January 29, 2015). This result is not surprising because Keio University is a long established and internationally famous university. More than half of the total R&D projects are medical and clinical research projects that are carried out by researchers of Shinanomachi campus. Likewise, Toyo University, also a long-established private university, uses commissioned R&D projects as the most frequent modes, but the results of collaboration are mostly process improvement (A. Nishizawa, personal communication, July 27, 2015). On the other hand, TIT focuses on local community development through both R&D and consultation. Most funds come from the university itself. In case of TTI the university is likely to closely work with parent companies in

Toyota Group on joint R&D mode. However, these joint R&D projects focus on basic research, as most applied R&D is done inside the companies (M. Yoshimura, & K. Yamashita, personal communication, January 28, 2015). Providing technical infrastructure, such as laboratories and equipment, is also one of the important modes of collaboration. Due to government financial support, TTI's technical infrastructure is very advanced and reliable. It is a member of Nanotechnology Platform Japan, which provides infrastructure services for the public (M. Yoshimura, & K. Yamashita, personal communication, January 28, 2015).

Thai private universities like RSU, DPU, Siam, NCMU have a mission greatly emphasizing education because they still rely on the tuition fee as their main source of income. In addition, the faculty members in these universities have a relatively high teaching load. Support of government, especially competitive funds to private universities, is also limited compared to public universities due to high competition (N. Pantaratorn, personal communication, March 5, 2015). Although they have several collaborative projects with industry through cooperative education, they are mostly based on both personal connection and a given university's Cooperative Education Center (N. Pantaratorn, personal communication, March 5, 2015; P. Punyathep, personal communication, July 29, 2015; S. Satyarakwit, personal communication, February 11, 2015). PIM is a special case. It is an arm of the country's largest conglomerate (CP Group). It aims to produce quality human resources for CP. PIM's students spend every three months alternating between attending classes and taking an internship in CP's subsidiaries

or their suppliers and customers (S. Chocksawangwoong, personal communication, February 12, 2015; S. Manarungsan, personal communication, February 13, 2015).

With regard to its technology licensing mode, in Thailand the technology licensing office (TLO) is one of the main government schemes for supporting industry. Generally, Thai researchers have not paid much attention to technology licensing modes compared to other modes. Most researchers commonly agree that officers of TLOs often set technology licensing fees too high because they mainly consider the financial return. In fact, some technologies discovered inside universities may not be the best compared to existing technologies on the market. At present, some universities have already set up and fully operate TLOs (B. Withyachumnarnkul, personal communication, February 14, 2015; S. Ekasit, personal communication, February 17, 2015; M. Nopharatana, personal communication, February 10, 2015).

More interestingly, this thesis found that different historical backgrounds among different types of universities influenced universities' roles in supporting industry. Interestingly, UBIs may have different functions across universities. In the case of national universities, UBIs focus on creating start-ups that utilize technologies mainly discovered by university researchers, whereas UBI established in private university, such as DPU and PIM, put more emphasis on training programs for existing entrepreneurs (L. Suthamanon, personal communication, February 12, 2015; S. Satyarakwit, personal communication, February 11, 2015). In contrast, Siam University, originally a technical college, tends to

create technology start-ups, although it is a private university. With an engineering background, the President of Siam University actively plays a role in supporting collaboration with industry. For example, in the first year of UBI operation, he joined every committee meeting and also provided the concept to connect cooperative education to UBI (T. Limsarun, personal communication, February 19, 2015). Interestingly, despite originating from a teacher college and now being a local public university, PKRU's UBI is also specialized in technological collaboration. To operate UBI, the manager searched for technologies outside the university or selected only applicants with adequate technological capabilities. In other words, the PKRU's UBI acts as an intermediary body to match technologies and incubate start-ups. PKRU's UBI also invited entrepreneurs who succeed in establishing start-ups to be speakers for training programs. PKRU's distinctive characteristics, despite being a local university, owe a lot to its manager's vision and caliber (K. Tanawiratananij, personal communication, February 25, 2015).

5.3.2 Research Question (b): Do university types relate to size of collaborating firms? If so, why? If not, why not? Kondo (2008a, 2009) concluded that local public universities tend to collaborate with SMEs compared to other types of universities. This thesis supports his conclusion. Generally, national universities in both countries have quality graduate students, famous researchers, and advanced technical infrastructure; therefore, large firms prefer to work with them. Local public universities, in general, work with SMEs and local communities through consultation. However, in the case of Thailand, local public universities also arrange cooperative education program with large firms.

Private universities in both countries do not have specific industrial partners; rather, they depend on modes. For example, NCMU collaborated with a large firm to arrange cooperative education and some of its projects focus on development of micro enterprises (P. Punyathep, personal communication, July 29, 2015). PIM has strong relationships with one specific firm (the CP group), its partners, and CP's business partners (S. Manarungsan, personal communication, February 13, 2015). Also, PIM puts a great emphasis on creating networks. Its executives strongly encourage the faculty members to exchange ideas with various people, such as customers, suppliers, affiliated firms, and experts (P. Phacharintanakul & S. Chocksawangwoong, personal communication, February 13, 2015).

Modes of collaboration seem to be related to the size of the collaborating firms. This is first demonstrated by how joint R&D modes seem to be used by large firms and national universities. Tokyo University (Todai), Tokyo Institute of Technology (Tokodai), Chulalongkorn University (CU), and Mahidol University (MU) prefer to collaborate with large firms through R&D activities because they have a plenty of resources as well as relatively high R&D capabilities (O. Mitsuhiro, personal communication, December 15, 2014; N.K. Das, personal communication, July 24, 2015). Also, Sathirakul (2006) concluded that Tokodai's Office of Industry Liaison has no particular policy to support technology transfer to SMEs. However, commissioned R&D modes are used by both large firms and SMEs. In Thailand, even large firms may not be able to contribute human resources in joint R&D projects (S. Assabumrungrat, personal communication, February 17, 2015; S. Jomjunyong, personal communication, August 12, 2015). With this mode,

intellectual property rights issues can be negotiated (S. Ekasit, personal communication, February 17, 2015). In Japan, intellectual property rights must be transferred to universities in case of commissioned R&D modes. Japanese SMEs commission R&D projects to universities because the cost is lower than in-house R&D (A. Nishizawa, personal communication, December 11, 2014).

Second, technical consultation modes are often used by SMEs and local communities. Local public universities like Fukui Prefectural University (FPU) and Miyagi University (MYU) in Japan mostly work with small local firms, as their most important mission is to assist local community. Likewise, local public universities in Thailand are likely to provide academic or technical consultation to local communities and local SMEs including micro enterprises (Utagawa, T., personal communication, December 18, 2014; Moonpa, N., personal communication, February 10, 2015; Charoenchai, C., personal communication, February 19, 2015; Miyahara, I. and Furukawa, T., personal communication, July 23, 2015).

Third, cooperative education can be generally collaborated with various kinds of firms. However, large firm is a target group for its cooperative education program associated with R&D activities because the host firms have enough technological capabilities to co-supervise students and firms' activities must be consistent with students' theses (Nopharatant, M., personal communication, February 10, 2015). Medium and large firms are also involved in developing joint curriculum with universities. Some firms

provide scholarships to students in return for their services and hire quality graduates after graduation (Moonpa, N., personal communication, February 10, 2015; Prasankarn, H., and Chanrawang, N., personal communication, February 25, 2015).

5.3.3 Research Question (c): In a certain local area, do different types of universities play different roles in supporting industry? If so, why? If not, why not?

Miyagi prefecture of Japan and Chiang Mai province of Thailand were selected as case studies due to these areas having different types of universities and being far from the capital cities. Our results found that in these local areas, different types of universities play different roles in supporting industry. Below are detailed stories.

Japan. Miyagi prefecture is located in the Tohoku region of Japan. It faces the Pacific Ocean in the west and high mountains in the east. As a whole, two industries of Tohoku region—electrical machinery, equipment, and supplies (12.5%) and food (10.3%)²²—have large contributions to national income, whereas the strategic manufacturing industries set by the Tohoku Region Industrial Competitiveness Council are automobiles (manufacture and R&D) and medical equipment (production and development).²³ Specifically, in Miyagi prefecture, all of the abovementioned industries,

²² <http://www.tohoku-epco.co.jp/investment/overview/basic.html>

²³ <https://www.iist.or.jp/en-m/2014/0230-0927/>

including iron, steel, and other materials, have been considered as growth strategies for the prefecture.²⁴

Regarding university and industry collaboration, Tohoku University is a long-established and internationally renowned national university that plays an important role in supporting large firms through research activities because the university put research as its first priority mission and has many talented students, especially graduate students. The New Industry Creation Hatchery Center (NICHe) was established for large-scale research projects. This center aims at creating new industry, strengthening key industry, and supporting cutting-edge research. Examples of projects are autonomous urban traffic by small electric vehicles, simulator development for human behavior analysis, and modeling of mobility capabilities of elderly citizens. Nonetheless, Tohoku University is also a member of the Knowledge Center affiliated with the local Industrial Technology Institute and works with Miyagi prefecture to assist local SMEs (C. Ryoji, personal communication, July 23, 2015). Moreover, Tohoku University plays an active role in technology transfer and the creation of entrepreneurs. The university founded a technology licensing office (TLO) that assigns its staff to directly propose technologies to large firms. An example of intellectual property-related product is a brain testing product that was licensed to Nintendo (A. Nishizawa, personal communication, December 11, 2014). Meanwhile, T-Biz was established to incubate start-up firms (F. Hasegawa, O. Takenouchi, & N. K. Das, personal communication, July 24, 2015).

²⁴ <http://www.pref.miyagi.jp/kankou/en/>

Miyagi University (MYU), a local public university, emphasizes education and contribution to society rather than research activities. Therefore, its collaboration is mainly based on consultation in order to solve community problems. The Regional Liaison Center acts as a bridge between the university and region. Under the Ippo Ippo Nippon project, it introduces several demonstration projects to local communities, such as a small wood power plant, cultivation of silkworms and octopi, and saltbush for feeding sheep and hens. Due to the earthquake disaster in March 2011, MYU encouraged faculty members to restore the Tohoku area. For example, the faculty of nursing provided consultation on health conditions for the elderly, the faculty of architecture built huts for fishermen, and the faculty of project design initiated a new tourism program by collecting local data and creating a website (I. Miyahara, & T. Furukawa, personal communication, July 23, 2015).

TIT is a private university offering only engineering courses. The university actively collaborates with local organizations. Several agreements have been signed with local organizations, such as Sendai City, Sendai Industrial Estate Association, and Miyagi Museum of Art. The Community Outreach Center acts as a university arm to support the collaboration with external organizations, especially local organizations. It focuses on providing academic or technology consultation for local communities; for example, fishery assistance and environmental protection, practice for sports programs, village handicrafts, and rail vehicle design. Also, the university jointly conducts R&D activities with local communities, firms, and governments; for example, snow melting due to roof-integrated solar cells, electric smart carts for the elderly, new craft products with a combination of

natural dyes and lacquers, and security systems of the street as a disaster prevention city (Tohoku Institute of Technology website).

Thailand. Chiang Mai province is located in the northern region of Thailand. It is surrounded by the mountains. The Industrial Office of Chiang Mai Province, a regional branch of the Ministry of Industry, has set processed agricultural products and handicrafts as strategic industries.²⁵ Also, Chiang Mai is a popular city for tourists, which had top-ranked occupancy rates for accommodations in March 2015.²⁶ To promote creativity and innovation, the governor established a Creative City Development Committee consisting of representatives from academic, private, and government sectors. Together with Payap University and North Chiang Mai University, Chiang Mai University chairs the committee. The Chiang Mai University Science and Technology Park (CMU STeP) serves as the secretariat. The strategic focuses of the committee are tourism, digital information technology, software, and crafts.

On one hand, Chiang Mai University (CMU) provides consultation to SMEs in response to local needs. Meanwhile, the university has R&D collaboration with large firms due to its high technological capabilities. Based on implementation of the government's initiatives, it can be said that CMU has been considered to be a hub for regional development. For example, the university acts as a node of the northern science and

²⁵ <http://www.industry.go.th/chiangmai/index.php/2013-09-19-19-42-44/2013-11-21-11-38-26>

²⁶ The tourism situation was reported by Kobkarn Suriyasat Wattanavrangkul, Minister of Tourism and Sport on March 18, 2015

technology park project (STeP). It coordinates with six other universities in nearby provinces; Maejo University, Mae Fah Luang University, University of Phayao, Naresuan University, Pibulsongkram Rajabhat University, and Uttaradit Rajabhat University. CMU's STeP is very active in collaborating with firms, and it provides comprehensive services such as collaborative research, consultation, technology transfer, technology business incubation, and intellectual property commercialization. Within three years, CMU STeP could initiate 170 collaborative projects and incubate 50 start-ups. The success rate of collaborative projects is about 60% while revenue generated by start-ups is approximately \$130,000 US per year. In accordance with the province's strategies, the Food Innovation and Packaging Center (FIN) was established as an academic service center specializing in food and packaging. Interestingly, the bioplastic pilot plant is an example of a triple-helix collaborating projects with co-investors that are from academic, private, and government sectors (S. Jomjunyong, personal communication, August 12, 2015; M. Venzky-Stalling, personal communication, August 15, 2015; T. Anantana, personal communication, August 20, 2015).

In contrast, both North Chiang Mai University (NCMU) and Rajamangala University of Technology Lanna (RMUTL) mainly send their graduates to work for firms. Recently, NCMU and the CP Group signed a memorandum of understanding to jointly offer retail management courses to students. Nonetheless, both universities also provide academic and technology consultation. NCMU's collaborating firms are mainly microenterprises due to the limitation in both technological capabilities and financial

resources. In addition, local communities such as Bann Tawai and Doi Pu Muen are also partners of NCMU.

Regarding RMUTL, it established a Community Technology Transfer Center for transferring knowledge and technology. RMUTL could collaborate with various kinds of partners, including SMEs because it has enough technological capabilities to support local SMEs. In addition, local government has commissioned RMUTL to do projects with local communities (N. Moonpa, personal communication, February 10, 2015; M. Venzky-Stalling, personal communication, August 15, 2015; P. Punyathep, personal communication, July 29, 2015).

5.3.4 Research Question (d): Do the country context matter? Specifically, do universities of the same type collaborate with firms differently in different countries?

This study concludes that country context is likely to be a crucial factor that affects modes of collaboration more than university types. National universities (Tokyo University, Tohoku University, and Tokyo Institute of Technology) in Japan conducted joint R&D projects with large firms that are required to have substantial contributions in both aspects of financial and human resources. Nevertheless, the collaboration of Thai national universities (Chulalongkorn University and Mahidol University) is mostly based on commissioned R&D. Interestingly, King Mongkut's University of Technology Thonburi (KMUTT), which originated from a vocational college, frequently co-hosts a cooperative education program with large firms that is associated with R&D activities, where Chiang

Mai University (CMU) located outside Bangkok focuses on both consultation and commissioned R&D. Remarkably, even using similar modes, the results developed through collaboration are different. Joint patents are generated by Japanese universities and could be commercialized, whereas Thai universities mostly improve products and processes.

Regarding local public universities, universities in both Japan and Thailand (Fukui Prefectural University, Miyagi University, Phuket Rajabhat University, Rajamangala University of Technology Thonburi, and Rajamangala University of Technology Lanna) have roles in providing consultation to local communities and small local firms in order to raise the quality of life and to improve products and processes, respectively. Nonetheless, Thai local public universities greatly emphasize cooperative education due to their missions of producing hands-on human resources.

Thai and Japanese private universities have different kinds of collaboration with the industry. The interaction mode of Keio University is joint R&D, which is similar to national universities, whereas Toyo University and Toyota Technological Institute seems to frequently do joint R&D projects as well. Nonetheless, the difference among these universities is that the results of collaboration are different. Whereas Keio University could deliver commercialized products, Toyo University and Toyota Technological Institute's results have not reached a stage of commercialization. It is noteworthy that Toyota Technological Institute's collaboration is different from others. It often provides consultation for regional development. On the contrary, Thai private universities, such as

Rangsit University, Dhurakij Pundit University, Siam University, and North Chiang Mai University, have mainly relied on cooperative education rather than collaborative R&D and engineering activities.

5.4 Concluding Remarks

In relation to the research questions, the key findings can be summarized as follows. They can partially fill in the gaps in the existing literature on university and industry collaboration.

First, university type influences modes of collaboration to a certain degree. In both Japan and Thailand, national universities are different from other types of universities. They have distinctive modes of collaboration focusing on R&D, whereas other types of universities engage in several modes without specificity. This is because national universities are long-established and prestigious universities that have high R&D capabilities. Interestingly, a frequent mode of local public university in Japan is similar to a frequent mode of national university originating from a technical college in Thailand. In the Japanese cases, local public universities are likely to provide technical consultation to local communities and small local firms that may lack the technological capabilities to carry out joint and commissioned R&D projects with universities. In the Thai cases, it is national universities originating from technical colleges—not local public universities—that assist both SMEs and large firms through consultations and cooperative education programs of which R&D collaboration is a part. Regarding private universities and local public

universities in Thailand, their collaborative projects mostly rely on cooperative education programs only because teaching is their key mission and there is available government support. Japanese private universities have various kinds of collaboration depending on universities' specializations whereas Thai private universities' collaborations are mostly based on cooperative education. Besides, we also found that UBIs may have different functions across universities. UBIs in national universities focus on creating technology-based start-ups but UBIs established in private universities originating in business courses may put more emphasis on training programs for existing entrepreneurs. In contrast, UBIs in private universities originating from technical colleges are based on technological aspect of collaboration.

Second, rather than university type, types of modes relate to the size of collaborating firms. We found that universities do not have specific collaborating firms. They depend on what kinds of modes are used. Large firms are for joint R&D projects, whereas medium- large firms are for cooperative education programs associated with R&D activities. SMEs and local communities are targets of consultation. General cooperative education programs can be arranged for various kinds of firms. However, in some specific programs of cooperative education modes, collaborating firms are relatively large.

Third, different types of universities in the same geographical area play different roles in supporting industry. In general, national universities prefer to work with large firms having adequate R&D capabilities to collaborate, but national universities located outside

capitals have begun working with SMEs through both R&D activities and consultation. In contrast, local public universities and private universities are likely to provide consultation to microenterprises, SMEs, and local communities. Nonetheless, in the case of Thailand, all types of universities in Chiang Mai province play an active role in cooperative education programs. This may be because the government has strong policies in supporting this program, such as financial support and tax reduction for participating firms. Interestingly, Tohoku Institute of Technology and Rajamangala University of Technology Lanna are different types of universities but they involve more in collaborative R&D and engineering activities than their counterparts. This is probably because both of them have similarity in course offerings that focus on engineering and technology.

Fourth, country context is probably a crucial factor affecting modes of collaboration, more so than university types. In general, Japanese universities' collaborations are based on R&D activities, whereas Thai universities focus on education activities. In detail, while Japanese national universities frequently have collaborations that are joint R&D, Thai national universities' collaborations are based on both commissioned R&D and consultation. Japanese universities' roles are closer to entrepreneurial universities than Thai universities. They could generate joint patents reaching a commercialization stage. Specifically, King Mongkut's University of Technology Thonburi used to be a technical college and it frequently co-hosts cooperative education programs with medium and large firms that are associated with R&D activities. Local public universities in both countries have roles in providing consultation to local communities and small local firms,

but Thai local public universities greatly emphasize cooperative education programs to respond to industrial needs. Japanese private universities have different kinds of collaboration, such as joint R&D and consultation, but Thai private universities have mainly relied on cooperative education programs.

This chapter is a discussion of the influence of university types on collaboration modes and the sizes of collaborating firms. The next chapter analyses the influence of firm characteristics (firm sizes and industrial sectors) on collaboration modes and the influences of modes on collaboration outcomes.

Chapter 6

Results and Discussion:

Influences of Firm Characteristics and Modes of Collaboration

Chapter 6 analyses the university and industry collaboration data at firm levels from the surveys in order to fill research gap relating to firm characteristics and modes of collaboration. In the case of Japan, this study used the data of the Teikoku Databank (TDB) Survey of Business Trends carried out by TDB, National Graduate Institute for Policy Studies (GRIPS), and the Office of Economic and Industrial Research in the House of Representatives. The national survey of R&D and innovation conducted by the National Science Technology and Innovation Policy Office (STI Office) was used in the case of Thailand.

Section 6.1 explains which firms were target groups for data analysis. The relationship between firm characteristic and university and industry collaboration, and the influence of modes on outcomes, were analyzed and discussed in Section 6.2. Also, this section includes the comparative analysis between Japan and Thailand. Section 6.3 concludes the main findings drawn from Section 6.2.

6.1 Target Group for Data Analysis

In the Japanese case, firms conducting or used to conduct R&D activities (2,644 firms) were allowed to answer questions about collaboration with universities. Therefore,

this chapter includes R&D firms as a target group for data analysis. In contrast, both R&D and non-R&D firms were allowed to answer questions about collaboration with universities. Nonetheless, in order to compare to Japanese data, collaborating firms conducting or used to conduct R&D activities (452 firms) were selected as a target group for data analysis (see details in Chapter 3).

6.2 Data Analysis and Discussion

To test hypotheses, ordered probit and probit regression were used to analyze the relationship between firm size and R&D collaboration, whereas ordered probit regression, poisson regression, and linear regression were used to test the relationship between outcomes and modes of collaboration. Correlation coefficients were calculated to investigate the relationships between modes. Then, three pairs of the strongest correlation coefficients were multiplied and included as independent variables. These variables obtained from multiplying correlation coefficients were called complementary modes. Apart from complementary modes, single modes (see details in Chapter 3) were also included as independent variables to examine whether complementary modes have higher degrees of influence on outcomes than single modes.

6.2.1 Hypothesis (a): Large firms tend to engage in R&D collaboration. The results between the Thai and Japanese cases are contradictory (See Appendix Tables A3-1 and A3-2). In Japan, the results confirm Hypothesis (a), which is that larger firms tend to do R&D projects with universities, whereas the Thai case rejects Hypothesis (a), and smaller firms

in Thailand significantly engage in R&D collaboration with universities. These contradictory results can contribute to the debated issue on influences of firm size among scholars. Firm size, which impacts R&D resources, is not only one main factor influencing collaboration with universities. It might be possible that central and/or local governments could also guide the direction of collaboration between two parties. In the regional innovation system of Japan, local research institutes play active roles to support SMEs; for example, Kosetsushi Centers partially take the role of local universities in supporting Japanese SME manufacturers. Their services include technology guidance, technical assistance and training, networking, testing, analysis and instrumentation, and access to open laboratories (Stephen & Robert, 2011). On the other hand, larger firms collaborate with Japanese universities located in prefectures as seen in the NISTEP²⁷ survey on Fukui Prefecture's university and industry collaboration. This survey indicates that educational institutes often collaborate with larger firms. The most frequent mode of educational institutes is R&D (Nozawa & Yoshinaga, 2013). In contrast, in the case of the Industrial Research Center of Shiga prefecture or Kosetsushi Centers, it aims to provide technical assistance to local SMEs. In the year 2004, it could provide 6,048 cases for technical consultation, 6,157 times of using equipment, and 24 collaborative R&D projects (Seki, 2008). Regarding the Thai case, due to huge contributions of Thai SMEs (99% of total firms in Thailand, 70% of total employment, and 37% of GDP²⁸), the government policies have been geared towards upgrading technological capabilities of Thai SMEs; for example,

²⁷ The National Institute of Science and Technology Policy

²⁸ Bank of Thailand

the ITAP program operated by NSTDA closely works with SMEs to support technology transfer through a network of knowledgeable and experienced staff in universities. The regional science park also aims at providing technical assistance to and carrying out R&D project for SMEs in the local area.

6.2.2 Hypothesis (b): Food sector (specialized supplier as source of technology)

does not relate to R&D collaboration. The Japanese case rejects Hypothesis (b) (See Appendix Table A3-1). The R&D intensity²⁹ of this sector was not high (0.87%), comparing to Japanese manufacturing sector but it seems that this sector has relationship with various actors: government, public research institute, and industry. The Japanese government facilitated several forms of R&D in the food sector, including the establishment of national research institutes, the establishment of prefectural experiment stations, and the promotion of cooperation between industrial circles and government and other research organizations (Kamala & Saiura, 1977). Food valley Tochigi is one example of the industry–academy–government collaboration. In addition, according to Chamarik & Goonatilake (1994), both large and small enterprises, especially in food processing firms, are aggressive to carry out technological innovation and absorb the new technology.

The Thai case confirms Hypothesis (b) (See Appendix Table A3-2). R&D intensity of Thai food sector was relatively high (0.20%), comparing to Thai manufacturing sector but it does not relate to R&D collaboration. This result is in accordance with survey data

²⁹ % of R&D expenditure/total sales

and previous study. Based on survey data, customers, parent companies, and locally-owned suppliers are the most important external partners for R&D and innovation activities. With regard to previous study, Intarakumnerd et al. (2015) concluded that the R&D activities of many universities and public research institutes are limited and not in accordance with the needs of industry.

6.2.3 Hypothesis (c): Electrical apparatus sector (external collaboration as source of technology) significantly relates to R&D collaboration. The Japanese case confirms hypothesis (c) (See Appendix Table A3-1). In Japan, the electrical apparatus sector is one of the largest manufacturing sectors that cover a variety of products, such as industrial electric appliances, household electric appliances, electronic equipment, and information and communications technology (Farrell, 2008). It is a high-technology sector according to level of R&D intensity (6.01%). Based on METI's study, large firms in this sector manufacture various parts and products on their own in cooperation with their affiliated companies; however, because of rapid technological innovation and short lifecycles of products, the firms have to enhance the strength of R&D on the core businesses, as well as to advance collaboration with universities and government.³⁰

The Thai case rejects Hypothesis (c) (See Appendix Table A3-2) because Thai electrical apparatus sector had low R&D intensity (0.09%), comparing to Thai manufacturing sector. This sector heavily relies on technology transfer from their foreign

³⁰ <http://www.meti.go.jp/english/report/downloadfiles/gIT0333e.pdf>

affiliates. The foreign affiliates usually provide raw materials, machinery technology, and markets. In addition, the transnational corporations (TNCs)' headquarters play a major role in formulating marketing and production strategies (Sutthijakra & Intarakumnerd, 2015).

6.2.4 Hypothesis (d): Chemical sector (external collaboration as source of technology) significantly relates to R&D collaboration. The Japanese case confirms Hypothesis (d) but the Thai case rejects this hypothesis (See Appendix Tables A3-1 and A3-2). In Japanese case, METI's study concluded that the technology in the chemical industry has already reached a significant level of maturation in the area of so-called general-purpose products (3% on R&D intensity). Nonetheless, there is demand for competitiveness to be maintained and strengthened. Then this sector needs to accumulate technology based on R&D. There are many cases in which academia- industry-government cooperation takes place in order to introduce new knowledge that will become the foundation for the R&D of companies.²⁵

In Thailand, the R&D intensity of chemical industry³¹ was relatively high (0.39%), comparing to Thai manufacturing counterparts. However, the results indicate that there is no significant relationship between the chemical sector and the R&D collaboration. It is possible that chemical firms also collaborate with other actors, such as national research institutes and non-profit organizations (e.g., National Center for Genetic Engineering and

³¹ The chemical industry includes chemical products, pharmaceutical products, herb products, fertilizer, etc.

Biotechnology, National Nanotechnology Center, Thailand Research Fund, Plastics Institute of Thailand, and Synchrotron Light Research Institute).

6.2.5 Hypothesis (e): The automobile sector (internal knowledge as source of technology) does not significantly relate to R&D collaboration. The Japanese case confirms hypothesis (e) but the Thai case rejects this hypothesis (See Appendix Tables A3-1 and A3-2). Japanese automobile sector had high R&D intensity (5.25%) but it does not relate to R&D collaboration with universities. Japanese automotive firms seem to conduct in-house R&D or R&D with business partners. They accumulate technical know-how through collaboration on the manufacturing site and divisions involved in development, production, and other activities (METI).²⁵ Auto parts manufacturers develop parts jointly with the automobile manufacturers who are their customers. This means that automobile manufacturers are both the providers of external technologies and customers (Kani & Motohashi, 2013).

In contrast, the Thai automobile industry invests had low R&D intensity (0.04%), comparing to Thai manufacturing sector but it seems to collaborate with universities through R&D mode. Based on Intarakumnerd et al. (2012), universities and public research institutes have played supporting roles in helping the automotive industry. Since the 1990s and early 2000s, Thai universities³² have targeted automotive engineering programs to

³² Chulalongkorn University (CU), King Mongkut's Institute of Technology Ladkrabang (KMUTL), King Mongkut's University of Technology Thonburi (KMUTT), King

produce qualified manpower. They provided such courses with significant collaboration with leading private firms. In addition, large firm donates modern equipment and send their managers to be guest lecturers. Based on close relationship between two partners, it is possible that automobile firms and universities initiated collaborative R&D activities. As for research institutes, NSTDA provided training and consulting services to firms.

6.2.6 Hypothesis (f): Rather than country contexts, firm size and industrial sector influence modes of collaboration. From the results in Tables A3-1 and A3-2 (See Appendix 3), this study rejects Hypothesis (f) because levels of technological capabilities of firms located in countries are different. The R&D intensity of the industries in both countries is different: (1) food sector: Japan (0.87%), Thailand (0.20%); (2) electrical apparatus sector: Japan (6.01%), Thailand (0.09%); (3) chemical sector: Japan (3.59%), Thailand (0.39%); and (4) automobile sector: Japan (5.25%), Thailand (0.04%) (Statistics Bureau & STI Office).

6.2.7 Hypothesis (g): Complementary modes have positive relationships with outcomes that are higher than those of single modes.

6.2.8 Hypothesis (h): Country contexts do not have influence on the relationship between modes and outcomes. Complementary modes work well in both Japan and Thailand. The relationship between modes in the Japanese case is *not* strong. The

maximum correlation coefficient is approximately 0.15. On the contrary, the Thai results shows that the relationship between modes is relatively strong (with a maximum correlation coefficient of 0.6) (see Appendix Tables A3-3 and A3-4). This may be that Japanese universities offer an appointed visiting professorship attached to R&D projects. For example, together with an R&D sponsored fund, Tokyo Institute of Technology accepts company researchers as specially appointed faculty members along with a collaborative R&D project, and the company could send the researchers to be visiting researchers.³³

In the Japanese case, the results reject Hypothesis (g). All modes influence both product innovation and sales, but the most effective modes for generating product innovation and contributing to sales are the technology licensing mode and the personnel exchange mode. Combinations of difference modes do not help firms enhance the outcomes of collaboration. Instead of complementation, the results present substitutions of modes. In contrast, the Thai case confirms Hypothesis (g). As a whole, different modes significantly generate different outcomes whereas complementary modes significantly influence outcomes of collaboration. Unlike the Japanese case, the HR mode has a negative relationship with outcomes. In detail, a single mode (infrastructure mode and technology licensing mode) and a complementary mode (interaction term of R&D and consultancy mode) significantly influence product innovation. With regard to process innovation for a single mode, the consultancy mode and the R&D mode are the most effective modes, whereas the complementary mode does not enhance process innovation. In terms of sales,

³³ Office of Liaison, Tokyo Institute of Technology

only the complementary mode (R&D and consultancy; in combination) has a significant relationship, whereas a single mode does not have a significant relationship. Interestingly, the informal mode seems to be a trivial mode, but it can have a significant and positive relationship with process innovation (See Appendix Tables A3-5 and A3-6).

The differences between the Japanese and Thai results (which reject Hypothesis [h]) may be caused by the level of technological capability of participating firms. Japanese firms are relatively innovative and invest in R&D, whereas only a minority of large subsidiaries of TNCs, large domestic firms, and SMEs in Thailand has the capability to conduct R&D (Intarakumnerd & Lecler, 2010; Odagiri & Goto, 1993). Hence, in the Thai case, R&D and consultancy may be used in combination to enhance outcomes. This is because firms and universities may not be able to equally contribute to R&D projects. The experts from universities must provide technical consultancy to firms as a guideline to carry out R&D projects. The personnel exchange mode is an effective mode in Japan, since researcher exchange is a part of R&D collaborating projects. On the contrary, the HR mode in the Thai case is mostly based on education (359 out of 452 surveyed firms host a student internship program) due to government policies on cooperative education.

Surprisingly, the infrastructure mode generates substantial outcomes. This implies that most Thai firms do not invest in their own R&D facilities; therefore, a university's laboratory is necessary for firms to conduct innovation. In addition, a university's testing service can certify firms' products in accordance with domestic or international standards

necessary for exporting to demanding markets overseas. For example, the DNA technology laboratory (DNATEC; jointly established by Kasertsart University and NSTDA) certifies DNA fingerprinting for plants and animals. Hybrid or parent seeds and animals' species can be verified. Moreover, the laboratory certifies high-quality Jasmine rice for export.³⁴

6.3 Concluding Remarks

This chapter investigates three main issues: (a) the influence of firm size on university and industry collaboration, (b) the influence of the industrial sector on university and industry collaboration and (c) the influence of mode of collaboration. Thailand and Japan were selected as representatives of developing and developed countries, respectively. The findings indicate that firm characteristics, namely size and industrial sector, influence collaboration. However, firm characteristic is not the only influencing factor. There is a contradiction between Japanese and Thai results. Large Japanese firms carry out R&D activity with universities, whereas Thai SMEs tend to do so. In Japan, it is likely that local public research institutes partially take a role in supporting SMEs as seen in the case of the Industrial Research Center of Shiga Prefecture. In Thailand, there are no local public research institutes; therefore, the government commissions the universities located across regions to host and operate the government initiatives. It is not surprising that Thai SMEs have significant relationships with universities through R&D modes. The natures of key actors in the triple helix concept, especially government policy, do matter.

³⁴ DNA Technology Laboratory, Kasertsart University

In Japan, the food sector, electrical apparatus sector, and chemical sector engage in collaborative R&D activities. The Japanese food sector is not a low-technology sector because firms are aggressive enough to absorb the new technology and the government established public research institutes upgrade their technological capabilities. The electrical apparatus sector and chemical sector have to enhance their technological capabilities and maintain their competitiveness; therefore, they have to collaborate with universities. Unlike other sectors, the automobile sector tends to conduct in-house R&D and has a relationship within business partners. In the Thai case, the collaboration is mainly based on various kinds of collaboration. It can be concluded by the contradictory results between Japan and Thailand that technology classification for the manufacturing sector cannot be generalized for all countries because of different levels of technological capabilities. More importantly, in the Thai case, R&D intensity of an industry does not matter. Firms are likely to carry out in-house research and other actors such as public research institute are likely to play active role in supporting industry. This result is against the previous conclusions of innovation studies scholars, which state that industrial sectors are another important variable explaining intensity and nature of innovation activity (Freeman, 1995; Nelson, 2008) and also that the intensity of industry-university R&D collaboration varies with industries because of different levels of technological capabilities (Rasiah & Chandran, 2009; Schartinger et al, 2002). According to the R&D and Innovation Survey of Thailand, the chemical industry had the second highest amount of R&D spending in year 2011. However, results indicate that there is no significant relationship between this sector and the R&D mode because chemical firms conduct in-house R&D and collaborate with public research

institutes. Instead of R&D collaboration, this industry tends to develop personal connections with university researchers. Interestingly, the food industry was the third largest investor in R&D. Nonetheless, like the chemical industry, the industry has no significant relationship with universities regardless of modes because R&D activities of universities are not in line with the needs of the industry. In contrast, the automotive industry (moderately investing in R&D) seems to collaborate with universities through various modes, namely R&D and informal modes, because Thai universities have played active roles in collaborating with automotive firms.

Modes of collaboration are also an important determinant influencing collaboration. In the Japanese case, the technology licensing mode and the personnel exchange mode are the most effective modes to generate product innovation and to increase sales. These results provide remarkable implications: (a) promoting technology licensing from a university may be a good policy for increasing Japanese firms' competitiveness and (b) personnel exchange, as a part of collaborative R&D projects may be an appropriate policy to transfer knowledge or technology to participating firms. In the Thai case, the informal mode, which seems to be trivial, is likely to be an effective mode. The informal mode could have a significant relationship with innovation. Therefore, the government should not overlook facilitating or empowering this mode; for example, by continuously building concrete networks of researchers across sectors through informal discussion, informal meetings, and conferences. Launching the open laboratory initiative in Thai universities may be suitable. Thai SMEs do not have enough resources to invest in their own R&D facilities. The

universities' technical infrastructure can help firms upgrade local products by benchmarking against high-quality products. It can also certify that products match domestic or international standards, allowing them to be exported to demanding markets overseas. In the Thai case, using modes in combination (especially R&D mode and consultancy mode) helps firms enhance outcomes of collaboration; hence, universities should consider offering more comprehensive services to firms.

The next chapter is a conclusion of the main findings (Chapter 5 and 6) which are the influence of key actors' characteristics on collaboration mode, the influence of collaboration mode on collaboration outcome, and the impact of the national innovation systems on those findings. In addition, theoretical contributions to partially fill knowledge gaps and policy recommendations to foster university and industry collaboration were suggested.

Chapter 7

Conclusion

7.1 Introduction

This study aims at investigating how university type affects collaboration modes throughout the process of knowledge and technology transfer, starting at the beginning stage (starting point of the collaboration), continuing in the intermediate stage (selecting mode), and ending at the final stage (collaboration outcome). In addition, this study includes a comparative analysis of different nations to see differences in the roles of key actors and the importance of university and industry activity across nations.

The literature review (Chapter 2) indicates the contradictory viewpoints on universities' roles in supporting industry. Triple helix research has defined universities as the primary collaboration source of human resources, knowledge, and technology that embraces a mission of economic and social development, while innovation system (IS) approach scholars have concluded that the universities' role is not to be incubators for start-ups or for patents but to give long-term contributions to knowledge creation. Importantly, based on the IS approach, universities should support firms in developing technology rather than substituting for the technological efforts of firms, but the triple helix concept claims that an institution can take on the roles of other institutions to perform new roles as well as to fulfill their traditional functions. This argument provokes an interesting investigation of whether universities play different roles in supporting industry.

Nonetheless, the flow of collaboration does not depend solely on universities. A firm's specific nature, such as firm size, industrial sector, and technological capability, is also a main factor. Nonetheless, the influence of firm characteristics on collaboration has been a debated issue. A large number of empirical studies (e.g., Arundel & Geuna, 2004; Becker & Dietz, 2004; Cassiman & Veugelers, 2002; Cohen et al., 2002; Laursen & Salter, 2003; Miotti & Sachwald, 2003; Negassi, 2004) concluded that the intensity of collaboration among larger firms is higher than that of small firms because they have resources for carrying out R&D activities, benefit more from cooperation (Veugelers, 1998), and innovate more openly than SMEs (De Backer, 2008). In addition, small firms hardly do basic research because research findings are difficult to patent and hence the flow of payoffs cannot be capitalized, thus these payoffs must be appropriated through incorporating knowledge in the form of improved goods or processes (Rosenberg, 1989). However, Schumpeter (1943) was aware of the rise of in-house corporate R&D in large firms. In terms of the industrial sector, previous studies have mentioned that the intensity of R&D collaboration varies by industry because firms in high-technology sectors must keep up with cutting-edge research in high-technology industries. However, actors may behave differently across countries (Edquist, 1997).

Beyond the two key actors, as mentioned earlier, an understanding of the relationship among actors, collaboration modes, and collaboration outcomes is crucial. Despite providing a comprehensive framework, triple helix scholars and IS scholars have not paid much attention to this issue. IS scholars have analyzed the importance of the

modes through which knowledge flows from university to industry, but they have not clearly identified the relationship between collaboration mode and collaboration outcome. Interestingly, several studies have reported the importance of a combination of various collaboration modes (D'Este & Patel, 2007; Meyer-Krahmer & Schmoch, 1998), but these studies did not clearly explain how a combination of various modes or complementary modes is important.

In that light, this study is an investigation of three main questions:

1) Do university types influence the roles of universities in supporting industry?

- Do university types relate to modes of collaboration? If so, why? If not, why not?
- Do university types relate to firm size? If so, why? If not, why not?
- In a certain local area, do different types of universities play different roles in supporting industry? If so, why? If not, why not?
- Do country contexts matter? Specifically, do the same types of universities in different countries use same distinctive collaboration modes?

2) Do firm characteristics influence collaboration modes?

- Do firm characteristics (firm size and industrial sector) affect modes of collaboration?

3) Do collaboration modes influence collaboration outcomes?

- Do the modes relate to each other? And how do these relationships between

These three research questions have been addressed through the collection of several sources, namely survey data, existing studies, university documents, and interviews with university executives and university researchers.

The structure of Chapter 7 is as follows. Section 7.2 concludes the main conclusion discussed in Chapters 5 and 6: the influences of university types and firm characteristics on collaboration mode, the influence of collaboration mode on outcome, and the influence of national system on university–industry collaboration. Finally, Section 7.3 concludes the implications for theory, policy, and future research.

7.2 Main Conclusion

7.2.1 Influence of university type. Chapter 5 examined the first research questions about the influence of university type. It analyzed the data at the university level from the interviews of Japanese and Thai university executives responsible for university–industry interactions and also analyzed interviews with policy makers and experts. Three types of universities (21 universities) are examined: (1) national universities, (2) local public universities, and (3) private universities. The answers to these research questions are as follows (Tables 7-1, 7-2, and 7-3).

Previous studies about university–industry collaboration in Japan (Kondo, 2008a, 2009) that mainly focused on R&D activities found that university type relates to R&D mode due to the influence of Japanese government policy. This study confirms the results

of previous studies and presents the additional findings. First, national university type has distinctive modes focusing on R&D. Japanese national universities jointly conduct R&D activities with firms and sometimes offer visiting researchers to do joint R&D projects. Those universities can generate joint patents to reach the commercialization stage, whereas Thai national universities mainly focus on product or process innovation and product or process improvement. Cooperative education programs associated with R&D activities often exist in Thai national universities. Second, the most frequent mode of Japanese local public university is technical consultation, whereas cooperative education and consultation are the most frequently seen in Thai local public university. Third, Japanese private universities use various kinds of collaboration (e.g., commissioned R&D, joint R&D, and consultation) depending on each university's specializations, whereas Thai private universities' collaborations are mostly based on cooperative education.

Beyond the influence of university type on R&D mode (Kondo, 2008a, 2009), this study aimed to examine the influence of various types of collaboration modes. The main findings are that rather than university types, types of collaboration modes relate to the size of the collaborating firm. Large firms tend to pursue joint R&D projects, whereas medium-large firms are target groups for cooperative education programs associated with R&D activities. SMEs and local communities are targets of consultation. A general cooperative education program can be arranged for various kinds of firms. However, in some specific programs operating in a cooperative education mode, the collaborating firms are relatively large.

Additionally, both local and country contexts were included in this study to investigate their impacts on the roles of universities. With regard to local context, different types of universities in the same geographical area play different roles in supporting industry. National universities seem to do joint R&D projects and to be able to reach the IP commercialization stage more than other types of universities (see Tables 2-2, 4-1). They have begun working with SMEs through both R&D activities and consultation. In contrast, many local public universities and private universities provide consultation to microenterprise, SMEs, and local communities. Interestingly, in the case of Thailand, all types of universities play an active role in cooperative education programs due to government policies.

In terms of country context, it is probably a crucial factor affecting modes of collaboration more than university type. In general, Japanese universities' collaboration is based on R&D activities, whereas Thai universities focus on education activities. Japanese universities' roles are more entrepreneurial than those of Thai universities. They can generate joint patents that reach the commercialization stage. Local public universities in both countries have roles in providing consultation, but Thai local public universities greatly emphasize cooperative education programs. Japanese private universities use different kinds of collaboration, such as joint R&D and consultation, but Thai private universities mainly rely on cooperative education programs.

Table 7-1: Summary of Influence of University Type on Collaboration Mode and Collaborating Firm

| University Type | Collaboration Mode | |
|-------------------------|--|---|
| | Japan | Thailand |
| National university | <ul style="list-style-type: none"> Joint research (generating joint patents and commercialization) | <ul style="list-style-type: none"> Commissioned R&D (improving product and process) Cooperative education associated with R&D activities Consultation |
| Local public university | <ul style="list-style-type: none"> Consultation on product and process improvement | <ul style="list-style-type: none"> Cooperative education Consultation |
| Private university | <ul style="list-style-type: none"> Various kinds of collaboration with variety of outputs (e.g., joint R&D, commissioned R&D, and consultation) | <ul style="list-style-type: none"> Cooperative education |
| Firm Size | Collaboration Mode | |
| | Japan | Thailand |
| Large firm | <ul style="list-style-type: none"> Joint R&D (aiming to apply for patent) | <ul style="list-style-type: none"> Commissioned R&D Cooperative education associated with R&D activities Cooperative education (joint curriculum) Cooperative education |
| SME | <ul style="list-style-type: none"> Commissioned R&D Consultation | <ul style="list-style-type: none"> Consultation Cooperative education |

Table 7-2: Summary of the Influence of Local Context on a University's Role in Supporting Industry

| University Type | Collaboration Mode | |
|-------------------------|---|---|
| | Miyagi prefecture, Japan | Chiang Mai province, Thailand |
| National university | <ul style="list-style-type: none"> Joint research (generating joint patents and commercialization) | <ul style="list-style-type: none"> Commissioned R&D (improving product and process) Consultation Cooperative education |
| Local public university | <ul style="list-style-type: none"> Consultation | <ul style="list-style-type: none"> Cooperative education Consultation |
| Private university | <ul style="list-style-type: none"> Consultation Cooperative education | <ul style="list-style-type: none"> Cooperative education |

Table 7-3: Summary of the Influence of Country Context on a University's Role in Supporting Industry

| University Type | Influence of Country Context |
|-------------------------|---|
| National university | National universities in both countries focus on R&D, but Japanese universities do joint R&D and are able to generate patents, whereas Thai universities mainly improve products and processes. |
| Local public university | Local public universities in both countries provide consultation to local communities and small SMEs, but Thai local public universities greatly emphasize on cooperative education. |
| Private university | Japanese universities have different kinds of collaboration, but Thai private universities mainly rely on cooperative education. |

7.2.2 Influence of firm characteristics and collaboration mode. Chapter 6 investigates the second and third research questions: (a) influence of firm characteristics on collaboration mode and (b) influence of collaboration mode on collaboration outcome. This chapter analyzes at the firm level the university and industry collaboration data from the Teikoku Databank (TDB) Survey of Business Trends carried out by TDB and the National Graduate Institute for Policy Studies (GRIPS). An econometric analysis was used to analyze the data. The answers to the research questions are as follows (Tables 7-4 and 7-5).

With regard to the second research question, the intensity of collaboration among larger firms is higher than that of small firms due to their resources for carrying out R&D activities, but some scholars argue that large firms tend to conduct in-house R&D. In terms of the industrial sector, firms in high-technology sectors must keep up with cutting-edge research in high-technology industries; therefore, those firms more frequently exploit scientific knowledge that originates from public research. However, firms across countries may behave differently.

The main findings of this study are interesting. Contradictory results were found for Japan and Thailand.³⁵ Large Japanese firms carry out R&D activity with universities, whereas Thai SMEs tend to do so. In Japan, it is possible that local public research institutes partially take a role in supporting SMEs. In Thailand, probably, there are no local public research institutes; therefore, the government has commissioned universities located across regions to host and operate the government initiatives with the aim to upgrade the technological capabilities of SMEs. In terms of the industrial sector, in Japan, the food sector, electrical apparatus sector, and chemical sector engage in collaborative R&D activities. In food sector, the Japanese government facilitates various forms of R&D activities to upgrade technological capabilities and the collaboration between universities and food firms. The electrical apparatus sector and chemical sector need to enhance their technological capabilities and maintain their competitiveness; therefore, they collaborate with universities through R&D activities. Unlike in other sectors, firms in the automobile sector tend to conduct in-house R&D and have relationships with business partners. In the Thai case, the automotive industry engage in R&D collaboration because Thai universities have played active roles in supporting automotive firms, whereas other industrial sectors (the food, electrical apparatus, and chemical sectors) do not engage in R&D collaboration

³⁵ Pavitt Taxonomy was used to set the hypotheses because it stands out as the best known and most influential taxonomy (Peneder, 2008). However, there are criticisms on Pavitt Taxonomy. For example, Fontana et al. (2016) used data on 13 countries from Community Innovation Survey to analyze heterogeneity of innovative behaviors at the lowest possible level of aggregation. Their results suggest that differences among firms' innovative patterns remain relevant and largely independent of both sectoral and national contexts. Nonetheless, up to now, no detailed taxonomies of sectoral system have been proposed yet, also because firm level data have not been available until recently.

with universities. In this case, it seems that the R&D intensity of an industry does not matter. Firms are likely to carry out in-house research, and other actors such as public research institutes may play active roles in supporting industry. The Thai chemical industry has relatively high R&D intensity, but it has no significant relationship with the R&D mode. Perhaps chemical firms conduct in-house R&D and often collaborate with public research institutes. Instead of engaging in R&D collaboration, the chemical industry tends to develop personal connections with university researchers. Interestingly, the R&D intensity of the food industry is relatively high, but this sector has no significant relationship with universities because the R&D activities of universities are not in line with the needs of the industry.

Table 7-4: Summary of the Influence of Firm Characteristics on R&D Collaboration

| Firm Characteristics | Relationship with R&D Collaboration | |
|--------------------------|--|--|
| | Japan | Thailand |
| Firm size | | |
| Large firm | Significantly related to R&D collaboration | Not significantly related to R&D collaboration |
| SME | Not significantly related to R&D collaboration | Significantly related to R&D collaboration |
| Industrial sector | | |
| Food | Significantly related to R&D collaboration | Not significantly related to R&D collaboration |
| Electrical apparatus | Significantly related to R&D collaboration | Not significantly related to R&D collaboration |
| Chemical | Significantly related to R&D collaboration | Not significantly related to R&D collaboration |
| Automobile | Not significantly related to R&D collaboration | Significantly related to R&D collaboration |

Source: Author

Regarding the third research question, previous studies reported the results of a survey among German academics on the importance of various types of links with industries, but those studies did not clearly describe how the simultaneous use of various modes was important. This study found that mode of collaboration is a determinant influencing collaboration. In the Japanese case, the technology licensing mode and the personnel exchange mode are likely to be the most effective modes to generate product innovation and to increase sales. In the Thai case, the R&D mode is related to product and process innovation, whereas the consultation mode is related to process innovation. The infrastructure mode is significantly related to product innovation. Interestingly, the informal mode, which seems to be trivial, is likely to be an effective mode that has a significant relationship with innovation. Interestingly, the use of two modes, especially a combination of R&D and consultation, is related to product innovation and sales.

Table 7-5: Summary of Influence of Collaboration Mode on Collaboration Outcome

| Collaboration Outcome | Most Effective Mode (Highest Marginal Effect) and Influence of Combination of Two Modes on Outcome | |
|-----------------------|---|--|
| | Japan | Thailand |
| Product innovation | <ul style="list-style-type: none"> • Technology licensing • Combination of two modes has a negative relationship with product innovation. | <ul style="list-style-type: none"> • Infrastructure • Combination of R&D and consultation has a positive relationship with product innovation. |
| Process innovation | N/A | <ul style="list-style-type: none"> • Consultation • Combination of R&D and consultation has a negative relationship with process innovation. |
| Sales | <ul style="list-style-type: none"> • Researcher exchange • Combination of two modes has a negative relationship with | <ul style="list-style-type: none"> • Combination of R&D and consultation has a positive relationship with sales. |

| Collaboration Outcome | Most Effective Mode (Highest Marginal Effect) and Influence of Combination of Two Modes on Outcome | |
|-----------------------|--|----------|
| | Japan | Thailand |
| | sales. | |

Source: Author

7.3 Implications for Theory, Policy and Further Research

This study generates a new model for investigating the characteristics of university and industry collaboration in developed countries and catching-up countries and suggests significant implications for existing theories and areas of study.

7.3.1 University–industry collaboration model. The university–industry collaboration model integrates the characteristics of university and industry collaboration in both developed countries and catching-up countries (Figure 7-1). The similarities in university–industry collaboration between developed countries and catching-up countries are local public universities provide consultation service to local SMEs and consultation mode seems to be suitable for SMEs. The main differences in university–industry collaboration between developed countries and catching-up countries are the starting point of collaboration, collaboration mode, and collaboration outcome. At the beginning, student mobility in a catching-up country is used to build universities’ relationships with private firms, whereas researcher mobility from companies to universities frequently occurs at the start of collaborative R&D projects in developed countries. Student mobility programs associated with R&D or engineering activities in catching-up countries are operated by all

types of universities but in developed countries, researcher mobility often occurs only in national universities. Large firms in both developed and catching-up countries participate in those human mobility programs. To upgrade technological capabilities, consultation mode is important for catching-up countries, but developed countries are more likely to engage in collaborative R&D activities. Joint R&D activity, in which two partners contribute substantially with both financial and human resources, is often carried out by national universities in developed countries, whereas commissioned R&D is a preferable collaboration mode for national universities in catching-up countries. In developed countries, large firms often engage in joint R&D activities but SMEs prefer to use commissioned R&D mode. On the contrary, commissioned R&D is a preferable collaboration mode for large firms in catching-up countries. In developed countries, some private universities have high technological capabilities and their collaboration modes are similar to national universities whereas private universities in catching-up countries put great emphasis on education. In terms of collaboration outcome, in catching-up countries, the intellectual property (IP) law/enforcement regime may not be well developed. Even the collaboration between national universities and large firms, patent is not an expected result of collaboration because firms are not interested in applying for patents. Instead, product/process innovation and product/process improvement are needed.

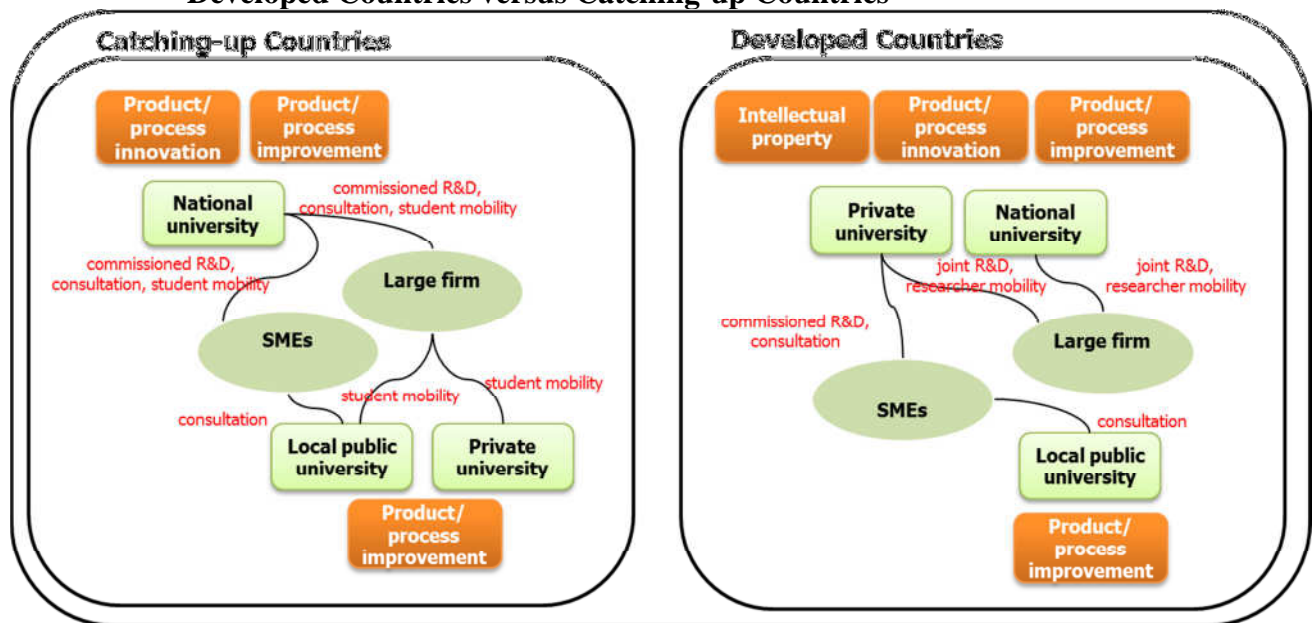
The characteristics of university–industry collaborations in both developed countries and catching-up countries are described in detail as follows. In developed countries, the technological capabilities of universities and firms are relatively high. Large

firms with high technological capabilities are eager to learn new knowledge and conduct cutting-edge research. In doing so, these firms prefer to work with universities. At the beginning stage of collaboration, researchers often move from a firm to a university. Then, new research areas are explored to initiate joint R&D projects with the aim of applying for joint patents. To maintain competitiveness, intellectual property is an important mechanism for large firms to protect their market position. Likewise, national universities prefer to work with large firms, as they have higher financial resources for R&D, which gives them more opportunities to conduct new research initiatives. Private universities have a higher degree of autonomy than other types of universities. These universities probably collaborate with various kinds of firms through various modes. In the case of private universities with high technological capabilities, their mode of collaboration is similar to that of national universities, whereas others may use different modes of collaboration with the aim to generate product or process innovation. Local public universities provide consultation services to local SMEs, which focus on improving products or processes.

In catching-up countries, the technological capabilities of universities and firms are not as high as those in developed countries. University–industry collaboration relies on consultation and human resource development. Consultation mode is important for technology upgrading while student mobility is the starting point for building relationship with firms. Most student mobility programs operated by local public universities and private universities may not be associated with R&D or engineering activities, especially collaborative programs with SMEs but there are some cases that those universities

collaborate with large firms and aim to improve products or processes. In case of national universities, student mobility programs are associated with R&D activities, and such programs become the starting points of collaborative R&D projects. R&D collaboration in catching-up countries is based on commissioned R&D because firms may not be able to contribute both financial and human resources to collaborative R&D projects. The expected results of R&D collaboration may not be patents because firms are not interested to apply for patents. Instead, product or process innovation and product or process improvement are needed to reduce cost or increase sales. With the government support, national universities also collaborate with SMEs through commissioned R&D and students are project assistants. Unlike in developed countries, most universities in catching-up countries often engage in consultation services.

**Figure 7-1: Integrated University–Industry Collaboration Model:
Developed Countries versus Catching-up Countries**



Source: Author

7.3.2 Implications of the innovation system (IS) approach. The central idea of all three IS approaches (national, regional, and sectoral) is the premise that interactions among actors are a key factor in generating, using, and diffusing knowledge. Institutions of laws, regulations, values, norms, etc., influence the activities and decisions of actors. All approaches consider the roles of actors to be the same. Actors should not substitute the roles of others to perform new roles. From IS scholars' perspective on university–industry collaboration, universities should support firms in developing technology rather than substituting for the technological efforts of firms. Importantly, the main role of universities is not to be incubators for start-ups or for patents; rather, they need to make long-term contributions to knowledge creation (see Chapter 2).

This study found that universities are not identical entities. There are several types of universities that have different roles. National universities focus on research activities because they have plenty of talented researchers and postgraduate students. Importantly, these universities are heavily influenced by the central government; therefore, the universities must implement the government policies. In Japan, national universities promote technology transfer through intellectual property licensing because this is the government policy. In contrast, local public universities, influenced by the local government or local community, focus on the mission of contribution to society rather than research activities; therefore, these universities often provide consultation services with the aim to improve products or processes. Private universities have a higher degree of autonomy than other types of universities, but they can be influenced by the central

government due to funding and incentive policy. Japanese private universities often engage in R&D activities due to incentive policies. In contrast, in the Thai case, R&D resources provided by the central government are limited; therefore, private universities must rely on tuition fees and put greater emphasis on education. The collaboration approach of these universities is based on cooperative education.

Beyond the set of components in a system of innovation (actor, network, institution), Edquist (1997) proposed the list of activities to pursue innovation processes—that is, to develop, diffuse, and use innovations (see Chapter 2). To further develop and contribute to the IS approach, Edquist identified research gaps for further study, including “which activities of which actors are important for the development of innovation” and whether it is “possible to distinguish between important activities and less important ones.” This study partially fills his research gaps. An activity is associated with capabilities of actors. UIC activities vary in accordance with the technological capabilities of the collaborating firms. R&D activity associated with high technological capability is important for university–industry collaboration in Japan. On the contrary, consultation is not involved in advanced technology activities and is suitable for technology upgrading in Thailand.

In addition, IS scholars have not paid attention to studying collaboration outcomes. This study found the relationship between activities and collaboration outcomes. In Japan, R&D is an important mode for generating patents as well as product and process

innovation. On the contrary, providing consultation services is an important mode of collaboration for process innovation in Thai universities, and a combination of R&D and consultation is related to sales and product innovation.

7.3.3 Implications of the triple helix (TH) concept. The TH concept puts emphasis on actors (government, university, and industry), especially the prominent role of universities in innovation, relationships among actors (e.g., technology transfer, conflict management), and the functions of interaction (e.g., knowledge generation). The institution issue is neglected in the TH concept. Even though this study does not aim at investigating the influence of the government policy, it can be observed that the government policy is likely to influence the direction of university and industry collaboration (see Chapter 4). In Japan, the national university reform has changed the behavior of the national universities to some extent in R&D collaboration with the industry and dramatically changed their intellectual property management (Kondo, 2009). In the Thai case, government initiatives such as the cooperative education program have influenced the direction of Thai universities. The number of universities participating in this program has increased from 56 universities in 2008 (17,399 students and 553 courses) to 117 universities in 2013 (36,735 students and 1,282 courses; OHEC, 2015). Therefore, institutions should be included in the study of university–industry collaboration because they shape the roles of actors.

In sum, this study provides a better understanding of the relationship among the factors of actor, activity (collaboration mode), technological capability, collaboration outcome, institution, and national system.

7.3.4 Implications for government policy. The results of this study suggest that one size fits all policies such as launching technology licensing offices and incubators in all universities may not be the most effective approach to foster collaboration with industry. Instead, policy makers should work to create separate policies for different types of universities, firms with different sizes, and countries with different technological capabilities.

Policies supporting universities of different types. Although IS scholars and TH scholars often assign one collaborative profile to all universities, it was found here that there are various types of universities and that each type adopts a distinct approach for the support of industry. In that light, this study identifies a set of policy recommendations reflecting the distinct characteristics of three types of universities, national universities, local public universities, and private universities (Table 7-6).

National universities

National universities have distinctive modes of R&D collaboration with large firms. Large firms with high technological capabilities prefer to work with national universities, expecting many joint patents as outcomes. In Japan, firms often send their researchers to

collaborating universities as visiting researchers. In Thailand, on the other hand, national universities often engage in commissioned R&D in which the collaborating firms do not contribute R&D resources (e.g., financial and human resources) to a significant degree. Cooperative education programs associated with R&D activities often generate significant student mobility, which can be an ignitor of collaborative R&D projects. For Thai national universities, then, research activities should be the primary focus of collaboration. To that end, it may be appropriate to create a space where firms can set up advanced laboratories that require sophisticated technical expertise; or to establish, through a public-private partnership among government, industry and academia, an advanced laboratory as a site for the initiation of large-scale joint R&D projects. To build relationships between large firms and universities, an intermediary body such as the Thai Office of Industrial Liaison is essential.

In the case of Japan, the exchange of professors and researchers between national universities and firms might be an interesting approach to the initiation of large-scale joint R&D projects. The secondment of professors from universities to firms (now a rare phenomenon) is also a promising approach, since university researchers could gain practical knowledge from experience in industry.

In the case of Thailand, the Thai government has implemented a talent mobility program in which university researchers spend time working at firms. Nonetheless, secondment from large firms to national universities is rare. This mechanism would help

university professors and students to benefit from the industrial experience of company researchers. However, since local firms might not be able to hire highly skilled researchers. Multinational corporations are a the most interesting target group for researcher mobility since their technological capabilities are relatively high and Thailand receives a larger amount of foreign direct investment than other ASEAN countries.³⁶

Local public universities

In both Thailand and Japan, local public universities often engage in consultation aimed at upgrading the technological capabilities of local SMEs. In that light, researcher placement in industry may not be appropriate, since local SMEs rarely engage in R&D. An engineering-related student mobility program would provide a foundation for the enhancement of the engineering capabilities of universities and the creation of relationships between universities and local SMEs. To answer to the needs of local SMEs as far as technology upgrading, local/regional centers should be set up to focus on analysis, rather than technology licensing. Launching government supported open laboratory initiatives would likely help local SMEs to upgrade their local products by benchmarking against high-quality products.

Private universities

Private universities generally place a strong emphasis on education by increasing faculty teaching loads, so researcher mobility and long-term R&D projects may not be

³⁶ <http://www.indexmundi.com/facts/indicators/BM.KLT.DINV.GD.ZS/rankings>

appropriate for private universities to collaborate with universities. Instead, a student mobility program associated with problem-solving activities would be a good start for university–industry collaboration. Financial aid for launching laboratories might be a suitable approach to the enhancement of the education and research capabilities of universities. In the case of Japanese private universities with high technological capabilities, policy should be similar to that recommended above for national universities.

Table 7-6: Specific Policy Recommendations for Universities

| University Type/Key Characteristic | Specific Policy Recommendation | | | |
|--|---|---|-------------------------------|---|
| | Human Mobility | Intermediary Body | Promoted Mode | R&D/Technical Infrastructure |
| National universities <i>Collaborate with large firms in R&D activities</i> | Researcher mobility associated with R&D activities | Central organization focusing on collaborative R&D activities | Large-scale joint R&D project | Providing a space for firms to set up advanced laboratories (public–private partnerships) |
| Local public universities <i>Engage in consultation aiming at assisting local SMEs</i> | Student mobility associated with engineering activities | Local center focusing on problem-solving | Consultation | Setting up (government-supported) open laboratories and testing services for local SMEs |
| Private universities <i>Emphasize education</i> | Student mobility associated with engineering activities | Central organization focusing on problem-solving | Consultation | Providing financial aid for launching laboratories |

Policies supporting firms of different sizes. The results of this study point to the fact that firms of different sizes have different technological capabilities. This can influence firms’ approach to collaboration with universities (Appendix 4). As in the discussion of the case of firms of different sizes, there is a need for differentiation of policy formulation to enable matching with firm behavior (Table 7-7).

SME access to collaboration

SMEs normally use knowledge generated by universities and often need an intermediary body to create relationships with those universities. For SMEs with low technological capabilities, an intermediary body is very important because generally SMEs cannot access the universities' knowledge and technologies directly. An intermediary body could make an initial identification of partners, connect them with the SME, and monitor relations and help resolve conflicts as they occur. In such scenarios, financial incentives may be required for the launching of collaborative projects. SMEs with medium technological capabilities can make approaches to universities themselves and enter collaboration as users of existing knowledge or co-creators of new knowledge or both. However, in most cases the universities already possess the knowledge that the SMEs desire access to. Such firms are suitable an upgrading of their technological capabilities because they already have some base of technology capabilities. Financial incentives, such as grants to upgrade engineering, design, and R&D capabilities, should be provided for SMEs.

Large firm collaboration

Large firms can access university partners directly, without an intermediary. These firms are co-creators of new knowledge with universities, as evidenced by numerous joint patent applications. They can access research information and can contact university researchers directly, but an intermediary body offering one-stop service may be an efficient inroad. To strengthen the relationships between universities and large firms, the government

could provide incentives (e.g., tax breaks) for such firms to do collaborative R&D projects and to set up collaborative R&D laboratories inside universities, especially in the Thai case; this study found that large firms are not likely to collaborate with universities.

Table 7-7: Specific Policy Recommendations for Firms

| Actor/Key Characteristic | Specific Policy Recommendation | |
|---|--|---|
| | Intermediary Body | Incentive |
| SMEs <i>Use existing knowledge generated by universities (knowledge user); requires an intermediary body to access those universities</i> | Organization aiming at serving needs of local SMEs | Grant for upgrading engineering, design and R&D capabilities |
| Large firms <i>Co-creators of new knowledge with universities</i> | Organization offering one-stop service | Tax incentives for conducting collaborative R&D projects and setting up advanced laboratories inside universities |

Policies for developed countries versus catching-up countries. The results of this study indicate that since the collaboration approaches of developed countries are different from those of catching-up countries (see Section 7.2), university and industry collaboration policy should be created separately for developed countries and catching-up countries (Table 7-8).

Collaboration in developed countries

Since both universities and firms in developed countries have high technological capabilities they can collaborate as equals. The most frequent mode of collaboration in such scenarios is R&D collaboration aimed at patent applications and licenses. Two-way researcher mobility between universities and firms is the start of collaborative R&D

projects. Encouraging firms to set up advanced laboratories or R&D centers inside universities can enhance the education and research capabilities of universities.

Collaboration in catching-up countries

The technological capabilities of universities and firms in catching-up countries are not high. The most frequent mode of collaboration is human resources development collaboration and technical consultation. Student mobility programs associated with R&D or engineering activities should be suitable for building relationship with firms. Instead of setting up centralized technology licensing offices, technology incubators and science parks, attention should be placed on the creation of consultancy services to solve firms' specific problems. Such consultancy can be done in the form of either informal or formal collaboration.

Table 7-8: Specific Policy Recommendations for Developed and Catching-up Countries

| Actor/Key Characteristic | Specific Policy Recommendation |
|--|--|
| Developed countries Rely on R&D collaboration aimed at applying for and licensing patents | Establish two-way researcher mobility between universities and firms Encourage firms to set up advanced laboratories inside universities |
| Catching-up countries Focus on human resources development collaboration and technical consultation | Establish a student mobility program associated with R&D or engineering activities Pay greater attention to consultancy services to solve firms' specific problems. This consultancy can be done through informal or formal collaboration |

7.3.5 Implications for future research. The results of this study point to the need for further study of several aspects of university and industry collaboration analysis, as outlined below.

Integrated university and industry collaboration model

This study proposes an integrated model of university and industry collaboration for developed countries and catching-up countries. The application of the model involves determining the three components of university and industry collaboration for analysis of given scenario in a developed or catching-up country: the starting point of collaboration; the collaboration mode; and the collaboration outcome.

Evolution of university and industry collaboration activities

This study has examined the influence of combining two collaboration modes on collaboration outcomes. To deepen understanding of the historical background of university and industry collaboration activities, it would be interesting to conduct longitudinal research on the evolution of collaboration modes (activities) over time; on the mechanisms influencing that evolution; and on the influence of key actors' characteristics (e.g., university type and firm size) on that evolution.

University specialization

A comparison of university and industry collaboration at S&T-specialized universities (those offering science and engineering courses) and at comprehensive universities would afford a better understanding of how areas of specialization influence the choice of collaboration mode.

Influence of national contexts

There are a number of differences between developed countries and catching-up countries in terms of systems of innovation and university and industry collaboration, so it is to be expected that those countries differ in choice of collaboration mode as well. For example, the science-based sector in developed countries engages primarily in R&D collaboration, whereas the science-based sector in catching-up countries engages primarily in consultation. To characterize the difference in university and industry collaboration between developed countries and catching-up countries, careful case by case hypothesis construction is required.

Appendix

Appendix 1: Appendix to Chapter 3

Appendix Table:

Table A1-1: Operationalized Definition of University Types

| University Type | Operationalized Definition |
|-------------------------|--|
| National University | National university is established by the central government. It emphasizes research mission to gain frontier knowledge and/or technology. |
| Local Public University | Local public university is established by either the local government or the central government. Local government allocates budget to the university while the central government provides grant to the universities to assist local community. Main mission of local public university is to provide higher education opportunities to local people and to serve as intellectual and cultural centers within the local community. |
| Private University | Private university is established by private individuals and supported by private funds. It can design academic curricula and has the autonomy to promote its own unique education and research activities, based on the spiritual legacy of its foundation. |

Table A1-2: Criteria for University Selection

| University Type/ Name of University | Course Offering | | |
|--|---|----------------------------------|-----------------------------|
| | Science and Engineering | Medical and Health Science | Social Science and Humanity |
| National University | | | |
| Japan | | | |
| • University of Tokyo (Todai) | √ | √ | √ |
| • Tohoku University (Tohoku) | √ | √ | √ |
| • Tokyo Institute of Technology (Tokodai) | √ | | |
| Thailand | | | |
| • Chulalongkorn University (CU) | √ | √ | √ |
| • Mahidol University (MU) | √ | √ | √ |
| • Chiang Mai University (CMU) | √ | √ | √ |
| • King Mongkut's University of Technology Thonburi (KMUTT) | √ | | |
| Local Public University | | | |
| Japan | | | |
| • Fukui Prefectural University (FPU) | √ (Biotechnology and Marine) | √ (Nursing) | √ |
| • Miyagi University (MYU) | √ (Food, Agricultural, Environmental Science and Information System) | √ (Nursing) | √ |
| Thailand | | | |
| • Phuket Rajabhat University (PKRU) | √ (Industrial Technology, Construction Technology and Agricultural Technology) | √ (Health Science) | √ |
| • Rajamangala University of Technology Thanyaburi (RMUTT) | √ (Engineering Courses, Agricultural Technology, Home Economic) | √ (Thai Traditional Medicine) | √ |
| • Rajamangala University of Technology Lanna (RMUTL) | √ (Agricultural Science, Fisheries, Food Science, Animal Science, | | √ |

| University Type/ Name of University | Course Offering | | |
|---|-------------------------|-------------------------------|--------------------------------|
| | Science and Engineering | Medical and Health Science | Social Science and Humanity |
| | Engineering Courses) | | |
| Private University | | | |
| Japan | | | |
| • Keio University (Keio) | √ | √ | √ |
| • Toyo University (Toyo) | √ | √ | √ |
| • Tohoku Institute of Technology (TIT) | √ | | |
| • Toyota Technological Institute (TTI) | √ | | |
| Thailand | | | |
| • Rangsit University (RSU) | √ | √ | √ |
| • Dhurakij Bandit University (DBU) | √ | | √ |
| • Siam University (Siam) | √ | √ | √ |
| • North-Chiang Mai University (NCMU) | √ | | √ |
| • Panyapiwat Institute of Management (PIM) | √ | | √ |

Source: University

Table A1-3: Operationalized Definition of Collaboration Modes

| Mode | Coverage of Sub-Modes | | Explanation |
|--------------------------------------|---|--|---|
| | Japan | Thailand | |
| Research and development (R&D) | <ul style="list-style-type: none"> • Joint R&D • Consignment of R&D • Funding for university research • Exchange of research sample | <ul style="list-style-type: none"> • Joint R&D • Contract out R&D • Co-publication | <ul style="list-style-type: none"> • Joint or Collaborative R&D: Both or all of parties make a substantial contribution to the resource requirements • Contract out or Commission: Research commissioned by a private firm to pursue a problem of interest • Co-publication: Both or all of parties jointly publish publication which is output of R&D activity • Fund for university research: Research paid for by an external party • Exchange of research sample: <i>It is defined as the transfer of tangible research sample between two organizations</i> |
| Consultancy | Technical guidance | Academic consultant | Consultancy is a service provided by expert staff |
| Infrastructure | | <ul style="list-style-type: none"> • Use of testing service • Share of technical infrastructure | Testing service and use of infrastructure: development, analysis and testing for industrial products and processes in university department |
| Human resource transfer | Personnel exchange | <ul style="list-style-type: none"> • Temporary personnel exchange • Student internship • Training for employees | Multi-context learning mechanisms such as training of industry employees, postgraduate training in industry, graduate trainees and secondments to industry, adjunct faculty |
| Informal interaction | | <ul style="list-style-type: none"> • Meeting or conference • Personnel contact | Formation of social relationships and networks at conferences, etc. |
| Intellectual property (IP) licensing | Technology licensing | Technology licensing | Transfer of university-generated IP (such as patents) to firms, e.g. via licensing |
| Business venture | Business venture | | Development and commercial exploitation of technologies pursued by academic inventors through a company they (partly) own |

Source: Adapted from Shartinger *et al.* 2002; Perkmann & Walsh 2007; Eom & Lee 2009; Ponomariov & Boardman 2012; Vea 2013

Table A1-4: Level of Variables for Research Question 2

| Type of variable | Level of variable | |
|----------------------|---|---|
| | Case of Japan | Case of Thailand |
| Dependent variable | <ol style="list-style-type: none"> 1. R&D mode level 1: use one of all sub-modes, level 4: use all sub-modes 2. Technical guidance mode use technical guidance (1), otherwise (0) 3. Personnel exchange mode host personnel exchange (1), otherwise (0) 4. Technology licensing mode license technology (1), otherwise (0) 5. Venture business mode establish business venture mode (1), otherwise (0) | <ol style="list-style-type: none"> 1. R&D mode level 1: use one of all sub-modes, level 3: use all sub-modes 2. Consultancy mode use consultancy service (1), otherwise (0) 3. HR mode level 1: use one of all sub-modes, level 3: use all sub-modes 4. Technology licensing mode license technology (1), otherwise (0) 5. Infrastructure mode level 1: use one of all sub-modes, level 2: use all sub-modes 6. Informal mode level 1: use one of all sub-modes, level 2: use all sub-modes |
| Independent Variable | <ol style="list-style-type: none"> 1. Size large firm (1), otherwise (0) 2. Industrial sector <ul style="list-style-type: none"> • food (1), otherwise (0) • chemical (1), otherwise (0) • electrical apparatus (1), otherwise (0) • automotive (1), otherwise (0) | <ol style="list-style-type: none"> 1. Size large firm (1), otherwise (0) 2. Industrial sector <ul style="list-style-type: none"> • food (1), otherwise (0) • chemical & petroleum (1), otherwise (0) • electrical apparatus (1), otherwise (0) • automotive (1), otherwise (0) |

Table A1-5: Level of Variables: Research Question 3

| Type of variable | Level of variable | |
|---|--|---|
| | Case of Japan | Case of Thailand |
| Dependent variable | <ol style="list-style-type: none"> Product innovation developed through collaboration (% of total products) (level 1-4) <ul style="list-style-type: none"> level: 1 : $0\% < x < 10\%$, level 2 : $10\% < x < 30\%$, level 3: $30\% < x < 100\%$, level 4: 100% Contribution of results developed through collaboration to sales (level 1-4) <ul style="list-style-type: none"> level: 1 : $0\% < x < 10\%$, level 2 : $10\% < x < 30\%$, level 3: $30\% < x < 100\%$, level 4: 100% | <ol style="list-style-type: none"> Number of product innovations developed through collaboration <ul style="list-style-type: none"> Counting number Number of process innovations developed through collaboration <ul style="list-style-type: none"> Counting number Amount of total sales <ul style="list-style-type: none"> ln (amount of total sales) |
| Independent variable (see details in Table 4 except for manufacturing) | <ol style="list-style-type: none"> R&D mode Technical guidance mode Personnel exchange mode Technology licensing mode Business venture mode Complementary mode Size Manufacturing manufacturing (1), otherwise (0) | <ol style="list-style-type: none"> R&D mode Consultancy mode HR mode Technology licensing mode Infrastructure mode Informal mode Complementary mode Size Manufacturing manufacturing (1), otherwise (0) |

Equation:

Correlation coefficient

$$r = \frac{n (\sum xy) - (\sum x)(\sum y)}{\sqrt{[n \sum x^2 - (\sum x)^2] [n \sum y^2 - (\sum y)^2]}}$$

Where $r = \text{correlation coefficient}$, $n = \text{sample size}$
 $x = \text{mode } x$, $y = \text{mode } y$

Interaction term

Interaction term = $x * y$

Where $x = \text{mode } x$, $y = \text{mode } y$

Ordered probit regression (Japanese case)

$$\Pr(\text{outcome}_j = i) = \Pr(K_{i-1} < \beta_1 x_1 + \beta_2 x_2 \dots + \mu_j \leq K_i)$$

Where $i = \text{number of possible product innovation and sales}$
 $\beta = \text{coefficient}$; it is estimated with cutting point, K
 K_0 is taken as $-\infty$ and K_i is taken as $+\infty$
 $x = \text{mode}$
 μ_j is assumed to be normally distributed

Poisson regression (Thai case)

$$C_i = e^{\ln(E_j) + \beta_0 + \beta_1 x_1 \dots + \beta_k x_{k,j}}$$

Where $C_i = \text{product innovation and process innovation}$
 E_j is assumed to be 1
 $\beta = \text{coefficient}$
 $X = \text{mode}$

Linear regression (Thai case)

$$y = \beta x + \varepsilon$$

Where $\beta = \text{coefficient}$

$X = \text{mode}$

$Y = \text{sales}$

List of Interviewees:**Japan (December 1, 2014 – July 25, 2015) (22 Interviewees)****Policy maker and Policy expert**

| Name | Position and Affiliation | Interview Date |
|-------------------------|--|-----------------------|
| Dr.Masaru Nagura | Unit Chief, University-Industry Collaboration and Regional R&D Division. MEXT | April 4, 2014 |
| Prof.Hisanori Nei | Deputy Director of GRIPS Innovation, Science and Technology Policy Program | November 27, 2014 |
| Prof.Dr.Hiroo Niiyama | Professor Emeritus. Tokyo Institute of Technology | December 1, 2014 |
| Prof. Akiko Nishizawa | Professor. Faculty of Business Administration. Toyo University (Former Professor of Entrepreneurial Policy. Graduate School of Economics and Management. Tohoku University) | December 11, 2014 |
| Prof.Dr.Takahiro Ueyama | Professor, Faculty of Policy Management, Keio University | January 30, 2015 |
| Mr.Chiba Ryoji | Knowledge Center. Industrial Technology Institute. Miyagi Prefectural Government | July 23, 2015 |

University**1. University of Tokyo**

| Name | Position and Affiliation | Interview Date |
|----------------------|---|-----------------------|
| Mr.Takafumi Yamamoto | <ul style="list-style-type: none">• CEO and President Registered Technology Transfer Professional.TODAI Technology Licensing Office• Board members of UNITT (AUTM Japan) | December 13, 2014 |
| Mr.Kazuya Tanaka | Ph.D. student and researcher. Todai Future Faculty Program | July 3, 2015 |

2. Tokyo Institute of Technology

| Name | Position and Affiliation | Interview Date |
|---------------------------------|---|-------------------|
| Prof.Dr.Wiwut Tanthapanichakoon | <ul style="list-style-type: none">• Professor, Faculty of Engineering• Emeritus Professor of Chulalongkorn University, Thailand | December 4, 2014 |
| Prof.Mitsuhiko Oi | <ul style="list-style-type: none">• Director of International Collaboration Division, Office of Industry Liaison• Senior University Research Administrator, Research and Administration Center | December 15, 2014 |
| Dr.Xiaodong Gu | Postdoctoral researcher. Koyama Laboratory Photonics Integration System Research Center. P&I Laboratory | July 5, 2015 |

3. Tohoku University

| Name | Position and Affiliation | Interview Date |
|------------------------------|---|----------------|
| Prof.Fumihiko Hasegawa | Vice Director. New Industry Creation Hatchery Center | July 24, 2015 |
| Prof.Akihiro Isomura | Specially Appointed Professor. New Industry Creation Hatchery Center | July 24, 2015 |
| Asst.Prof. Nishith Kumar Das | Assistant Professor. Shoji Project. New Industry Creation Hatchery Center | July 24, 2015 |
| Mr.Amnart Boonkajay | Ph.D. student and researcher. Faculty of Communication Engineering | July 13, 2015 |

4. Fukui Prefectural University

| Name | Position and Affiliation | Interview Date |
|----------------------------|--|-------------------|
| Prof.Dr.Masahiro Shimotani | President | December 18, 2014 |
| Prof.Dr.Takashi Utagawa | <ul style="list-style-type: none">• Vice President• Professor. Faculty of Biotechnology | December 18, 2014 |

5. Miyagi University

| Name | Position and Affiliation | Interview Date |
|------------------------|--|----------------|
| Prof.Dr.Ikuko Miyahara | Professor. Faculty of Project Design (Tourism and Geography) | July 23, 2014 |
| Mr.Takashi Furukawa | Manager. Regional Planning and Community Design | July 23, 2014 |

6. Keio University

| Name | Position and Affiliation | Interview Date |
|------------------------|--|-----------------------|
| Prof.Dr.Kenichi Hatori | <ul style="list-style-type: none"> • Project Professor. Graduate School of Science and Technology • Former Director of Intellectual Property Center • Former Director of Headquarters of Research Administration and Coordination | January 29, 2015 |

7. Toyo University

| Name | Position and Affiliation | Interview Date |
|-----------------------|--|--|
| Prof. Akiko Nishizawa | <ul style="list-style-type: none"> • Professor, Faculty of Business Administration, Toyo University • Former Professor of Entrepreneurial Policy. Graduate School of Economics and Management, Tohoku University | December 11, 2014 July 27, 2015 October 23, 2015 |

8. Tohoku Institute of Technology

| Name | Position and Affiliation | Interview Date |
|-------------|--|-----------------------|
| Telephone | General Affairs Office. Tohoku Institute of Technology | July 21, 2015 |

9. Toyota Technological Institute

| Name | Position and Affiliation | Interview Date |
|-----------------------------|---|-----------------------|
| Prof.Dr.Masamichi Yoshimura | <ul style="list-style-type: none"> • Fellow. The Surface Science Society of Japan • Head of the International Affair Committee • Professor. Surface Science Laboratory | January 28, 2015 |
| Mr.Katsuji Yamashita | General Manager. Research Administration Department | January 28, 2015 |

Thailand (February 10 – August 27, 2015) (52 Interviewees)

Policy maker and Policy expert

| Name | Position and Affiliation | Interview Date |
|------------------------------------|---|-----------------------|
| Assoc. Prof. Dr.Somchai Chatratana | <ul style="list-style-type: none"> • Deputy Secretary General to the Prime Minister for Political Affairs (Science & Technology, Education and Public Health) • Deputy Secretary General. National Science Technology and Innovation Policy Office | October 21, 2014 |
| Dr.Kitipong Promwong | <ul style="list-style-type: none"> • Political Official. the Secretariat of the Cabinet • Secretary of Sub-Committee on Science and Technology. The National Legislative Assembly • Deputy Secretary General. National Science Technology and Innovation Policy Office | February 17, 2015 |
| Dr.Thitapha Smitinont | Director of Industrial Technology Assistance Program. National Science and Technology Development Agency | February 18, 2015 |
| Dr.Nattaka Singhavitai | Manager. Industrial Technology Assistance Program. National Science and Technology Development Agency | February 18, 2015 |
| Ms.Soawapa Yuwawutto | Manager. Industrial Technology Assistance Program. National Science and Technology Development Agency | April 22, 2015 |
| Ms.Watcharin Wittahayaweerasak | General Manager. Thai Business Incubators and Science Parks Association | March 13, 2015 |
| Dr.Patthareeya Lakpetch | <p>Lecturer. National Institute of Development Administration</p> <p>(Research funded by National Research Council of Thailand (Topic: Knowledge Transfer Effectiveness of University-Industry Alliances)</p> | February 24, 2015 |
| Mr.Martin Venzky-Stalling | Senior Advisor at the Chiang Mai University Science & Technology Park | August 17, 2015 |

University

1. Chulalongkorn University

| Name | Position and Affiliation | Interview Date |
|--|---|-------------------|
| Assoc.Prof. Dr.Wisanu Subsompon, | <ul style="list-style-type: none"> • Former Vice President for Research • Former Director of Chulalongkorn University Intellectual Property Institute • Lecturer. Faculty of Engineering | October 17, 2014 |
| <i>Dr.Supichai</i> Tangjaitrong | Director of University and Industry Linkage Division. UNSEARCH | August 27, 2015 |
| Prof.Dr.Suthichai Assabumrungrat | Deputy Dean for Research. Faculty of Engineering | February 17, 2015 |
| Asst. Prof.Dr.Anongnat Somwangthanaroj | Assistant Dean for Research. Faculty of Engineering | February 24, 2015 |
| Assoc. Prof.Dr. Pichet Sampatanukul | Head of Cytopathology. Faculty of Medicine | February 16, 2015 |
| Assoc. Prof. Dr.Sanong Ekasit | Lecturer. Faculty of Science | February 17, 2015 |
| Mr.Wisit Leelasiriwong | <ul style="list-style-type: none"> • Lecturer. Faculty of Science • Researcher. Unisearch | February 16, 2015 |

2. Mahidol University

| Name | Position and Affiliation | Interview Date |
|--------------------------------------|--|-------------------|
| Prof. Dr.Sansanee Chaiyaroj | <ul style="list-style-type: none"> • Vice President for Research and International Relations • Advisor. Crown Property Bureau | February 16, 2015 |
| Prof. Dr. Boonsirm Withyachumnarnkul | <ul style="list-style-type: none"> • Department of Anatomy. Faculty of Science • Center of Excellence for Shrimp Molecular and Biotechnology. Faculty of Science • Science and Technology Award Thailand Toray Science Foundation Year 2000 | February 14, 2015 |
| Dr.Poomporn Thamsatitdej | Manager. University Incubation | June 24, 2015 |

3. Chiang Mai University

| Name | Position and Affiliation | Interview Date |
|--------------------------------|---|-----------------|
| Assoc.Prof.Sermkiat Jomjunyong | Vice President for Research and Academic Services | August 12, 2015 |
| Dr.Tanyanuparb Anantana | Director, Science and Technology Park | August 20, 2015 |

4. King Mongkut University of Technology Thonburi

| Name | Position and Affiliation | Interview Date |
|-----------------------------------|--|-------------------|
| Asst.Prof. Dr.Montira Nopharatana | <ul style="list-style-type: none">• Assistant to Vice President for Industry Engagement• Faculty of Engineering | February 10, 2015 |
| Ms.Suttiporn Thanglerttanab | Technology Liaison Officer | February 10, 2015 |
| Ms.Hatairat Thangvarawut | Technology Liaison Officer | February 10, 2015 |

5. Phuket Rajabhat University

| Name | Position and Affiliation | Interview Date |
|---------------------------------|--|-------------------|
| Dr.Hiran Prasankarn | Vice President for Planning and Budget | February 25, 2015 |
| Asst.Prof.Dr.Kulvara Suwanpimol | <ul style="list-style-type: none">• Director of Research and Development Institute• Head of Tourism Industry Program | February 25, 2015 |
| Asst.Prof.Noppadol Chanrawang | Dean of Faculty of Management Sciences | February 25, 2015 |
| Asst.Prof.Suwanit Chainarak | Deputy Dean, Aquaculture Program, Faculty of Agricultural Technology | March 1, 2015 |
| Asst.Prof.Pavarana Achariyabout | Head of Public Health Program, Faculty of Science | February 25, 2015 |
| Ms.Montira Chaitayakul | <ul style="list-style-type: none">• Lecturer. Faculty of Agriculture Technology• Entrepreneur. Phuket Hydroponics Co., Ltd. | February 26, 2015 |
| Ms.Khanitta Tanawiratananij | <ul style="list-style-type: none">• Manager. University Business Incubation.• Lecturer. Faculty of Industrial Technology | February 25, 2015 |

6. Rajamongkol University of Technology

| Name | Position and Affiliation | Interview Date |
|----------------------------------|--|-----------------------|
| Asst.Prof.Dr.Charoen Charoenchai | <ul style="list-style-type: none"> • Member of the RMUTT Faculty Senate • Lecturer. Faculty of Agriculture • Former Vice President for Research | February 19, 2015 |
| Asst.Prof.Dr.Niwat Moonpa | Director. College of Integrated Science and Technology. RMUTL | February 10, 2015 |

7. Siam University

| Name | Position and Affiliation | Interview Date |
|---------------------------|---|-----------------------|
| Dr.Kanjana Mahattanatawee | Dean of Faculty of Science | February 19, 2015 |
| Dr.Thanakorn Limsarun | <ul style="list-style-type: none"> • Manager. University Business Incubation • Lecturer. Faculty of Business Administration | February 19, 2015 |

8. Rangsit University

| Name | Position and Affiliation | Interview Date |
|---------------------------------------|--|-----------------------|
| Asst.Prof.Dr.Nares Pantaratorn | Vice President for Academic Affairs | March 5, 2015 |
| Mr.Watchara Loysmut | <ul style="list-style-type: none"> • Director of Academic Service Center • Lecturer. Faculty of Engineering | March 5, 2015 |
| Asst.Prof.Dr.Walaiporn Nakapan | <ul style="list-style-type: none"> • Director of Center of Innovative Learning • Lecturer. Faculty of Architecture | March 5, 2015 |
| Dr.Walaiporn Nakapan | Director of Center of Innovative Learning | March 5, 2015 |
| Ms.Bencha Santhithananont (telephone) | <ul style="list-style-type: none"> • Director of Business Incubator and Intellectual Property • Lecturer. Faculty of Business Administration | January 16, 2015 |

9. Dhurakij Pundit University

| Name | Position and Affiliation | Interview Date |
|-------------------------------------|---|-----------------------|
| Assc.Prof.Dr.Somboonwan Satyarakwit | Vice President for Academic Affairs | February 11, 2015 |
| Asst.Prof.Dr. Kom Campiranon | Deputy Dean of Dhurakij Punsit University International College (DPUIC) | March 8, 2015 |

10. North Chiang Mai University

| Name | Position and Affiliation | Interview Date |
|---------------------|---|-----------------------|
| Mr.Puchit Punyathap | Faculty of Engineering (Mechanical Engineering) | July 27, 2015 |

11. Panyapiwat Institute of Management

| Name | Position and Affiliation | Interview Date |
|----------------------------------|---|-----------------------|
| Assc.Prof.Dr.Sompop Manarungsan | President | February 13, 2015 |
| Mr.Phornvit Phacharintanakul | Vice President for Academic Affairs | February 13, 2015 |
| Mr.Siam Chocksawangwoong | Vice President for Administrative Affairs | February 12, 2015 |
| Dr.Lertchai Suthamanon | Assistant to the President for Planning and Development | February 12, 2015 |
| Ms.Parichart Buakao | Assistant to the President for Organization Communication | February 12, 2015 |
| Assc.Prof.Dr.Pisit Charnkeitkong | Dean. Faculty of Engineering and Technology | February 12, 2015 |
| Dr.Usanee Kulintornprasert | Deputy Director. Office of International Relations | February 12, 2015 |
| Mr.Viwat Maikaensarn | Assc. Dean for Administrative Affair. Faculty of Innovative Agricultural Management | February 13, 2015 |
| Ms.Nirada Jutagasut | Section Manager. International Business Networking Management | February 12, 2015 |
| Ms.Waranglak Udol | Specialist, CP All | February 12, 2015 |

Appendix 2: Appendix to Chapter 5

University-Background Information:

Japanese National University

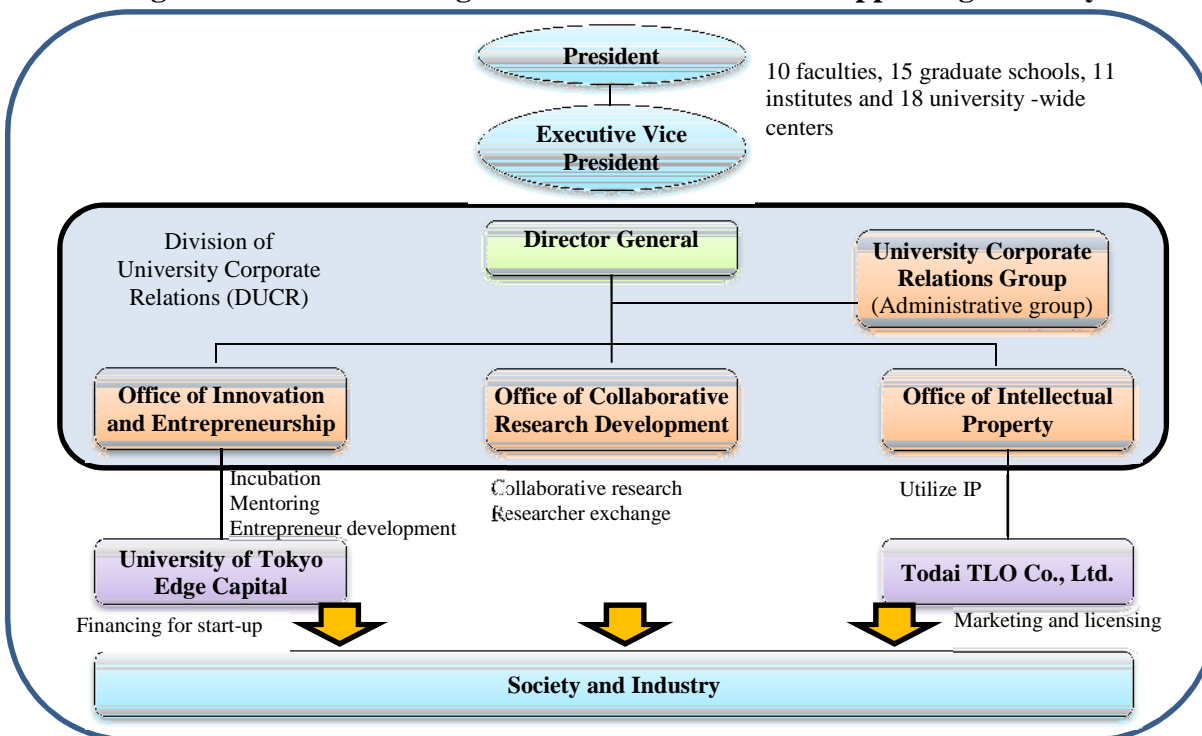
1. University of Tokyo (Todai)

The University of Tokyo was established in 1877 as the first National University in Japan. It originated with several specialized schools in various fields such as the Imperial College of Engineering and Tokyo School of Agriculture and Forestry, and it transformed to become a comprehensive research university (University of Tokyo website) that offers a wide range of areas including science and engineering (S&E), medicine and social science. In 2015, the university had 14,050 graduate students and 13,887 undergraduate students.

To stimulate university and industry collaboration (UIC) activities at the institutional level, Todai established two organizations to collaborate with the industry during the 1990s, which are the Center for Collaborative Research and Todai Technology Licensing Office (TLO) Co., Ltd. In 2004, the Center for Collaborative Research was transferred to be subordinate to the Division of University Corporate Relations (DUCR). The DUCR was founded as a central organization overseeing UIC activities, which has three main functions: 1) collaborative research development generates innovative collaborative research; 2) intellectual property manages and utilizes intellectual property and 3) innovation and entrepreneurship development facilitate start-up firms. This division has incubation rooms to incubate start-ups at three places: the University Corporate Relations

(UCR) Plaza, the Komaba Campus Collaborative Research (CCR) building and the University of Tokyo Entrepreneur Plaza, including Todai mentors through a network of external professionals. It also provides entrepreneurship education programs, namely the University of Tokyo Entrepreneur Dojo. In the same year of DUCR's establishment, the University of Tokyo Edge Capital (UTEC), an early stage technology venture capital firm with \$280 million funding, was also founded (Figure A2-1). In addition, DUCR launched the University Corporate Relations Network cooperating with the Japan Business Federation (Nippon Keidanren) in 2005. This network has served as an information exchange forum between the university and industry and an open forum for receiving the industry's requests and opinions. Interestingly, Todai has a policy to eliminate barriers between faculties and departments; therefore, DUCR has been assigned to support all activities of the multi cross-departmental and non-departmental program.

Figure A2-1: Todai's Organizational Structure for Supporting Industry



In order to encourage faculty members to work with the industry, the university provides financial incentive to inventors. Royalty fees will be distributed to the university (30%), to the institute or laboratory with which the inventor is affiliated (30%) and to the inventor (40%) after deduction of administration fees and any patent expenses.

2. Tokyo Institute of Technology (Tokodai)

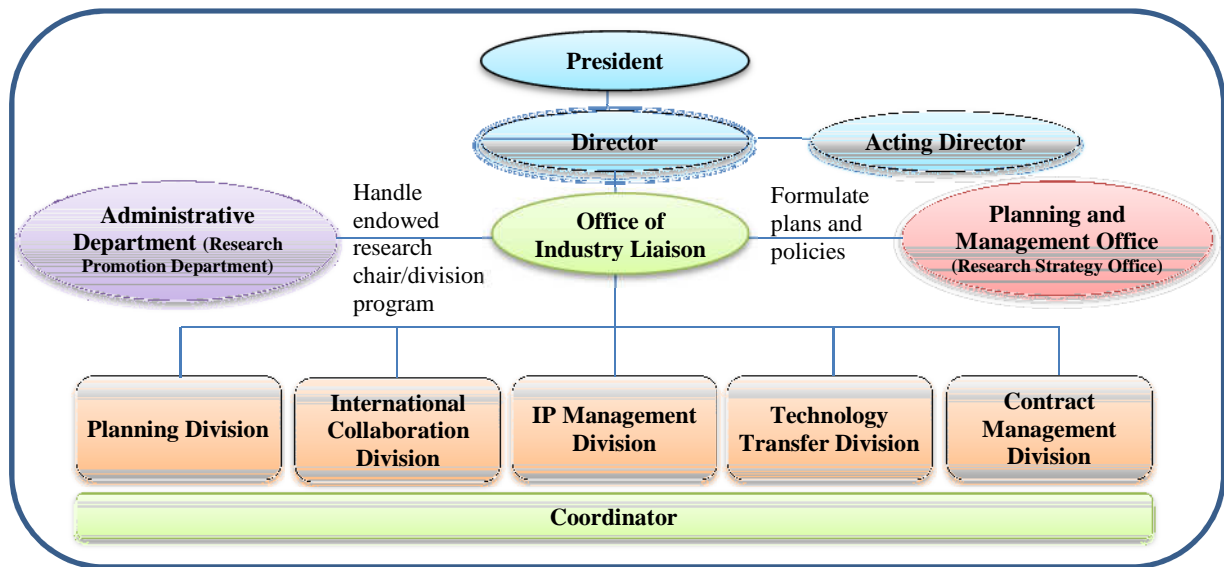
The Tokyo Institute of Technology (Tokodai) was established in 1881. It used to be a vocational college and transformed its status to become a national university. Tokodai currently offers science and engineering courses at the undergraduate and graduate level. In total, the institute has 9,982 students (4,788 undergraduate students, 5,101 graduate

students and 93 research students). The student-faculty member ratio is approximately 1:8.5.

Tokodai greatly emphasizes UIC activities by establishing an office of industry liaison (OIL) and setting up various programs such as the collaborative R&D, research alliance program and visiting researcher program. Similar to Todai, along with the government's initiatives, the institute's structural organization has gradually evolved for more than thirty years. The role of the institute in supporting the industry has been recognized and established as a formal form since 1982. At that time, Tokodai founded the Center for Research Cooperation and Information Exchange, which was restructured and renamed twice to Frontier Collaborative Research Center in 1998 and Integrated Research Institute in 2010. This institute has the main mission of facilitating and promoting the institute's joint research with the industry in four fields of frontier science, such as life science, information science, material science and environmental science, through collaboration with researchers within and/or outside the institute. Due to the establishment of the TLO Act, MEXT program's IP department was founded. When establishing OIL, the IP department was transferred to OIL, which acts as a central organization of the Tokyo Institute of Technology overseeing UIC activities. Except for the endowed research chair/division program, the research promotion department under the administrative department handles it. OIL cooperates with the research strategy office under the planning and management office through deployment of the institute's R&D plans and policies. OIL serves as an R&D supporting body that cover material purchase, employment, cost

management and reporting. Meanwhile, it provides one-stop service for external organizations such as business and government, and it facilitates faculty members to carry out research within and outside the institute (Figure A2-2).

Figure A2-2: Tokodai's Organizational Structure for Supporting Industry



This office offers the different collaborative programs to the industry as follows, whereas the research promotion department deals with the endowed research chair/division program aimed at maintaining a new research chair or research division on the basis of an endowment from private companies or other organizations.

- **Collaborative research program:** Both parties collaborate in research on a topic of mutual interest.
- **Sponsored research program:** The institute undertakes research commissioned by private companies, and the faculty member conducts research as an employee of the

university. Intellectual property generated through this program belongs to the institute.

- **Sponsored researcher program:** The institute accepts sponsored researchers from external organizations to conduct studies on the campus under the direction of faculty members.
- **Collaborative research chair/division program:** With funds from the sponsoring company, the chair/division program can be established on the campus, and company researchers are appointed as faculty members.
- **Academic consultation:** It provides academic consultations regarding the institute's research.
- **Technology consultation:** It provides consultations on R&D conducted by private companies.

The contract-based programs are handled by OIL. Generally, the agreement requires an overhead cost that accounted for approximately 23% of the total cost. Three programs, which are collaborative program, sponsored researcher program and collaborative research, the chair or division allows the company researchers to conduct research at the institute through three programs, which are collaborative program, sponsored researcher program and collaborative research (Table A2-1).

Table A2-1: Collaborative Programs offered by Office of Industrial Liaison

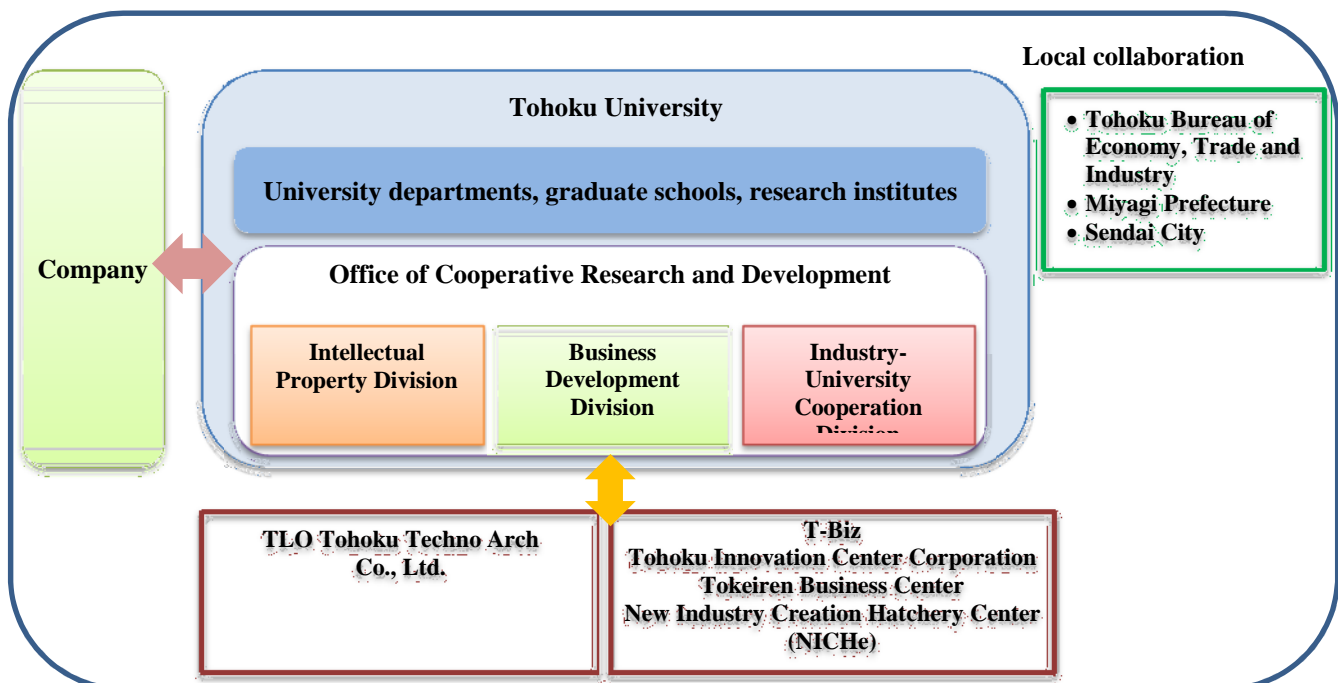
| Program | Conducted by | Location | Company researchers in institute | Contract with the institute | Overhead (% of total costs) | Department in the institute |
|---|--|------------------------|----------------------------------|-----------------------------|-----------------------------|-------------------------------|
| Collaborative research program | Faculty/Company researchers | Tokyo Tech and company | √ | √ | 23% | OIL |
| Sponsored research program | Faculty | Tokyo Tech | x | √ | 23% | OIL |
| Sponsored researcher program | Company researchers | Tokyo Tech | √ | On application from company | 200,000 yen (for 1 year) | OIL |
| Collaborative research chair/division program | Faculty, Faculty of the chair of division, Company researchers | Tokyo Tech | √ | √ | 23% | OIL |
| Endowed research chair/division program | Faculty of the chair of division | Tokyo Tech and company | x | x | None | Research promotion department |
| Academic consultation | Faculty/Company researchers | Tokyo Tech | x | √ | 23% | OIL |
| Technology consultation | Company researchers, Faculty in a private capacity | Company | x | No (faculty sideline) | - | Human affair department |

3. Tohoku University (Tohoku)

The Tohoku University was established in 1958 as the third imperial university with a “research first” principle and “open-door” policy. During the process of preparation for the establishment, the Ministry of Education sent eight professors to Europe to study who embedded the culture in pursuing cutting-edge knowledge. As a result, the university aims to become a world-class university and a university for the region. Tohoku currently provides various courses, which are science and engineering (S&E), medicine and social science. As of November 2014, Tohoku had 7,853 graduate students and 11,224 undergraduate students.

Although the Office of Cooperative Research and Development acts as a central organization for UIC activities, faculty deans have the authority to sign contracts with firms. This office offers several services, which are intellectual property, incubation, technology licensing, joint R&D, commissioned R&D and consultation (Figure A2-3). Because Tohoku is a national university located in a local area, it established the New Industry Creation Hatchery Center (NICHe) to conduct advanced research with the industry, while T-Biz was also founded as an incubation facility for regional development. Both the deans and Office of Cooperative Research and Development have the authority to sign contracts.

Figure A2-3: Tohoku's Organizational Structure for Supporting Industry



To encourage faculty members to create innovation, Tohoku set up the financial incentive scheme. For example, income obtained by licensing patents is paid back to inventors, research funds and the university. After deduction of technical transfer (1/3), the remaining licensing fees are distributed to inventors (30%), laboratories (30%) and the headquarters (40%). In the case of copyright and trademark, all incomes are distributed to the headquarters. R&D funding can range from 0% to 30% for inventors, and the funding rate for laboratories can vary from 30% to 60%.³⁷

Japanese Local Public University

4. Fukui Prefectural University (FPU)

Fukui Prefectural University (FPU) was originally set up in 1992 with a bio-resource and nursing course. It recently opened economic faculty. At present, the university has 1,819 students, which include 1,625 undergraduate students and 194 graduate students. Interestingly, this university aims to collaborate with local businesses through the Research Institute for Regional Economics. This institute aims to share information among local businesses and conduct research on Asian countries in order to provide this information to companies in the Fukui prefecture. FPU was partly influenced by government policy, such as the Public University Corporation Law, but in terms of financial support, the local government directly influences universities through R&D funding. Due to a relatively new university, there is still no important milestone or turning point in the university's policies toward supporting the industry. So, as to encourage professors to conduct R&D activities,

³⁷ http://www.rpip.tohoku.ac.jp/english/files/ip_manual_en.pdf

the university annually allocates an equal budget to professors. Nonetheless, the president considers that this R&D budget allocation approach might not be appropriate because professors' interests in conducting R&D may be different. He is therefore considering reviewing the R&D budget allocation approach to become more appropriate and efficient. However, the university does not yet have a rule to clearly distribute the professors; work load to work with industry yet. It still depends on the professors' interests. In FPU, there is no central organization to support the industry to do scientific research. At this moment, it only has a small incubation, but it is not the kind of central organization to handle all the university's incubation activities. In the case of this university, it may not be necessary to establish TLO inside because its focused partner is mostly the small local business.

'Even though our university is relatively small and most of the faculty members are interested in teaching rather than doing research, I continue strongly supporting research activities. Each year the university allocates the R&D fund to faculty members including the annual fund from local government. I believe the research activities benefit local community.'

'In my opinion, establishing TLO in the university may not be appropriate for us. Our partners are mostly small local firms, but I think a central organization handling documents and coordinating with our partners is more appropriate.'

Utagawa, T., Interview, December 18, 2014.

‘Mutual respect is very important. It helps to build trust between two sides. In order to build mutual respect, the university researcher’s status should not be higher than the firm.’

Utagawa, T., Interview, December 18, 2014.

5. Miyagi University (MYU)

In 1997, Miyagi University was established in the Kurokawa district, Miyagi prefecture with a School of Nursing and School of Project Design. In 2001, the university established the Graduate School Programs for Nursing and Project Design. In 2005, Miyagi Agricultural College, a junior college located in Sendai, merged with Miyagi University, and the School of Food, Agricultural and Environmental Sciences opened in the same year. Now, 1,658 students have enrolled in the university.

‘I think that our university mainly focuses on education because it is a main mission of the university whereas contribution to society seems to be the second priority issue.

MYU has an explicit policy to contribute to the local community by providing funding.’

Miyahara, I., Interview, July 23, 2015

Furukawa, T., Interview, July 23, 2015

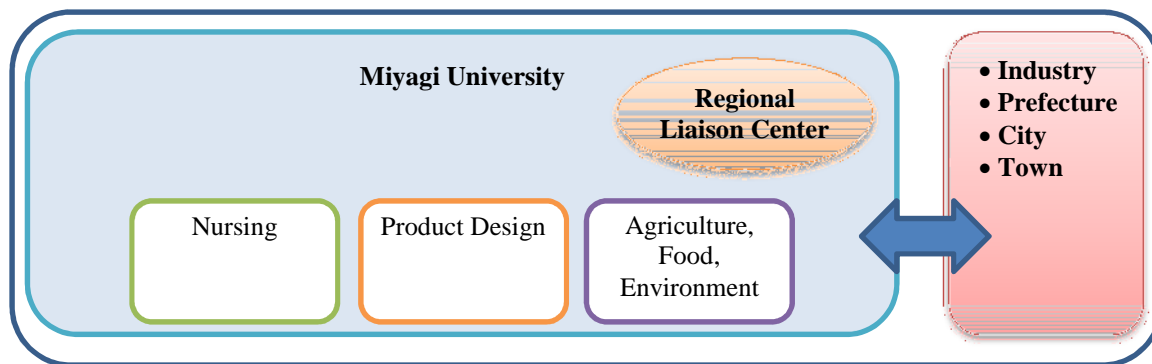
The Regional Liaison Center was established in April 2004 to develop closer research ties and networks with communities in Miyagi. To meet the society's evolving needs, the center initiates and facilitates collaborative projects between MYU researchers, private industry, government organizations, non-governmental organizations, think-tanks and other academic institutions. Staffed with full- and part-time researchers and professionals, we

make working for the betterment of today's community the driving force behind our activities. However, firms sometimes directly contact faculties or individual researchers (Figure A3-4).

‘We voluntarily work with local people; therefore, we do not receive extra remuneration.’

Miyahara, I., Interview, July 23, 2015.

Figure A2-4: MYU’s Organizational Structure for Supporting Industry



Japanese Private University

6. Keio University (Keio)

Keio University (Keio) was established in 1858. It was initially a Dutch studies school and transformed to an English studies school. After that, it set up an elementary and secondary school, followed by the School of Medicine. At this moment, it has become a comprehensive university. Of the total students, there are 37,000 undergraduate students and 4,000 graduate students. Most of undergraduate students study in areas of social

sciences and humanities, whereas a major proportion of graduate students are in the area of science and technology, including medicine. Keio has one main campus and seven regional campuses.

In the 1990s, the Japanese government enacted the law of the Technology Licensing Office (TLO) and Bayh-Dole Act. At the same time, Keio University established TLO in 1998. The ownership of invention was transferred to the university, thus leading to rule enforcement on the allocation of income remuneration in 1999. The university's administrative system, regarding collaborative activities with the industry, significantly changed in 2003. The university established an organization for research advancement and administration, a center for research promotion and an incubation center. During those periods, the rules/regulations, codes of conduct and policies regarding collaboration with industry were enacted; for example: (1) rules/regulations for handling intellectual and tangible properties, inventions and entrepreneur support fund; (2) codes of conduct for research ethics and (3) conflict management policy. In 2007, the Keio Advanced Research Center (KARC) was established to serve collaborative activities in various research fields. In 2011, research advancement and administration were transformed into the headquarters for research coordination and administration. The intellectual property center and center for research promotion were restructured to two divisions under the headquarters for research coordination and administration. Each of those centers played an important role in promoting patent application, technology transfer, research collaboration and facilitation

and business incubation. The committees on research ethics and intellectual property mediation have been appointed to oversee the related issues.

‘Even though the university has corporate status to own intellectual property rights, before enactment of Japanese Bayh Dole Act (1998), firms collaborating with us solely owned the rights. This is because, at that time, individual researchers were not aware of intellectual property ownership.’ ‘After 1998, we also set up TLO. I think we also follow government initiatives and National University like Todai.’

Hatori, K., Interview, January 29, 2015.

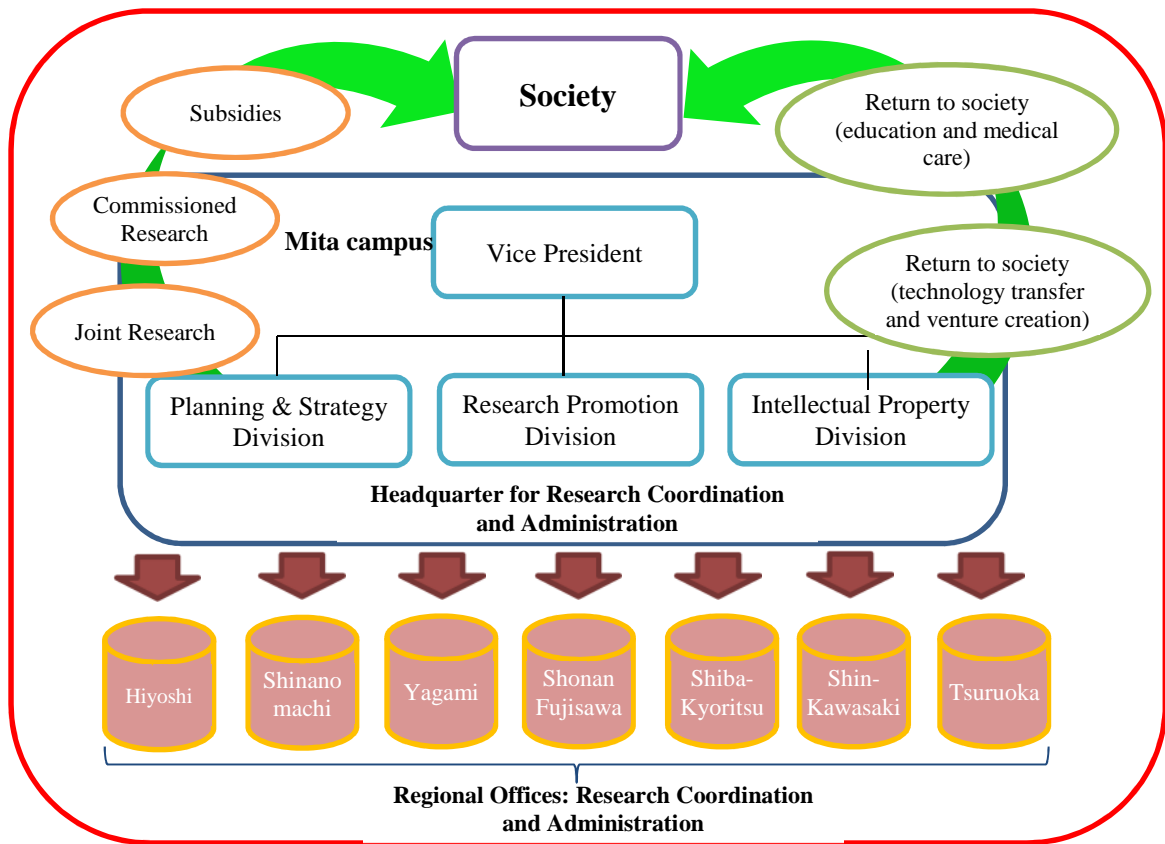
The office of research administration provides comprehensive support for research project management. It offers a variety of other support services, including negotiations and completion of contracts for joint or commissioned research, management of research expenses and research spaces and compilation and presentation of research results. Interestingly, Keio University also focuses on collaboration with the industry at the regional level. It has a head office located on Mita campus and regional offices located at each campus of the university. The headquarters office, headed by the vice president, consists of three divisions: (1) planning and strategy office to propose R&D plan and strategy of university; (2) research promotion to manage external R&D funds and build long-term relationships and (3) technology licensing office to manage the intellectual property issue. With seven or eight staffs, regional offices support and manage R&D budgets, including providing preliminary advice services for the intellectual property issue and maintaining close contact with individual researchers. However, the regional offices

are required to pass the cases through the headquarters office if they need to make technology licensing agreements. Head office and regional offices closely work together. During the weekday, two regular meetings at the head office on Mita campus are arranged for two days, and the rotation schedule to visit each campus is set up for another three days (Figure A2-5). In the case of technology licensing, the income from the royalty fee is distributed to the inventor (42.5%) and university (42.5%), whereas 15% is deducted for the management fee.

‘We work closely with regional offices. During the week, one or two regular meetings with regional offices are arranged at the headquarters office, and then the rotation schedule to visit each of the campuses is set up for another three days.’

Hatori, K., Interview, January 29, 2015.

Figure A2-5: Keio's Organizational Structure for Supporting Industry



7. Toyo University (Toyo)

Toyo University (Toyo) was founded in 1887 by Dr. Enryo Inoue. At the beginning, its name was the Private Philosophy Academy. It is now one of the largest universities in Japan with over 30,193 students in both liberal arts and science courses. More than 90% of the total students are graduate students.

‘Toyo University has significantly evolved from being a faculty of letter as the oldest faculty to offering a wide range of study areas including S&T area. Also, our laboratory is advanced. Sometimes, firms are surprised when they learn that we have

already offered an S&T degree. After that, they started the collaboration with us, even the large firms.'

Nishizawa, A., Interview, October 23, 2015

The research facilities at the university are associated with a wide range of knowledge for comprehensive research. The researchers are encouraged to conduct in-depth research for the future. The university's research activities include programs adopted for the Strategic Research Foundation Grant-aided Project for Private Universities and other projects implemented by the Ministry of Education, Culture, Sports Science and Technology (3,765,413,000 yen in fiscal year 2014).

Research institutes were established for carrying out UIC activities. For example, the Research Institute of Industrial Technology evolved from the Research Group of Industrial Technology. This institute is a focal point for collaboration with the industry in order to promote practical education for industrial technology, mainly in university and industry collaboration. Its activities include joint research, commissioned research, commissioned experiment, technology consultation and other social contribution activities (workshops, lectures etc.). The Asia Public/Private Partnership Institute (APPPI) aims to support research and education or training for infrastructure development in Asia. The APPPI conducts both education and research activities on public-private partnership (PPP) and supports firms and municipalities to participate in Asian countries' projects in the aspect of financial assistance and knowledge transfer.

8. Tohoku Institute of Technology (TIT)

The Tohoku Institute of Technology (TIT) was founded in 1964 to produce high-skilled technicians for the region. This institute offers an engineering course in various areas. There are 3,040 enrolled students. Of the total students, almost 90% are undergraduate students.

‘Since SMEs in the Tohoku area do not have high technological capabilities, Tohoku Institute of Technology relatively collaborates with local communities.’

Nishizawa, A., Interview, October 23, 2015

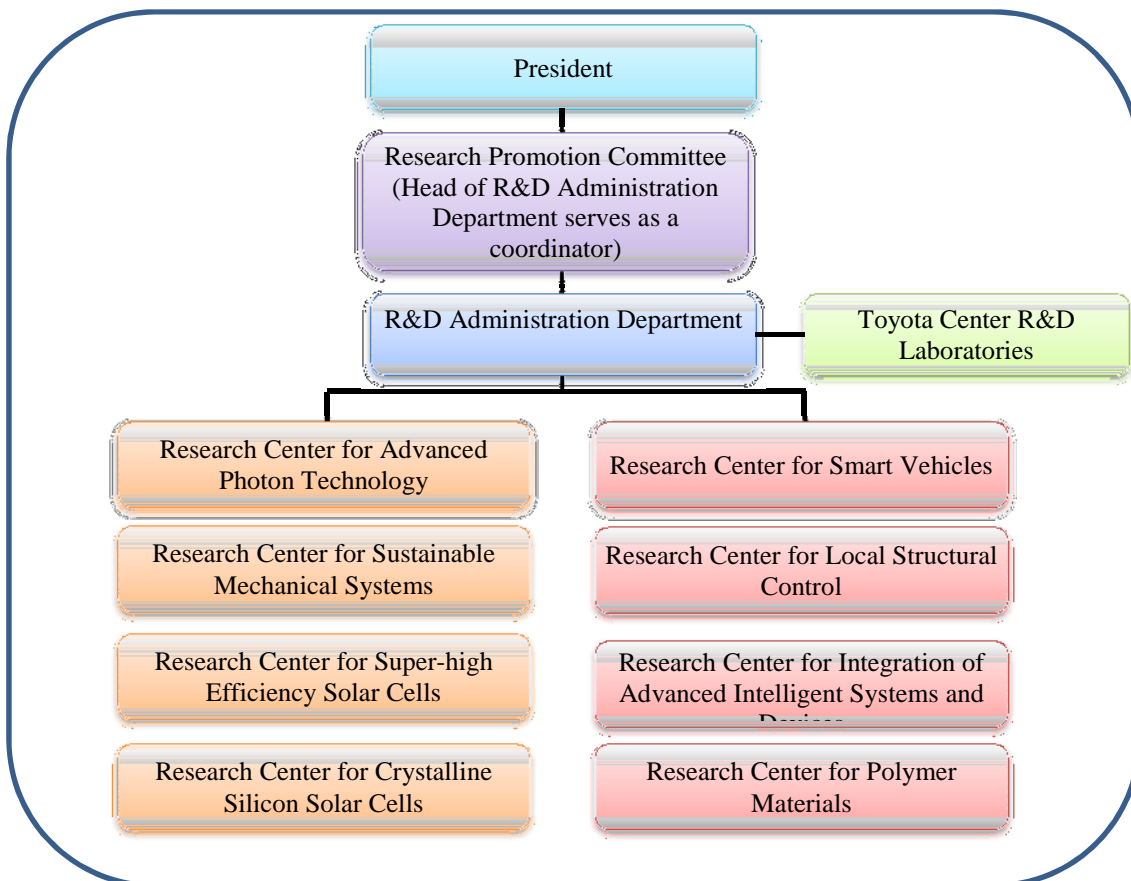
The Community Outreach Center supports regional cooperation, regional development, industrial development and human resources development. This center consists of three divisions: Regional Cooperation Division, Regional Human Resource Development Division and Research and Intellectual Property.

9. Toyota Technological Institute (TTI)

Toyota Corporation established the Toyota Technological Institute (TTI) in 1981 as a part of the social contribution activities. It originally only admitted students with industrial experiences and extended to admit high school students. This university used to offer a vocational and bachelor program in engineering, but now it also provides education in the master and doctoral level. TTI now has eight research centers mainly specialized in fields of energy and vehicle. Of these research centers, six of them have been supported by the

Ministry of Education, Culture, Sports, Science and Technology (MEXT), as well as projects running with significantly large grants supported by MEXT and other government agencies. These research centers have carried out collaborative activities with Toyota center R&D laboratories (TCRDL) under Toyota Corporation, especially the research center for smart vehicles. They set the schedule for periodic meetings. The difference between TTI's R&D activities and TCRDL's R&D activities is that TTI puts emphasis on basic research; in contrast, the research objectives of TCRDL are mainly based on applied research projects. The research themes of TCRDL are generated by the ideas of Toyota Group Companies and TCRDL, including social and economic demands. Nonetheless, TCRDL does not abandon fundamental research, but it still carries out cutting-edge research based on future trends in technologies. In TCRDL, it employs state-of-the-art analytical and measurement equipment in order to explore new technologies leading to prototypes (Figure A2-6). Owing to Toyota Corporation's affiliations, TTI's research centers closely collaborate with TCRDL, especially the center for smart vehicles. They set the schedule for periodic meetings.

Figure A2-6: TTI's Organizational Structure for Supporting Industry



Although Toyota has supported TTI, it seems to be an independent body. It has an authority to manage education, but in the aspect of R&D, it closely works with a parent company. Interestingly, Toyota's competitors also recruit TTI's graduates. Also, the government policy, such as Special Funds for the Creation of Strategic Research Infrastructure, affects TTI. It has become a member of the nanotechnology network that provides infrastructure service to the public.

TTI founded the R&D Administration Department to act as a central organization to oversee its overall R&D activities. With seven staffs, the head of this department assigns each staff to handle R&D contracts and agreements, including intellectual property management. The head of this department used to work for TCRDL. In the case of a joint research project, the Research Promotion Committee is appointed in order to review if a joint research project is useful or likely to face some obstacles before proposing the results of the review to the president. The head of the R&D Administration Department serves as a coordinator between the Research Promotion Committee and the department.

‘The university provides a relatively large amount of R&D funding compared to other universities. Our laboratories also have advanced R&D facilities and equipment. I think researchers have a favorable environment for doing research.’

Yoshimura, M., Interview, January 28, 2015.

Yamashita, K., Interview, January 28, 2015.

‘I think the university has received good support from MEXT, especially the R&D infrastructure. The nanotechnology laboratory is set up to assist the industry in various ways such as technical guidance and use of equipment.’

Yoshimura, M., Interview, January 28, 2015.

Thai National University

1. Chulalongkorn Universities (CU)

Chulalongkorn University (CU), the first higher educational institution in Thailand, was founded on March 26, 1917 with 380 students, taking classes in four faculties: Medicine, Public Administration, Engineering, and Arts and Science. The university was formed by Royal decree, with the aim of producing quality personnel for both the public and private sectors. CU offers 19 faculties of study including Science and Technology, Medicine, and Social Sciences with 39,750 students and 13,445 postgraduates.

‘CU is an old university which has very long history therefore the change in the university perhaps occurs gradually.’ ‘I think that KMUTT’s administrative system is relatively flexible.’

Leelasiriwong, .W, Interview, February 16, 2015.

Ekasit, S., Interview, February 17, 2015.

‘Yes, we are a comprehensive university but probably we do not take this advantage to integrate various fields of knowledge embedded in the university. I have two collaborative projects with other faculties (social sciences area) because I personally know some members there. The starting point of collaboration is not a university initiative to encourage faculty members to work across faculties.’

Ekasit, S., Interview, February 17, 2015.

‘Our university delegates a lot of power to the Dean of a faculty because the university is very large. Each faculty has its own management, for example, key performance indicators (KPI) vary by faculty.’

Subsompon, W., Interview, October 17 2014.

There are two levels of United International College (UIC) organizations founded at CU. At university level, UNISEARCH, an academic service center, aims to provide a research and consultation service including organizing human resource development, whereas the CU Intellectual Property Institute (CUIPI) functions to transfer technology, manage intellectual property (IP), and initiate start-up firms. To sell IP-related products, the university founded Chamchuri Innovation Co., Ltd. in 2006. Academic service fees are deducted at between 13 and 20% to the university. Fifty percent of the licensing fee is distributed to inventors³⁸. At faculty level, the Center for Engineering Service (CES) was set up at the faculty of Engineering to provide comprehensive engineering services and support for various types of engineering projects. These services include design, testing, training, industrial research, and consultation. CES allocates $\leq 60\%$ of the testing service fees to researchers; the cost for technical consultation varies depending on years of experience and workload. On the other hand, the faculty of Medicine was founded by the Clinical Research Center (CRC). This has four sub-centers: research clinic, clinic research laboratory, data management, and pharmacokinetic. The CRC offers research services to

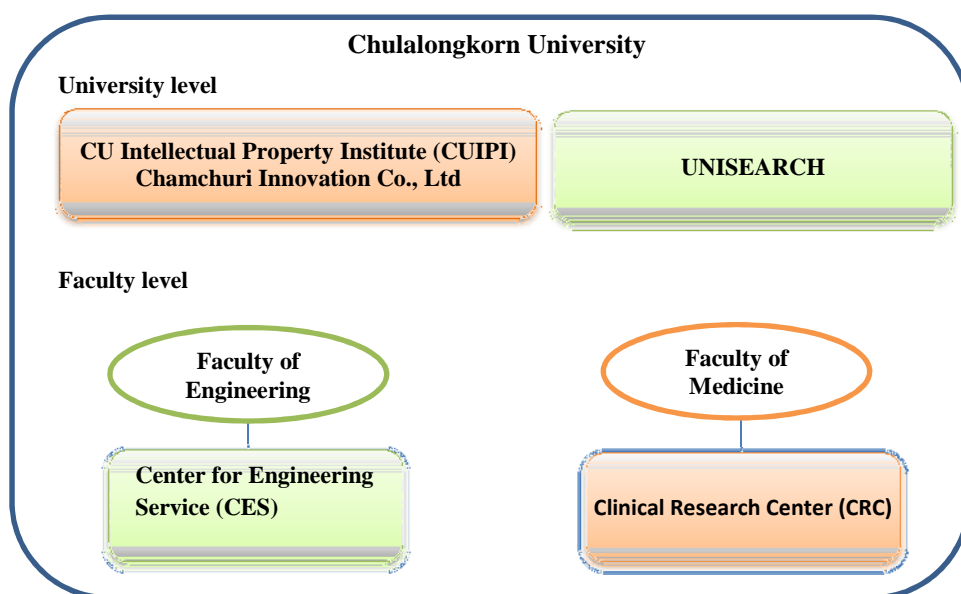
³⁸ Thanasukarn, L. (2013)

Clinical Research Organizations (CROs) and pharmaceutical businesses, and also provides them with access to the experienced academic staff within the faculty (Figure A2-7).

CUIPI often set too high prices for technologies discovered by universities. They use the calculation approach of foreign countries. In my case, this office could have assisted me in handling legal documents. However, I had to contact and negotiate with the prospective licensees by myself.'

Ekasit, S., Interview, February 17, 2015.

Figure A2-7: CU's Organizational Structure for Supporting Industry



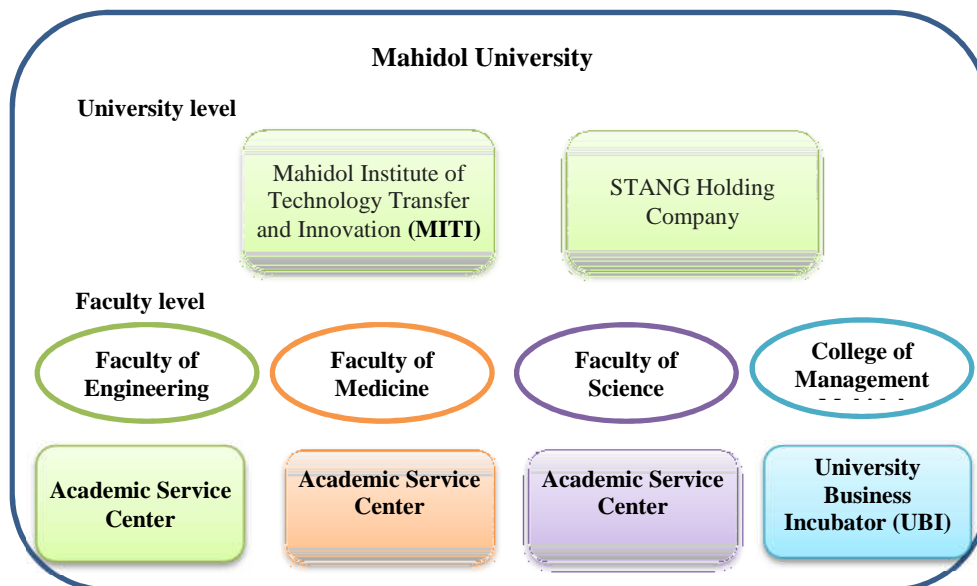
2. Mahidol University (MU)

The first Siamese medical school, the Rajapaethayalai was established in 1888 by a Royal decree. This was recognized in 1943 as a public medical school and has now become a comprehensive university, offering both undergraduate and graduate programs in many

fields including science and technology and social sciences. Mahidol University now has 18,702 undergraduate and 8,918 graduate students.

At university level, MU founded MAHIDOL Institute of Technology Transfer and Innovation (MITI) in October 2013 to disseminate university knowledge and academic research to Thai industries and society, and enhance national policy with a technology transfer approach. MITI provides two main services to industry as IP and commercialization and industrial liaison. In addition, Science Technology and New Business Innovation Group Co., Ltd. (STANG) Holding Company is another central organization which has invested in MU technology business ventures since 2004. Similar to CU, academic service centers were independently set up in some faculties (Figure A2-8).

Figure A2-8: MU's Organizational Structure for Supporting Industry



However, regarding medicine, all collaborative projects must be first approved by the University President. Ten percent of the total academic service fees are divided between the university (4%), and the faculty or department (6%). The remainder is allocated to researchers and also covers the operating costs. For the faculty of Engineering, 30% of the fee is retained by the university and 70% is allocated to the faculty as remuneration for the researchers depending on workload. For IP, the university does not specify the distribution rate of the royalty fees, but identifies the recipients of these fees as the inventor, university, central technology transfer center, and the affiliations of the inventor (faculty and department or laboratory). Interestingly, MU has a regulation for matching the fund by supporting between 20 and 50% of the total project costs.

‘I believe that the vision of a university’s executives and policies is the most critical factor for promoting university and industrial collaboration.’

Chairoj, S., Interview, February 16, 2015.

‘I have never worked with other faculties inside university. Faculty members are quite busy therefore I find the partners (working for other faculties) outside the university.’

‘I registered patents because the university and the R&D funding agency use a patent as a criterion to assess research success. In fact, I never thought I would license those technologies.’ ‘Patents are not important in my opinion. Knowledge or technology could be transferred through other channels’

Withyachumnarnkul, B., Interview, February 14, 2015.

‘Even though we are a research university, the outcomes of collaboration are mainly product and process improvement. In my opinion, we have to set a clear direction as to whether we shift toward entrepreneurial university’

Thamsatitdej, P., Interview, June 24, 2015

3. Chiang Mai University (CMU)

Chiang Mai University (CMU) was established in 1964 as the first institution of higher education in Northern Thailand under a Royal Charter granted by His Majesty King Bhumibol Adulyadej. CMU has now developed into a comprehensive higher learning institution, providing a broad range of academic programs including (science and technology, medicine, and social science). Today, CMU offers 92 bachelor degrees, 26 graduate diplomas, 127 master degrees, 15 higher diplomas, and 36 doctoral programs. CMU has 36,363 students as 27,343 undergraduates, and 9,020 postgraduates.

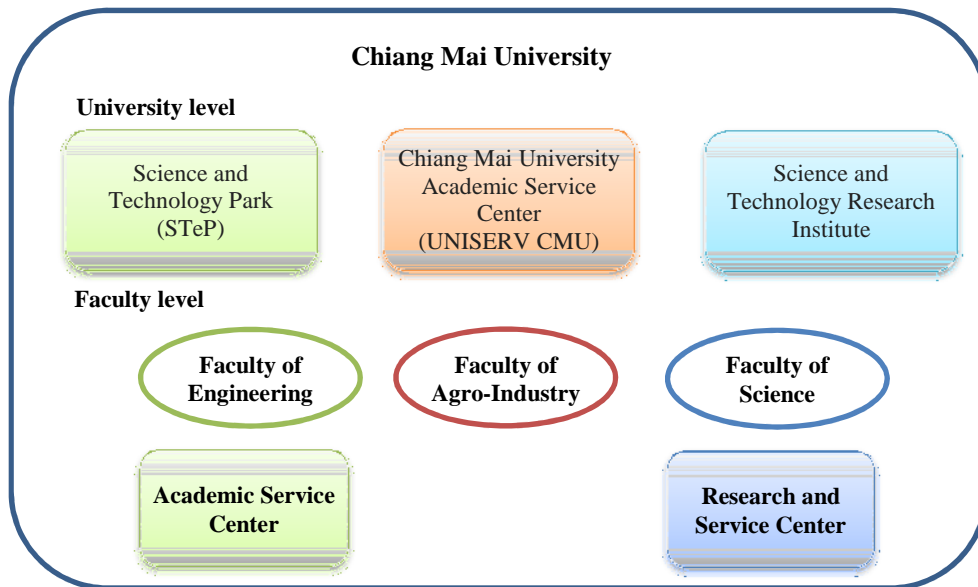
The central UIC organizations have been founded at CMU. Firstly, the Science and Technology Park (STeP), renamed from the Technology Development Center for Industry or TDCI. This organization was founded in 2012, based on official collaboration between the seven faculties: Engineering, Science, Agriculture, Agro-Industry, College of Art, Media and Technology (CAMT), Architecture, and Business Administration. Its mission is to provide one-stop-service for science and technology innovation for both researchers and industries, including collaborative research projects, technology business incubation and consultation, and technology transfer, intellectual property, and technology commercialization. Through financial support from the Ministry of Science and

Technology, STeP acts as the main hub for the Northern Science Park Project. This project collaborates with six other universities in the Northern region: Maejo University, Mae Fah Luang University, University of Phayao, Naresuan University, Pibulsongkram Rajabhat University, and Uttaradit Rajabhat University. Secondly, the Science and Technology Development Institute Establishment Project, later named the Science and Technology Research Institute (STRI) in July 1985, was established as part of the academic service unit, specifically for technology transfer activities for the communities. Several faculties operate independent research and academic centers. 1) The faculty of science set up four research service centers as The Doisuthep Nature Study Center, The Center for Multidisciplinary Science Research, The Center for Materials Science Research, and The Science and Technology Service Center. 2) The faculty of Engineering has an academic service center to assist local businesses, and a consulting business center for machine design and development for small and medium enterprises (SMEs) (Figure A2-9).

‘Compared to CU, we are relatively new, but I think we have performed well in terms of academic publications. However, our university has been pressured by several factors. Our research excellence mission must be achieved, to respond to international competitiveness. Product and process improvement for local SMEs and microenterprises must be done to serve local communities. More importantly, the government has considered our university as a regional hub; some government initiatives were implemented.’

Jomjunyong, S., Interview, August 12, 2015.

Figure A2-9: CMU's Organizational Structure for Supporting Industry



4. King Mongkut's University of Technology, Thonburi (KMUTT)

King Mongkut's University of Technology, Thonburi (KMUTT) was established on February 4, 1960 as the Thonburi Technology Institute (TTI), by the Department of Vocational Education, Ministry of Education. Its objective is to train technicians, technical instructors, and technologists. On April 24, 1971, the enactment of the Technology Act created three technical institutes to form one degree-granting institution under the name of King Mongkut's Institute of Technology (KMIT). In 1974, KMIT at Thonburi campus was transformed into a university, offering science and engineering courses. As of 2012, full and part-time students numbered 16,438, including 11,666 undergraduates and 4,772 postgraduates.

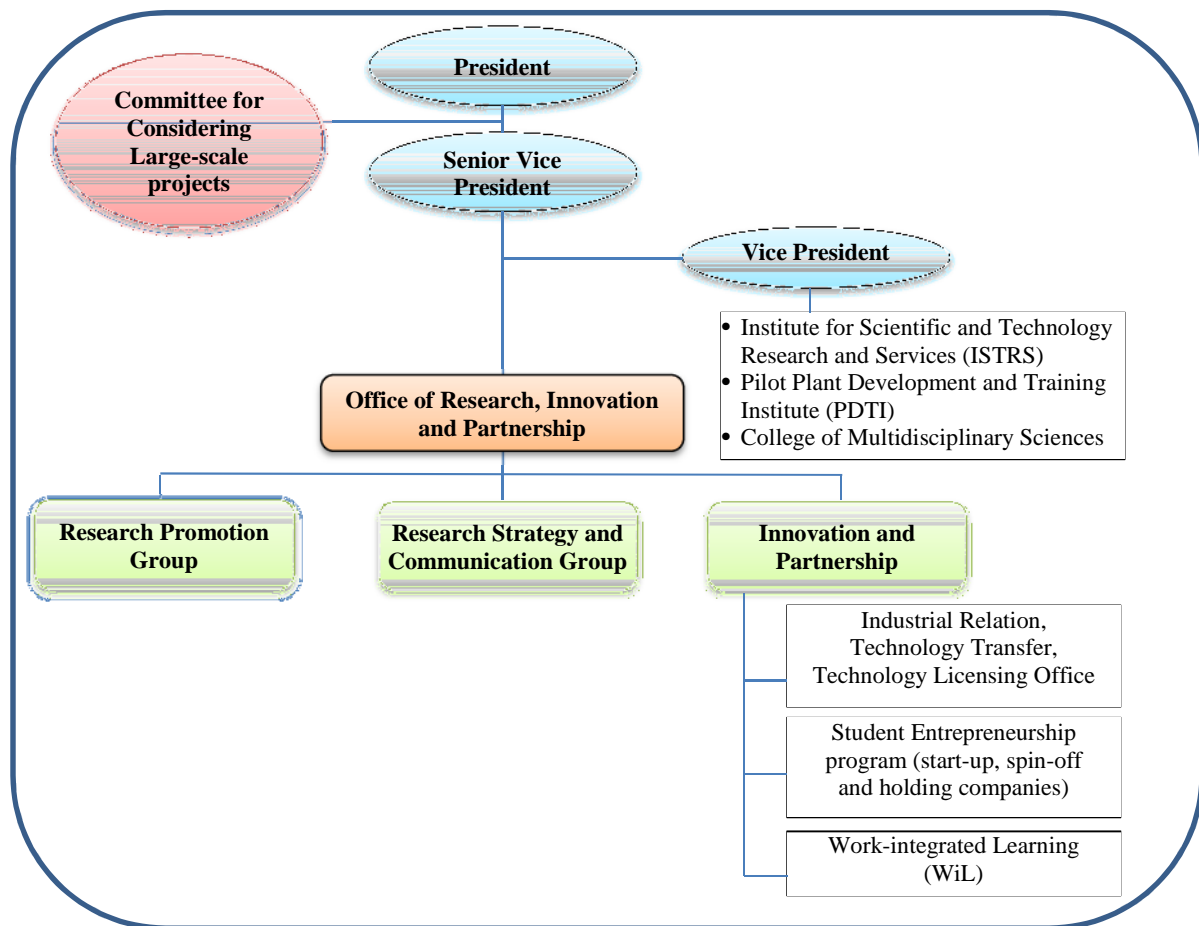
‘A mindset to respond to the needs of society and industry is likely to be deeply rooted in university culture. Even though the term of each president is limited and a newcomer takes the position, I feel that this culture has not changed. In addition, I guess that S&T-specialization may be a factor promoting collaboration with industry. We have similar educational backgrounds; Engineering and Science, therefore we have common understandings. We should collaborate with industry since S&T knowledge in universities is important for country development.’

Nopharatant, M., Interview, February 10, 2015.

KMUTT set up the Institute for Scientific and Technology Research and Services (ISTRS) under the faculty of Engineering, to provide academic services to the public and private sectors. During the 1990s, several programs were initiated to support industry. For example, establishment of the IP center in 1995, upgrading the ISTRS to become the equivalent of a faculty in 1997, and the operation of the Chemical Engineering Practice School (ChEPS)³⁹ with support from the Massachusetts Institute of Technology (MIT) in 1997. Later, in the 2000s, several government initiatives including the Clinic Technology Program of the Industrial Technology Assistance Program (iTAP) network, University Business Incubator (UBI), and talent mobility were implemented at the university. Recently, KMUTT set up an Office of Research, Innovation, and Partnership to serve as a liaison office and oversee KMUTT’s UIC activities (Figure A2-10).

³⁹ ChEPS, a 2-year master program based on Work-integrated Learning (WiL) principles

Figure A2-10: KMUTT's Organizational Structure for Supporting Industry



KMUTT operates differently from other universities. All collaborative projects are carried out on behalf of the university. The Dean of each faculty does not have the authority to sign contracts with external organizations. To fall in line with industry, KMUTT set up both a financial and non-financial incentive scheme. Testing services and technical consultation fees are split 5.5% to the university, 4.5% to the faculty, and between 12 and 20% to the department. Licensing fees are distributed as 60 to 80% to the inventor for copyright and trademark, and 40 to 70% to the inventor for the patent.

Thai Local Public University

5. Phuket Rajabhat University (PKRU)

Phuket Rajabhat University established in 1971, was formerly a training college for teachers and other educational personnel. In February 1992, Phuket Teachers College was renamed Phuket Rajabhat Institute, and in June 2004 the Royal Gazette announced the Rajabhat University Act and all Rajabhat Institutes were upgraded to become universities. PKRU offers science and technology, and social science courses at both undergraduate and postgraduate level.

‘PKRU focuses mainly on teaching. We aim to produce quality human resources as a response to industrial needs. Our faculty members must arrange at least 3 to 5 classes per semester (15 hours per week).

Prasankarn, H., Interview, February 25, 2015.

Chanrawang, N., Interview, February 25, 2015.

University Business Incubator (UBI) at PKRU was established through financial support from the Thai Office of the Higher Education Commission (OHEC). It aims to provide start-up funding and other services including technical consultation, training, marketing channels, and facilities (office space, meeting rooms). The incubation period varies from one to three years. This incubator specializes in information technology, art, agriculture, and food technology. Since establishment, nine incubates have been developed in total. Specifically, the PKRU’s UBI acts as an intermediary institution to match

technologies and incubate start-ups. The Manager searches for technologies outside the university and selects only those applicants with technological capabilities. This UBI encourages entrepreneurs to succeed in establishing start-up businesses as sources of knowledge for training programs. This distinction occurs at PKRU because of the Manager's vision and specialization. A prime example is the development of hydroponic vegetables at PKRU.

'A faculty member and owner of a spin-off originated from PKRU, has arranged eight training programs on hydroponic vegetable production per year since 2008, open to both entrepreneurs and the general public. Normally, the number of participants is limited to not more than 20 people. Some entrepreneurs faced technical problems regarding the harvesting of hydroponic vegetables; therefore they decided to join the training programs. After participation they were able to solve the problems by themselves and increase sales. Since 2008, this training program has generated approximately 20 entrepreneurs.'

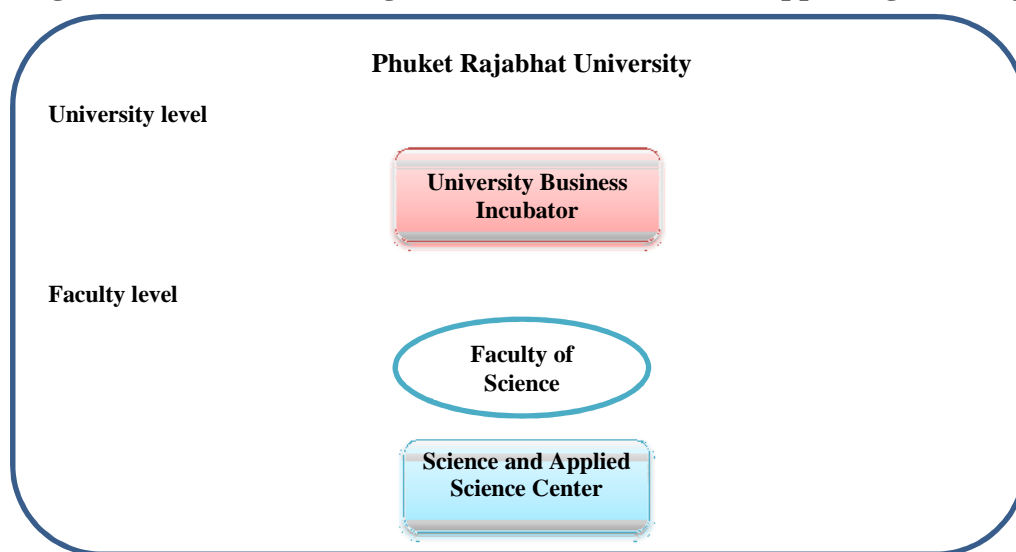
Chaitayakul, M., Interview, February 26, 2015.

Tanawiratananij, K., Interview. February 25, 2015.

The Science and Applied Science Center was established at faculty level under The World Bank Loan Project for Science and Applied Science Development at Rajabhat University. The national budget was US\$ 140.2 million. The purposes of this center are to provide training courses for science teachers, support teachers, and students to solve local

problems and conduct research activities. In addition, PKRU plays a very active role in providing a community service through short training courses including tourist guide training, foreign language courses, batik art courses, computer usage courses, and science camps (Figure A2-11).

Figure A2-11: PKRU's Organizational Structure for Supporting Industry



6. Rajamangala University of Technology

Rajamangala University of Technology (RMUT) was established as nine technical colleges in 1975, according to the Vocational Education and Technology College Act. These colleges aimed to produce vocational teachers at bachelor degree level for vocational education. The Act additionally promoted vocational research activities and provided technical services to the communities. Later, in 1989, the nine colleges were renamed as Rajamangala Institutes of Technology. After a legislative amendment in 2005, the Institutes were upgraded to Rajamangala Universities of Technology. Two of the nine institutes were

selected as case studies. (1) RMUT, Thanyaburi (RMUTT) which receives the largest share of the total budget, and (2) RMUT, Lanna (RMUTL). The President of RMUTL Council is a former Secretary General of the Office of the Higher Education Commission.

6.1 Rajamangala University of Technology Thonburi (RMUTT)

RMUTT college has eleven faculties of Engineering, Business Administration, Home Economics Technology, Fine and Applied Arts, Agricultural Technology, Technical Education, Architecture, Science and Technology, Communication Technology, Arts, and the Thai Traditional Medical College. This institute has 24,000 enrolled students (50% in business administration and engineering), and 1,900 staff (913 academic and 871 support).

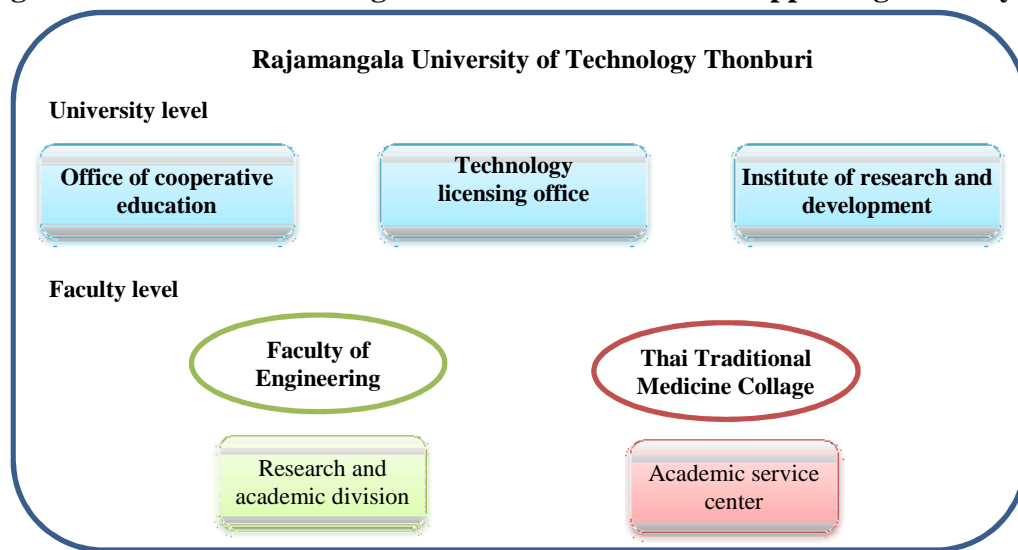
Three central organizations were set up for external collaboration: (1) the Office of Cooperative Education to handle the cooperative education program, (2) the Technology Licensing Office to facilitate applications for intellectual property and negotiate benefits of technology licensing, and (3) the Institute of Research and Development to provide testing services, give advice on research proposals, and draft regulations relating to research work and the utilization of intellectual property. Although these central organizations have been set up, the collaboration at faculty level is often more intense than at university level. The collaborations normally start with the relationships between faculty members and

company researchers. Faculty members in the engineering fields work with firms as consultants and blueprint designers (Figure A2-12).

‘Although the university has an explicit policy to promote collaboration with industry at the faculty level, there might be a normal practice hindering collaboration with external partners. For example, there is no platform facilitating discussion with firms, and the faculty prefers to see its members spending time within the university.’

Charoenchai, C., Interview, February 19, 2015.

Figure A2-12: RMUTT’s Organizational Structure for Supporting Industry



6.2 Rajamangala University of Technology Lanna (RMUTL)

RMUTL has five faculties of Business Administration and Liberal Arts, Arts and Architecture, Science and Agricultural Technology, Engineering, and the College of Integrated Science and Technology. Interestingly, the faculties of

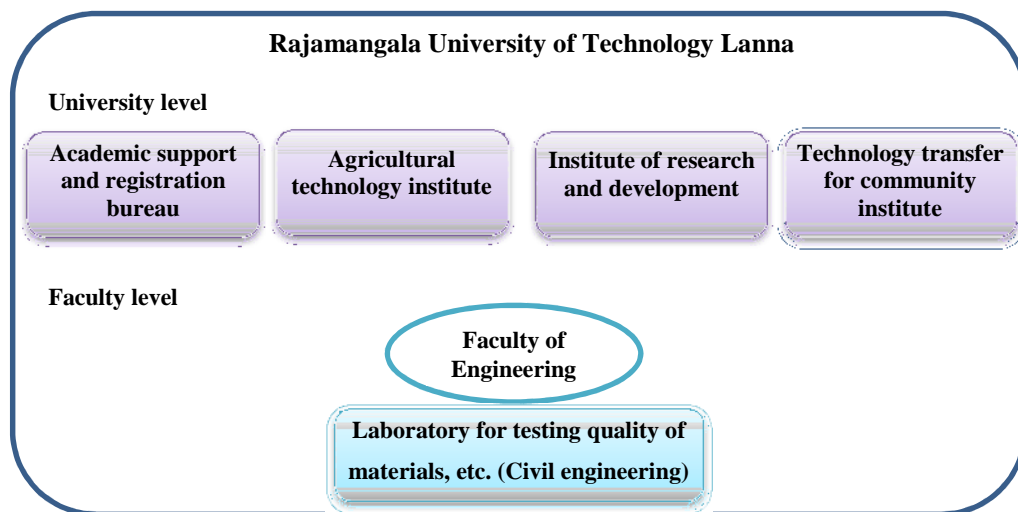
Science and Technology and Liberal Arts have small numbers of students, as they teach science and liberal art courses for students studying the other faculties. The six campuses in Chiang Mai, Chiang Rai, Pitsanulok, Nan, Lampang, and Tak have approximately 25,000 enrolled students (3,376 vocational, 22,231 undergraduates, and 73 postgraduates), and 2,400 staff (1,327 teaching and 1,076 support).

The Office of the President, RMUTL established four organizations to oversee the collaborative activities. The Agricultural Technology Institute carries out R&D on agricultural issues. The Academic Support and Registration Bureau handle cooperative education. The Technology Transfer for Community Institute provides academic services for communities. For contractual agreements, these three organizations refer to the Institute of Research and Development, which is responsible for managing and handling R&D contracts, HR contracts, and relating regulations. However, at faculty level, there is more intense collaboration with industry. For example, the laboratory services managed by the faculty and faculty members normally source the hosts of student internship themselves, even though theoretically, academic support and the registration bureau should be the responsible organizations (Figure A2-13).

‘Informal connection is an important mechanism to build relationships between two parties. In my opinion, I prefer to work with SMEs rather than large firms, because they respect university researchers and I feel like they are my friends.’

Moonpa, N., Interview, February 10 2015.

Figure A2-13: RMUTL’s Organizational Structure for Supporting Industry



Thai Private University

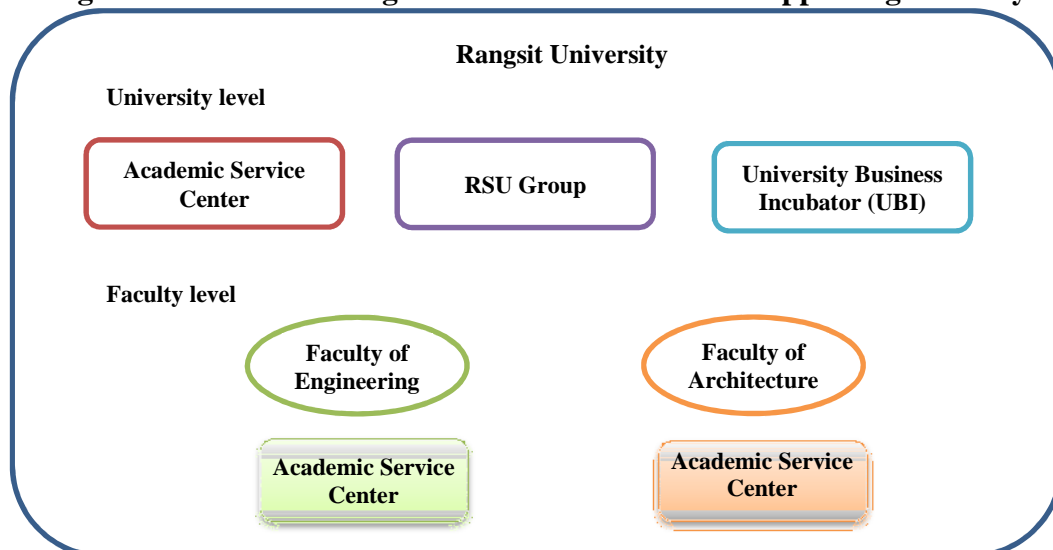
7. Rangsit University (RSU)

Rangsit University was founded under the name of Rangsit College by Mr. Prasith Ourairat, a former Provincial Governor of several provinces and a former Deputy Governor of the Greater Bangkok Metropolitan Region. The first batch of students enrolled in 1986. The college was upgraded to university status in 1990. Rangsit University aims to produce graduates in various areas of study mainly focusing on science and technology, design and management. Currently, there are 141 programs: 94 for undergraduates, 37 for Master

degrees, 1 graduate diploma, and 9 Doctoral degrees. There were 28,134 students during the 2012 academic year.

The RSU Group of Companies was established to strengthen the academic skills of all the faculty members, and provide academic services to society. The group comprises several divisions as follows: i) RSU healthcare (medical checkup service, laboratory tests, eye care center, and dental care), ii) RSU vision center, iii) RSU medical care (health and esthetic center), iv) RSU real estate development, v) RSU innovation products, vi) RSU medical resort and spa, and vii) RSU travel consultancy. The academic service center acts as a central organization to connect with external organizations, including government agencies and industry. It provides both consultation and research services (Figure A2-14).

Figure A2-14: RSU's Organizational Structure for Supporting Industry



Remark: UBI has not operated yet.

The Pruksa Real Estate Plc. was experiencing difficulties regarding products. The company owner hired RSU to solve the problem. He was aware of RSU as he was a friend of the Dean of the faculty of Engineering. In 2011, RSU signed a memorandum of understanding (MOU) with Pruksa. The main purpose of this MOU was to develop products, use the R&D facilities at RSU, provide technical guidance, and organize training programs for engineers and architects. The MOU covered the testing of materials (cement), and the use of IT to control production processes to facilitate just-in-time delivery.

‘It is very difficult for private universities to undertake R&D or share technological collaboration with industry, because firms need certificates to ensure the quality of their products.’

Loysmut, W., Interview, March 5, 2015.

‘In my opinion, it seems that the government has paid less attention to us. We hardly receive any support from the government.’

Pantaratorn, N., Interview, March 5, 2015.

Loysmut, W., Interview, March 5, 2015.

8. Dhurakij Pandit University (DPU)

Dhurakij Pandit University (DPU) was founded in 1968 by Dr. Sawai Suthipitak and Mr. Sanan Ketudat. In 1970, the institution became a college under the name Dhurakij Pandit College. The rapid growth and continuous success of the college led to the conferral of university status by the Thai Ministry of Education to become Dhurakij Pandit

University in 1984. The university currently employs 1,200 faculty and staff members, 18% are Doctoral degree holders, and over 76% have Masters' degrees. The total student enrolment at all levels is approximately 20,000.

The academic support and registration bureau assists the faculties to collaborate with host firms for cooperative education programs. Four faculties including Communication Art, Accounting, Engineering, and Science arrange one-year internship programs for fourth year students, whereas the others operate one-semester internships. In 2013, the OHEC provided grants to DPU to set up UBI, with the aims of organizing training programs for entrepreneurs and also assisting them to make business plans (Figure A2-15). Every faculty is ISO 9002 certified.

'Yes, our university launched UBI, but it has just started. We mainly focus on existing entrepreneurs rather than new ones.'

Satyarakwit, S., Interview, February 11, 2015.

'I decided to send one lecturer to work at a firm because of the importance of responsiveness to industry and upgrading the skills of human resources. As you said, the government has recently launched a talent mobility program. Actually, our university has already initiated this because private universities are relatively flexible. It is not necessary to change the regulation but the government seems to

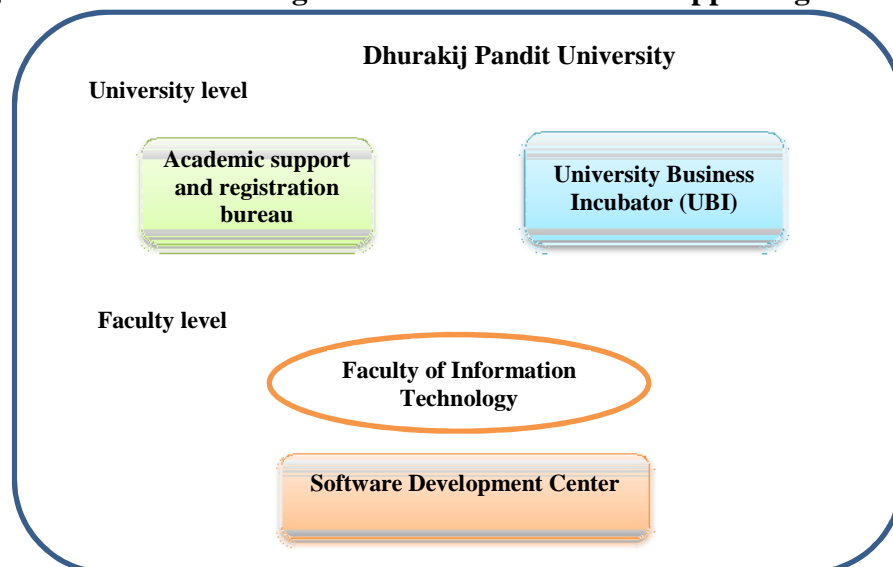
overlook us. I feel that there is a big gap between private universities and the government.'

Satyarakwit, S., Interview, February 11, 2015.

We faced some challenges at the beginning of the project, as DPU had to ensure that it met all the requirements from Centara regarding the training programs, not only for Centara staff but also for members of the public. Both Centara and DPU collaborated very closely, and we overcame these challenges. The senior managements from both organizations strongly supported these collaborations.'

Campiranon, K., Interview, March 8 2015.

Figure A2-15: DPU's Organizational Structure for Supporting Industry



9. Siam University (Siam)

Siam University was founded in 1965 by the late Dr. Narong Mongkhonvanit as the first 3-year private engineering school in Thailand. Initially, Siam offered only one two-year program for 200 students, covering Mechanical Technical Power. In 1973, the Siam Technical College was formally established as a private, higher education institution with the authority to confer degrees. In 1975, the college launched programs leading to Bachelors' degrees in Accounting, Marketing and Secretarial Science. In 1986, Siam Technical College became Siam Technical University, upgrading three years later to Siam University, and offering various fields of study including Science and Technology, Medicine, and Social Sciences. Siam is now the fifth largest Thai private university, educating over 16,000 students across eight schools, with both international and graduate programs.

The OHEC manages and handles the administration of all cooperative education programs. The students who join these programs must work on-site for at least 16 weeks. In 2013, Siam received grants from the OHEC to set up UBI to focus on technological improvements. The University President actively supports UBI. For example, in the first year of UBI operation, he attended every committee meeting, provided office space, and allocated support staff (Figure A2-16).

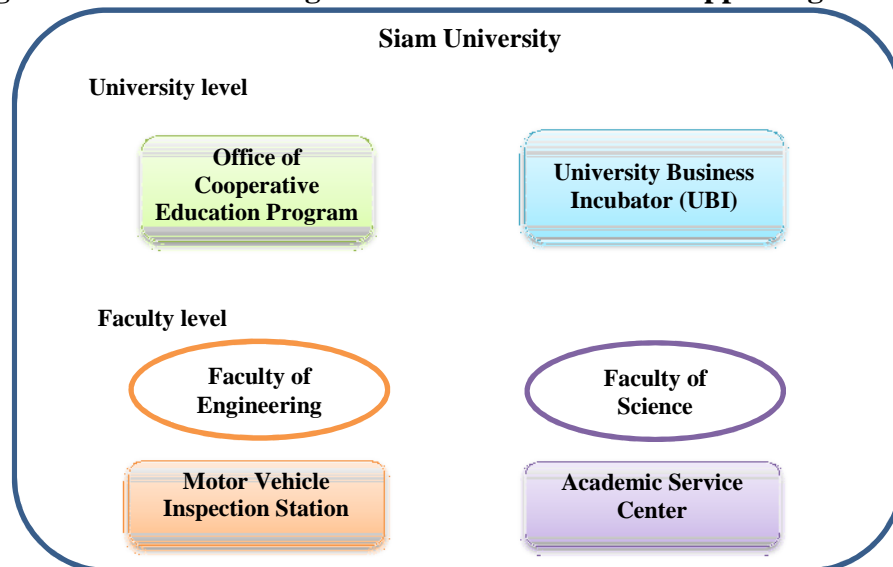
‘Generally, industry rarely considers private universities as technology development partners. Firms are likely to specify individual researchers whom they know’

Mahattanatawee, K., Interview, February 19, 2015.

‘I believe that the strong support from top executives is a key success factor for Siam UBI. Our president plays an active role in supporting UBI. In the first year of operation he attended every committee meeting. This committee consists of representatives from almost every faculty. He allocated three staff and office space for setting up UBI. Also, he clearly announced this concept to faculty members to connect the cooperative education program with UBI. Our incubatees are based on technologies created inside universities.’

Limsarun, T., Interview, February 19, 2015.

Figure A2-16: Siam’s Organizational Structure for Supporting Industry



10. North-Chiang Mai University (NCMU)

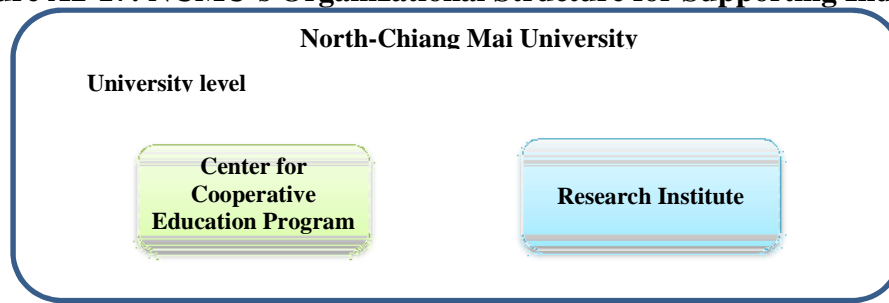
North-Chiang Mai University was founded in 1999 by Mr. Narong Chavasint with the faculties of Engineering, Business Administration, and the Department of General Education. NCMU was the first private higher education institute in Northern Thailand to offer engineering and political science (public administration) at graduate level, and e-commerce management at undergraduate level. In 2011, the college was upgraded to university status. NCMU now has 10 faculties offering 49 courses.

NCMU has two main organizations supporting both the university and industrial collaboration. The Center for Cooperative Education aims to send students to work with local firms, and the Research Institute handles and manages both internal and external R&D funds (Figure A2-17).

‘In terms of consultation, we often work with microenterprises. We do not yet operate with SMEs. However, the university is collaborating with a large firm to jointly arrange cooperative education programs.’

Punyathap, P., Interview, July 27, 2015.

Figure A2-17: NCMU’s Organizational Structure for Supporting Industry



11. Panyapiwat Institute of Management (PIM)

Panyapiwat Institute of Management (PIM) was established in 2007 as a subsidiary of CP ALL plc. which operates the 7-Eleven stores in Thailand. PIM offers Bachelor and Master degrees in retail management to produce quality personnel for the parent company. Recently, courses at PIM were extended to cover the fields of Science and Technology and Social Sciences. A Master degree in Business Administration (Chinese program) has also been initiated. PIM provides a unique work-based learning program where students integrate fully with both affiliated and other companies. PIM attaches great emphasis on creating networks. The management strongly encourages faculty members to exchange ideas with people from affiliated companies, staff, suppliers, experts, and university personnel. PIM hires young, new generation lecturers to impart new ideas and technologies. The environment here is very different from the traditional universities.

‘PIM is a kind of networking university. Networks are used as key performance indicators. We convene regular meetings between our faculty members and/or external partners to exchange ideas, because we believe that knowledge is not only written in textbooks, but also embedded in people and organizations. Most of our faculty staff are young. They are given a high degree of freedom to create innovative projects and propose new innovations to our executives’

Manarungsan, S., Interview, February 13, 2015.

Phacharintanakul, P., Interview, February 13, 2015.

Chocksawangwoong, S., Interview, February 12, 2015.

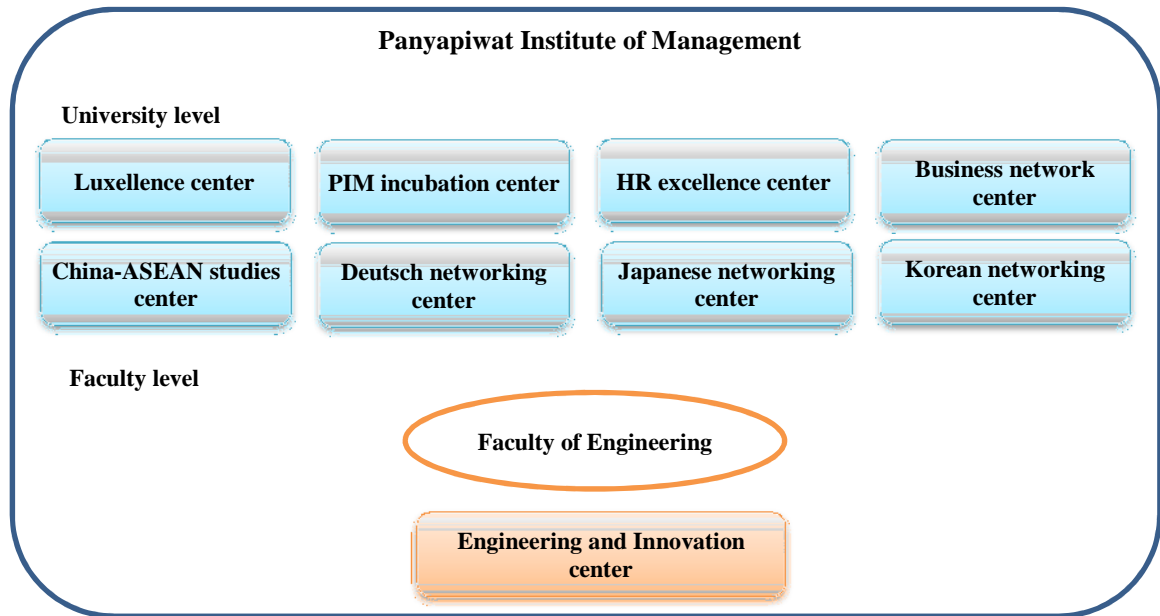
Suthamanon, L., Interview, February 12, 2015.

PIM has set up an academic service center offering various kinds of services. The PIM Business Incubation Center aims to provide consultation and transfer knowledge for setting up and managing businesses, including the creation of SME networks. The Luxellence Center was founded by the President of CP ALL Co., Ltd. He recognized the opportunity to develop luxury brand products in Thailand. The center now collaborates with the International Fashion Academy in France to arrange training and professional development programs, and provides consulting services in business management (brand management, etc.). The PIM HR excellence center specializes in human resource development, providing consultation services and training programs. In addition, there are international networking centers which collaborate with overseas companies and assist Thai businesses with overseas investment. At faculty level, the Engineering and Innovation Center was established to work with the parent company and affiliated companies (Figure A2-18).

‘The university’s programs such as business incubator were mostly initiated internally, not by government, because we realized the importance of these programs’

Suthamanon, L., Interview, February 12, 2015.

Figure A2-18: PIM's Organizational Structure for Supporting Industry



Incentive for Promoting University-Industry Collaboration:

| Country/Type of university | University | Incentive for encouraging researchers to collaborate with industry | |
|----------------------------|------------|--|---|
| | | Financial incentive | Non-financial incentive |
| 1. Japan | | | |
| National University | Today | <i>Intellectual property</i> : After deduction of administration fees and any patent expenses • 40% to inventor | |
| | Tokodai | <i>Intellectual property</i> : After deduction of necessary expenses • 30% to inventor | |
| | Tohoku | <i>Intellectual property</i> : After deduction of technical transfer (1/3) • <i>Patent</i> : Remainders of licensing fee are distributed to inventors (30%), laboratories (30%) and headquarter (40%). • <i>Copyright and trademark</i> : all incomes are distributed to headquarter. R&D funding can be ranged from 0% to 30% for inventors and funding rate for laboratories can be varied from 30% to 60% | |
| Local Public University | FPU | <i>R&D fund</i> R&D fund from university and local government (not focus on only collaborative work with industry) | |
| | MYU | Not clear. Normally, collaborative projects are voluntary basis. | |
| Private University | Keio | <i>Intellectual property</i> : After deduction of overhead cost (15%) • 50% to inventor | Keio Intellectual Property Center Prize Award ⁴⁰ |
| | TTI | <i>R&D fund</i> • Matching fund program (50% from firms and 50% supported by TTI) | |
| 2. Thailand | | | |
| National University | CU | <i>1.Academic service</i> • University level (case of central academic service center) – 13-20% to university (additional cost is not included in total cost of project) • Faculty level: vary by faculty or center’s regulation ✓ Faculty of Engineering ⁴¹ : Remuneration – Testing service: ≤ 60% of total budget – Technical consultancy: vary by years of experiences and workload <i>2.Intellectual property</i> | Ratchadapisek Somphot Endowment Fund Chulalongkorn University: Research Award (research benefits to society or industry) ⁴³ |

⁴⁰ For more information: <http://www.iab.keio.ac.jp/en/content/view/216/73/>

⁴¹ Chulalongkorn University's Notification about Faculty of Engineering's Criteria and Payment Rate for Academic Services (2nd version) B.E. 2548

| Country/Type of university | University | Incentive for encouraging researchers to collaborate with industry | |
|----------------------------|------------|---|---|
| | | Financial incentive | Non-financial incentive |
| | | <ul style="list-style-type: none"> • 50% to inventor⁴² | |
| | MU | <p><i>1. Academic service</i></p> <ul style="list-style-type: none"> • University level (external R&D fund)⁴⁴ <ul style="list-style-type: none"> – 4% to university – 6% to faculty or department – 90% to researcher (include operating cost) • Faculty level: approved by Dean in case of ≤ 2 million- baht project⁴⁵ <ul style="list-style-type: none"> ✓ Faculty of Engineering⁹: <ul style="list-style-type: none"> – 30% to university – 70% to faculty (remuneration for researcher depends on workload) ✓ Faculty of Medicine⁴⁶ (Siriraj hospital) <ul style="list-style-type: none"> – Collaborative work with industry must be approved by President <p><i>2. Intellectual property</i>⁴⁷</p> <ul style="list-style-type: none"> • Not specify the distribution of royalty fee but it must be distributed to inventor, university, central technology transfer center, affiliations of inventor (faculty and department or laboratory) <p><i>3. Matching fund with external partners</i>⁴⁸ (promote multidisciplinary research)</p> <ul style="list-style-type: none"> • 20-50% supported by university | Faculty member is allowed to work with industry as full-time or part-time staff ⁴⁹ |
| | CMU | <p><i>Intellectual property</i></p> <ul style="list-style-type: none"> • 50% to university, faculty, department • 50% to invetor | |

⁴³ For more information:

http://www.research.chula.ac.th/index.php?option=com_content&view=article&id=192&Itemid=1327

⁴⁴ Mahidol University's Notification about Criteria and Fee for External R&D Funds B.E. 2551

⁴⁵ Rule of practice of Faculty of Engineering for Academic Services B.E. 2556

⁴⁶ Siriraj Hospital's Notification about Criteria and practice for Academic Services on 12 January 2011

⁴⁷ Mahidol University's Rule on Intellectual Property and Benefits from Intellectual Property B.E.2557

⁴⁸ Mahidol University's Notification about Scholarship for Objective-Oriented Research and Scholarship for Joint R&D Investment B.E.2551

⁴⁹ Criteria and Practice for Academic Staffs to Provide Academics Works outside University

| Country/Type of university | University | Incentive for encouraging researchers to collaborate with industry | |
|----------------------------|------------|---|---|
| | | Financial incentive | Non-financial incentive |
| | KMUTT | <p><i>1.Academic service</i>⁵⁰</p> <ul style="list-style-type: none"> • Collaborative projects must be carried out on behalf of the university • Testing service: 5.5% to university, 4.5% to faculty and 12-20% to department • Technical consultancy: <ul style="list-style-type: none"> ✓ Individual: same rate as testing service ✓ Group: depend on amount of project budget <p><i>2.Intellectual property</i>⁵¹</p> <ul style="list-style-type: none"> • Copy right and trademark: 60-80% to inventor • Patent: 40-70% to inventor | <ul style="list-style-type: none"> • Collaborative work with industry is used as a criterion (relevance excellence) for academic career promotion • Faculty member is allowed to work with industry as full-time or part-time staff |
| Local Public University | PKRU | <p><i>External fund</i>⁵²</p> <ul style="list-style-type: none"> • > 1 million baht: 20% to university • 1> x > 0.5 million baht: 15% to university • 0.5> x > 0.1 million baht: 10% to university • > 0.1 million baht: 5% to university | |
| | RMUTT | <p><i>1.Academic service</i>⁵³</p> <ul style="list-style-type: none"> • Do not use university's facilities <ul style="list-style-type: none"> ✓ > 5 million baht: 5% to university and 1% to faculty ✓ 1.5 > x > 1 million baht: 8% to university and 1% to faculty ✓ 0.5> x > 1 million baht: 10 % to university and 2% to faculty ✓ < 0.5 million baht: 12% to university and 2 % to faculty • Use university's facilities <ul style="list-style-type: none"> ✓ > 5 million baht: 8% to university and 2% to faculty ✓ 1.5 > x > 1 million baht: 12% to university and 2% to faculty ✓ 0.5> x > 1 million baht: 15% to university and 2% to faculty ✓ < 0.5 million baht: 16% to university and 2 % to faculty | |

⁵⁰ King Mongkut University of Technology Thonburi's Regulation on Payment for Contracted Works and Academic Services (2nd version) B.E.2551

⁵¹ King Mongkut Institute of Technology Thonburi's Regulation on Management of Benefits from Intellectual Property B.E.2538

⁵² Phuket Rajabhat University's Notification about Criteria and Proportion of Budget Allocation for Project and Work Commissioned by External Partners and External R&D Fund on 4 March 2004

⁵³ Rajamangala University of Technology Thonburi's Regulation on Academic Services B.E.2553

| Country/Type of university | University | Incentive for encouraging researchers to collaborate with industry | |
|----------------------------|------------|---|---|
| | | Financial incentive | Non-financial incentive |
| | | 2. <i>Intellectual property</i> ⁵⁴ Distribution of royalty fee is not clearly specified | |
| | RMUTL | Academic service ⁵⁵ <ul style="list-style-type: none"> • 10% to university (before deduction) • 90% managed by project manager | Faculty member is allowed to work with industry as full-time or part-time staff |
| Private University | Siam | Academic service Negotiation | |
| | RSU | 1. <i>Academic service</i> ⁵⁶ <ul style="list-style-type: none"> • 10% to university (5% to affiliation of project manager) • 90% managed by project manager 2. <i>Intellectual property</i> ⁵⁷ <ul style="list-style-type: none"> • 50% to inventor | |
| | DPU | Academic service <ul style="list-style-type: none"> • 10% to university • 90% managed by project manager | |
| | PIM | Academic service <ul style="list-style-type: none"> • Annual support from the university • Academic service mainly focuses on supporting parent company (CP) • 10-15% to university • 85-90% managed by project manager (remunerations for faculty members must not be higher than 20% of total annual income, however, staffs working for central academic service center could not receive it.) | |

Remark: The interview data is not specified sources

Source: Interviews and University documents

⁵⁴ Rajamangala University of Technology Thanyaburi's Regulation on Intellectual Property Management B.E. 2551

⁵⁵ Rajamangala University of Technology Lanna's Regulation on Academic Services for Society B.E. 2555

⁵⁶ Rangsit University's Notification about Criteria for Allocating Incomes from Research Work on 31 October 2011

⁵⁷ Rangsit University's Regulation on Management of Intellectual Property and Benefits from Intellectual Property B.E. 2548

Statistical Data on University- Industry Collaboration:

Japanese Universities

| Mode | Today ¹ | Tokodai ² | Tohoku ³ | Keio ⁴ | Toyo ⁵ | Tohoku Insti. ⁶ | Fukui ⁷ | Miyagi ⁸ | Toyota ⁹ |
|---------------------------------|--------------------|----------------------|---------------------|----------------------------|-------------------|----------------------------|--|----------------------------|-----------------------------|
| Joint research (project) | 1,624 | 440 | 897 | 563* | 13 | 7* | ~2 patents/year* ~2 publications/year** | Few | 57 |
| Commissioned research (project) | 262 | 357 | 661 | 398** | 30 | | | Few | - |
| Technology licensing (item) | 63 | 73* | 48* | 14 | - | N/A | Few | Few | Not focus |
| Start-ups/Venture (start-ups) | 147 | 71 | 63 | 19 | - | N/A | 1 | - | - |
| Consultations (project) | - | 43 | 169 | - | - | 18** | ~3 projects/year*** | 5 | Mostly informal interaction |
| Researcher exchange (person) | - | 83 | 32 | Included in joint research | - | N/A | 1**** | Local government officials | 6 |

1. Source: a) <http://www.u-tokyo.ac.jp/en/about/finances.html> and b) Yamamoto, T. (2014). Interview. December, 13, 2014., Year of data: 2014-2015
2. Source: Tokyo Institute of Technology Profile 2013-2014, Year of data: 2013, Remark: *34 items with payment
3. Source: a) Tohoku University Fact Book 2014 and b) Tohoku University Fact Book 2006 , Year of data: 2013, Remark: *year 2005
4. Source: a) Keio Research Annual Report 2014 and b) Hatori, K. (2015). Interview. January, 29, 2015., Year of data: 2011-2013, Remark: *include personnel exchanges and/or sharing technology/facilities under the joint research agreement, with or without payment of research funds, ** include government agency
5. Source: Toyo University database, Year of data: 2014.
6. Source: <http://www.tohtech.ac.jp/outline/institution/coordinate/index.html>, Year of data: 2014, Remark: Budget comes from the university, *regional and industry-university cooperation project and ** improvement of industry and local communities (Sendai City and other regions)
7. Source: a) Japan Patent Office database, b) SCOPUS database, and c) Utagawa, T. Interview. December 18, 2014., Year of data: * 2007-2014, **1992-2014, ***2008-2014, ****2014
8. Source: Miyahara, I. and Furukawa, T. Interview. July, 23, 2015.
9. Source: Yoshimura, M. and Yamashita, K. Interview. January 28, 2015, Year of data: 2013

Thai Universities

| Mode | CU ¹ | MU ² | CMU ³ | KMUTT ⁴ | RSU ⁵ | NCMU ⁶ | DPU ⁷ | Siam ⁸ | PIM ⁹ | PKRU ¹⁰ | RMUTT ¹¹ | RMUTL ¹² |
|---|---|--|--|---|----------------------|----------------------|----------------------|------------------------|------------------------|----------------------------------|---|---|
| R&D (mostly commissioned R&D) (project) | <ul style="list-style-type: none"> •Fac. of engineering: 24 projects (2010) •Fac. of science: 17 projects (2011) •Fac. of med.: clinical research: 142 projects* (as of Feb. 2015) | 95 projects (2014) (8.11% of total R&D fund) | <ul style="list-style-type: none"> • Fac. of med.:81 (2014) projects • RSP: 15* projects (2013) • Fac. of eng.:19 companies | 55 projects/ year (48 projects associated with WiL) | ~5-10 projects | None | Few | Few | 4-5 projects | None | 30 projects* 93 projects (community service) (2013) | 19 projects* 50 projects (community service) (2009) |
| Consultation (project) | Unisearch:18 projects (2013) Mainly focus on government agencies | Mainly focus on government agencies | Academic Service Unit: 37 projects (2014) RSP: 45* projects (2014) | Consultation 70 projects/ year Testing service 32 projects/ year | | Few | Few | Few | 3-4 projects | 20 projects (community service)* | | |
| Cooperative education (student) | Few | Few | ~320 Students (2011) | ~340 students (2013) | ~459 students (2014) | ~193 students (2014) | ~496 students (2011) | ~1,500 students (2014) | ~8,300 students (2014) | ~76 students (2013) | ~3,043 students (2014) | ~855 students (2011) |
| Technology licensing (case) | 42 cases (2008-2011) | 2 cases (2008-2011) | 25 cases (2008-2011) | 2 cases (2013) | None | None | None | None | None | None | 3 cases (2008-2011) | Few |

1. Source: a) Faculty of Engineering's database, b) Faculty of Science's Annual Report 2010 (<http://planning.sc.chula.ac.th/content/form/files-20140623-1654380.pdf>), c) Faculty of Medicine (<http://www.chulacrc.org/performance.html>) and c) National STI Office, Remark: *Feasibility (16), Start-up (43), Active (68) and Finished (15) (include Clinical Research Organizations and businesses) ** Feasibility (4), Start-up (2), Active (11) and Finished (28)

2. Source: Mahidol University's Annual Report 2010 and 2014

3. Source: a) Annual Report. Academic Service Unit, b) Commission of Higher Education (<http://www.mua.go.th/users/bphe/cooperative/>) and c) Final Report: Northern Science Park Project 2013, Remark: *include members of RSP

4. Source: a) KMUTT's database and b) Annual Report 2014

5. Source: a) Interview and b) Rangsit University website

6. Source: NCMU website: <http://exp.northcm.ac.th/download/>

7. Source: Commission of Higher Education (<http://www.mua.go.th/users/bphe/cooperative/>)

8. Source: Mongkhonvanit, P. (2014). Siam University Employability Diversity Sustainability. UNU-IAU-IAUP Co-chaired Session: Higher Education for Sustainable Development. International Association of University Presidents 2014. June 11-14, 2014, Pacifico, Yokohama, Japan.

9. Source: Interview

10. Source: a) Budget allocation document 2014 and b) Annual Report 2013: http://www.uppersouthcoop.org/docsproj_all.php, Remark: *Target was set by PKRU

11. Source: a) Watjanatepin, N. (2012). University Industry Cooperation: Case Study of Rajamangala University of Technology. 2nd Taiwan-Thailand Higher Education Forum/ March,19 -21, 2012, b) Annual Report 2013 and c) <http://www.coop.rmutt.ac.th/?p=75>, Remark:* include joint lab service, licensing, product and package development.

12. Source: a)Watjanatepin, N. (2012). University Industry Cooperation: Case Study of Rajamangala University of Technology. 2nd Taiwan-Thailand Higher Education Forum/ March,19 -21 2012, b) Annual Report 2009 and c) <http://coop.rmutl.ac.th/welcome/studentbranch>, Remark:* include joint lab service, licensing, product and package development.

Appendix 3: Appendix to Chapter 6

Appendix Table:

**Table A3-1: Influence of Firm Characteristics on Collaboration with Universities:
Japanese Case**

| Independent variable (Characteristics of firm) | Dependent variable (Modes of collaboration) | | | | | | | |
|---|---|---------------------|---------------------|---------------------|------------------------------|-------------------------------------|----------------------------------|---------------------|
| | R&D mode (level 1-4) | | | | Consultancy mode (binary) | Personnel exchange mode (binary) | Technology licensing (binary) | Venture (binary) |
| | Level 1 | Level 2 | Level 3 | Level 4 | | | | |
| Food | 0.006 (0.005) | 0.058*** (0.016) | 0.035*** (0.012) | 0.012** (0.005) | 0.002 (0.020) | 0.007 (0.021) | -0.009 (0.017) | -0.024 (0.012) |
| Chemical | -0.002 (0.008) | 0.081*** (0.014) | 0.053*** (0.012) | 0.018*** (0.005) | 0.008 (0.018) | 0.028 (0.020) | 0.026 (0.019) | -0.014 (0.013) |
| Electrical apparatus | 0.004 (0.006) | 0.067*** (0.015) | 0.042*** (0.011) | 0.014*** (0.005) | 0.005 (0.019) | 0.053*** (0.024) | 0.026 (0.021) | 0.023 (0.019) |
| Automotive | -0.022 (0.027) | -0.033 (0.029) | -0.015 (0.012) | -0.004 (0.003) | -0.004 (0.038) | -0.035 (0.024) | -0.023 (0.028) | 0.007 (0.035) |
| Size | 0.012*** (0.002) | 0.047*** (0.009) | 0.026*** (0.006) | 0.008*** (0.002) | 0.001 (0.011) | 0.053*** (0.014) | 0.005 (0.011) | 0.010 (0.010) |
| No. of observations | 2,644 | | | | 2,644 | 2,644 | 2,644 | 2,644 |
| Log likelihood | -3,149.83 | | | | -589.89 | -599.87 | -530.32 | -466.50 |
| LR chi2 | 90.66 | | | | 0.29 | 29.76 | 5.53 | 6.82 |
| Prob>chi2 | 0.000 | | | | 0.9978 | 0.000 | 0.355 | 0.235 |

Remark: ***1% level of significance, **5% level of significance, *10% level of significance

Table A3-2: Influence of Firm Characteristics on Collaboration with Universities: Thai Case

| Independent variable (Firm characteristic) | Dependent variable (Modes of collaboration) | | | | | | | | | | | |
|---|---|---------------------|---------------------|--------------------------|------------------------------------|-------------------|------------------------------|----------------------|------------------------|-------------------|-------------------|-------------------------------------|
| | R&D mode (level 1-3) | | | Consultation (Binary) | Infrastructure mode (level 1-2) | | Informal mode (level 1-2) | | HR mode (level 1-3) | | | Technology licensing (binary) |
| | Level 1 | Level 2 | Level 3 | | Level 1 | Level 2 | Level 1 | Level 2 | Level 1 | Level 2 | Level 3 | |
| Food | 0.002 (0.018) | 0.003 (0.020) | 0.002 (0.014) | 0.021 (0.172) | 0.137 (0.013) | 0.041 (0.042) | 0.006 (0.008) | 0.030 (0.046) | -0.018 (0.018) | 0.039 (0.035) | 0.011 (0.010) | 0.038 (0.037) |
| Chemical | 0.007 (0.019) | 0.008 (0.023) | 0.006 (0.016) | 0.239 (0.183) | 0.026 (0.012) | 0.090 (0.050) | 0.013* (0.007) | 0.074 (0.054) | 0.011 (0.011) | -0.033 (0.038) | -0.008 (0.009) | -0.009 (0.037) |
| Electrical apparatus | -0.065 (0.069) | -0.058 (0.048) | 0.031 (0.021) | 0.193 (0.476) | -0.010 (0.047) | -0.025 (0.109) | -0.105 (0.064) | -0.213*** (0.067) | -0.020 (0.063) | 0.040 (0.103) | 0.011 (0.033) | omitted |
| Automotive | 0.051*** (0.014) | 0.085** (0.041) | 0.080 (0.052) | 0.099 (0.331) | 0.033 (0.008) | 0.180 (0.099) | 0.013* (0.007) | 0.172* (0.103) | -0.041 (0.051) | 0.071 (0.068) | 0.022 (0.026) | 0.071 (0.085) |
| Size | -0.033** (0.015) | -0.038** (0.018) | -0.027** (0.013) | -0.070 (0.141) | 0.005 (0.0122) | 0.145 (0.033) | 0.001 (0.008) | 0.003 (0.038) | -0.012 (0.011) | 0.031 (0.029) | 0.008 (0.007) | -0.023 (0.029) |
| No. of observations | 452 | | | 452 | 452 | | 452 | | 452 | | | 443 |
| Log likelihood | -435.59 | | | 214.41 | -419.06 | | -452.08 | | -473.69 | | | -135.29 |
| LR chi2 | 10.21 | | | 2.25 | 7.41 | | 9.12 | | 5.64 | | | 2.67 |
| Prob>chi2 | 0.069 | | | 0.813 | 0.192 | | 0.104 | | 0.342 | | | 0.615 |

Remark: ***1% level of significance, **5% level of significance, *10% level of significance

Table A3-3: Relationships between Modes: Japanese Case

| | R&D mode | Consultancy mode | Personnel exchange mode | Technology licensing | Venture |
|----------------------|---------------|------------------|-------------------------|----------------------|---------|
| R&D mode | 1.0000 | | | | |
| Consultancy mode | 0.0585 | 1.0000 | | | |
| HR mode | 0.1467 | 0.1294 | 1.0000 | | |
| Technology licensing | 0.1539 | 0.1250 | 0.0971 | 1.0000 | |
| Venture | 0.0399 | 0.0421 | 0.0766 | 0.0438 | 1.0000 |

Table A3-4: Relationships between Modes: Thai Case

| | R&D mode | Consultancy mode | Infrastructure mode | HR mode | Informal mode | Technology licensing |
|----------------------|---------------|------------------|---------------------|---------|---------------|----------------------|
| R&D mode | 1.0000 | | | | | |
| Consultancy mode | 0.5991 | 1.0000 | | | | |
| Infrastructure mode | 0.4550 | 0.4538 | 1.0000 | | | |
| HR mode | 0.3392 | 0.2787 | 0.2885 | 1.0000 | | |
| Informal mode | 0.4677 | 0.4095 | 0.4741 | 0.3212 | 1.0000 | |
| Technology licensing | 0.5078 | 0.5068 | 0.3709 | 0.2656 | 0.2928 | 1.0000 |

Table A3-5: Relationships between Modes and Outcomes: Japanese Case

| Independent variable | Dependent variable | | | | | | | |
|----------------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|--------------------|
| | Product innovation | | | | Sales | | | |
| | Level 1 | Level 2 | Level 3 | Level 4 | Level 1 | Level 2 | Level 3 | Level 4 |
| R&D mode | 0.102*** (0.009) | 0.054*** (0.004) | 0.032*** (0.003) | 0.007*** (0.002) | 0.170*** (0.011) | 0.033*** (0.003) | 0.010*** (0.002) | 0.001** (0.007) |
| Consultancy mode | 0.027*** (0.009) | 0.059*** (0.013) | 0.042*** (0.012) | 0.012*** (0.005) | 0.092*** (0.009) | 0.066*** (0.014) | 0.028*** (0.008) | 0.006* (0.003) |
| HR mode | -9.022 (0.031) | 0.103*** (0.018) | 0.087*** (0.022) | 0.031*** (0.012) | 0.069*** (0.025) | 0.101*** (0.023) | 0.049*** (0.016) | 0.012* (0.007) |
| Technology licensing | -0.085* (0.046) | 0.129*** (0.018) | 0.125*** (0.028) | 0.053*** (0.019) | 0.077*** (0.021) | 0.088*** (0.023) | 0.041*** (0.015) | 0.010* (0.006) |
| Venture | 0.029*** (0.007) | 0.051*** (0.014) | 0.036*** (0.012) | 0.010** (0.004) | 0.088*** (0.009) | 0.040*** (0.012) | 0.015*** (0.006) | 0.003 (0.002) |
| R&D * Technology licensing | -0.074*** (0.015) | -0.040*** (0.008) | -0.023*** (0.005) | -0.005*** (0.001) | -0.106*** (0.024) | -0.021*** (0.005) | -0.006*** (0.002) | -0.001* (0.000) |
| R&D * Personnel exchange | -0.079*** (0.014) | -0.042*** (0.007) | -0.025*** (0.005) | -0.005*** (0.001) | -0.138*** (0.023) | -0.027*** (0.005) | -0.008*** (0.002) | -0.001* (0.001) |
| Consultancy * Personnel exchange | 0.003 (0.041) | 0.002 (0.023) | 0.001 (0.014) | 0.000 (0.003) | -0.132 (0.105) | -0.015** (0.007) | -0.004** (0.002) | -0.004* (0.000) |
| Size | -0.019* (0.011) | -0.009* (0.005) | -0.005** (0.003) | -0.001* (0.001) | -0.018 (0.016) | -0.003 (0.003) | -0.001 (0.000) | -0.000 (0.000) |
| Manufacturing | 0.012 (0.008) | 0.006 (0.004) | 0.004 (0.002) | 0.001 (0.001) | 0.029** (0.013) | 0.006** (0.003) | 0.002** (0.001) | 0.0002 (0.000) |
| No. of observations | 2,643 | | | | 2,643 | | | |
| Log likelihood | -2,323.39 | | | | -1,883.68 | | | |
| LR chi2 | 570.35 | | | | 584.44 | | | |
| Prob>chi2 | 0.000 | | | | 0.000 | | | |

Remark: ***1% level of significance, **5% level of significance, *10% level of significance

Table A3-6: Relationships between Modes and Outcomes: Thai Case

| Independent variable | Dependent variable | |
|------------------------------------|--|--|
| | Product innovation (Poisson regression) | Process innovation (Poisson regression) |
| R&D mode | 0.724 (0.443) | 0.716*** (0.269) |
| Consultancy mode | -3.244 (2.127) | 1.806*** (0.451) |
| Infrastructure mode | 4.097*** (2.182) | -1.134*** (0.520) |
| HR mode | -0.085 (0.266) | -0.467** (0.208) |
| Informal mode | 0.585 (0.369) | 0.682*** (0.211) |
| Technology licensing mode | 2.222** (1.192) | -14.396 (957.236) |
| R&D * Consultancy | 1.353** (0.816) | -0.761** (0.312) |
| Consultancy * Technology licensing | 3.088 (2.216) | 12.512 (957.236) |
| R&D * Technology licensing | -2.138*** (0.827) | 0.375 (0.561) |
| Size | -0.506 (0.827) | -0.142 (0.278) |
| Manufacturing | -0.212 (0.475) | 1.595*** (0.599) |
| No. of observations | 452 | 452 |
| Log likelihood | -84.85 | -165.06 |
| LR chi2 | 99.94 | 104.83 |
| Prob>chi2 | 0.000 | 0.000 |

Remark: ***1% level of significance, **5% level of significance,
*10% level of significance

| Independent variable | Dependent variable |
|------------------------------------|-------------------------------|
| | Amount of sales (ln_sales) |
| R&D mode | 0.039 (0.273) |
| Consultancy mode | -0.956 (0.617) |
| Infrastructure mode | 0.993 (0.668) |
| HR mode | -0.163 (0.208) |
| Informal mode | 0.211 (0.188) |
| Technology licensing | 1.406 (1.202) |
| R&D * Consultancy | 1.284*** (0.421) |
| Consultancy * Technology licensing | -1.832 (1.388) |
| R&D * Technology licensing | -0.972 (0.669) |
| Size | 2.141*** (0.273) |
| Manufacturing | -0.347 (0.363) |
| Constant | 19.182*** (0.441) |
| R ² | 0.1759 |
| Observations | 447 |

Remark: 1. ***1% level of significance, **5% level of significance, *10% level of significance
2. Limitation of data: Size is dummy variable and amount of sales is continuous number.

Appendix 4:

Development Path of University-Industry Collaboration Activities

Articles

Development Path of University and Industry Collaboration (UIC) Activities: Case of Japan and Thailand

Siriporn Pittayasophon*¹ and Patarapong Intarakumnerd²

Abstract

This article investigates the development path of university and industry collaboration (hereinafter UIC). The remarkable findings are as follows; Firstly, Japan and Thailand have different level of national innovation systems; nonetheless, common development patterns were found. In the cases of UIC evolving overtime, two development paths were found: step-by-step (from low-to medium and to high relational intensity) and leapfrog (from low to high or from medium to high). For those not evolving overtime, both UIC set fixed specific goals and collaborative patterns. University's expertise (supply-push) and firm's technological capability (demand-pull), trust (built by both intermediaries and the two partners) and mutual interest are drivers shaping development paths. Secondly, university-industry collaboration activities have not developed when researchers were not interested to continue working or firm lacked capabilities to carry on projects after government supports were terminated. Lastly, important activities in two national systems are different. Researcher mobility from companies to universities frequently happened in the Japanese cases, but in the Thai cases, mobility of students is much more prevalent.

Keywords: university and industry collaboration, development path, Japan, Thailand

1. Introduction

University and industry collaboration (UIC) are one of main activities in national innovation systems. UIC has become an important policy issue. Scholars from several schools of thoughts, namely innovation systems, triple helix, and technology management have made significant attempts to study UIC but there are several issues have not been extensively examined, especially the development path of UIC.

The collaboration between these two parties could be made through various activities, and differ in several aspects such as relational intensity, type of activity and formal or informal collaboration. Besides, those activities are dynamic and evolve over time. The relationship between partners could become deeper. Personal relationship has been considered as a starting point and a critical factor

¹ National Graduate Institute for Policy Studies, 7-22-1 Reppongi, Minato-ku, Tokyo 106-8677, Japan
National Science Technology and Innovation Policy Office, 319 Chenchuri Square BD., 14, Phayathai Rd., Patumwan, Bangkok, 10330, Thailand

² National Graduate Institute for Policy Studies, 7-22-1 Reppongi, Minato-ku, Tokyo 106-8677, Japan

*Corresponding author, e-mail address: doc13151@grips.ac.jp and siriporn@sti.or.th

deepening the relationship (Larson, 1992; Inkpen and Currall, 2004). Nonetheless, previous studies did not explicitly identify the deepening or development paths of UIC activities.

To partially fill in research gaps of existing studies, this article aims at investigating the development paths of collaborations and identifying the factors affecting these development paths.

2. Literature Review

A system of innovation (SI) consists of components and activities (Edquist, 1997). Components are key actors (firm, university, government, and others) and institution (rule, law, norm, and so forth). Activities³ are factors that influence innovation processes. They are interdependent. To pursue innovation process, collaboration between university and industry is important and can be made through various activities. They include, but not limited to, conference, publication, consultation, personnel exchange, patent, license, joint R&D project, contracting R&D, spin-offs (Cohen et al., 2002; Bekkers and Freitas, 2008).

Those UIC activities differ in several aspects such as relational intensity, type of activity and formal or informal collaboration. This article used relational intensity as criterion to identify development paths of UIC activities because the relational intensity is defined as 'interaction between knowledge creators and users and transfer of tacit knowledge'⁴ (Leonard-Batton, 1995; Perkmann and Walsh, 2007; Ponomarev and Boardman, 2012; Merchán-Hernández and Valmaseda-Andia, 2013). Those scholars well studied the classification of relational intensity activity. They agreed with three levels of

relational intensity activities.

High relational intensity activities are joint research projects, commissioned research, consultation and incubation or start-up or spin-off because these activities could circulate both tacit and explicit knowledge. The knowledge exchange is based on the personal contact between the parties and obviously, these activities are not understood without high levels of personal interaction.

Medium relational intensity activity mostly relates to human mobility such as training of industry employees, postgraduate training in industry, graduate trainees, hiring of graduates and adjunct faculty. Although this mode has a high level of personal interaction, it plays an important role in transferring tacit knowledge rather than explicit knowledge.

Low relational intensity activities are technology licensing and use of scientific publication which are main sources of explicit knowledge⁵. These activities do not require a close relationship between two partners and have a low capacity to transform explicit knowledge into tacit knowledge.

Nonetheless, there are different points of view among scholars. Perkmann and Walsh (2007) believed that the informal mode could accompany all modes whereas Ponomarev and Boardman (2012) grouped this mode into medium relational intensity. We disagree with conclusion of Ponomarev and Boardman (2012) because degree of relational intensity increases when tacit knowledge is transferred and to effectively facilitate flow of tacit knowledge, rich communication such as frequent informal interaction is needed. This article, therefore, adapted the classification of relational intensity activities from those studies as below (Table 1).

³ A set of activities which may be important in most SIs was provided such as research and development (R&D), competence building, formation of new products, incubation, consultancy service, financing of innovation processes.

⁴ In general, tacit knowledge could be transferred through rich communication which is face-to-face communication and informal interaction (Urza, 2011).

⁵ Explicit knowledge can be transferred through written media which is manuals, database, written instructions and blueprints (Urza, 2011).

Table 1: Indicator and Classification of Relational Intensity Activity

| Degree of Relational Intensity | Indicator | Activity |
|--------------------------------|--|---|
| Low | Mainly transfer of explicit knowledge Low level of personal interaction | Technology licensing |
| | | Use of publication |
| Medium | Mainly transfer of tacit knowledge High level of personal interaction | Human mobility (Student mobility, Personnel exchange, Training for employee, Hiring of graduates) |
| High | Circulation of both explicit and tacit knowledge High level of personal interaction | Joint or Collaborative R&D |
| | | Contract out or Commission R&D |
| | | Academic consultant or Technical guidance |
| | | Incubation |

Informal interaction can accompany with all activities. This activity includes conference, informal meeting, personal contact and so forth.

Source: Adapted from Leonard-Batton (1995); Perkmann and Walsh (2007); Ponomarev and Boardman (2012); Marchán-Hernández and Valmaseda-Andrés (2013)

Although those previous literatures carefully studied about the classification of relational intensity activity, they did not explicitly examine the sequences of UIC activities. A closer interaction between knowledge creator and user is generally supposed to take longer time. Shartinger et al. (2002) concluded that the duration of the partnerships give an account of the intensity of knowledge transfer between two agents and the more long-lasting relationships are likely to facilitate greater exchange of knowledge flows. Likewise, these scholars (Haldin-Herrgard, 2000 as cited in Morone and Taylor, 2009) identifies that the internalization of tacit knowledge takes a long time, as it involves direct experience and reflection on these experiences. In contrast, when the formalized knowledge has been made explicit, it can be shared broadly and quickly with many people (Camison et al., 2009). In the context of university, the most important knowledge is often in the mind of academics but it is difficult to spread through the university and its internal stakeholders due to time and resource constraints. It is noted that academicians have a role to transform

the tacit knowledge into explicit form in order for the reuse of knowledge by other stakeholders (Chugh, 2013). However, the knowledge flow between knowledge sender and recipient will be successful when they trust each other and have knowledge energy. With the higher trust, the flow of knowledge between them will be more efficient. The sender and recipient with higher level of knowledge energy are more able to learn, use and create knowledge in its relevant field (Jarrahi and Kangavari, 2012).

3. Research Methodology

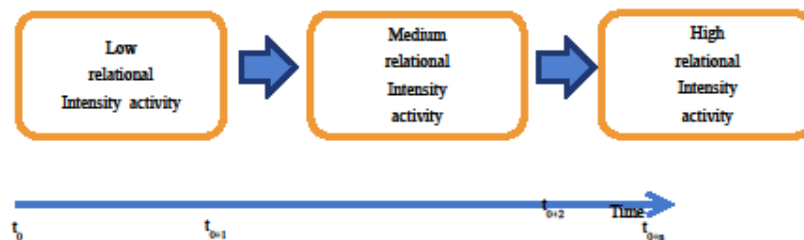
Qualitative case study method was applied to this article due to its ability to answer the why and how questions. This method could provide more detailed explanations of historical evolution of the university-industry collaboration by examining longitudinal changes of important collaborative projects. Inductive approach was applied to explain our findings which emerge from the field work exploring collaboration with the industry by different types of universities, namely national universities, local

universities and private universities. Storytelling about collaborative projects was given by university researchers during the interviews when we raised the issues about historical background and perception of universities on collaborative activities.

Analytical framework (Figure 1) was drawn from the literature review in Section 2. The levels of

relational intensity mode are classified based on the interaction between knowledge creators and users and transfer of tacit knowledge. Transferring tacit knowledge takes longer time than explicit knowledge (Haldin-Herrgard, 2000; Sharteringer et al., 2002; Camison et al., 2009).

Figure 1: Analytical Framework for Identifying Development Path of UIC Activity



Two different development levels of national systems⁶, i.e., Japan and Thailand were selected but this paper does not aim at making a direct comparative analysis to see the differences between two national systems. Rather, two cases were used to find the common issues such as development paths of UIC activities. The following twelve case studies of UIC were analyzed to investigate how development paths of those activities evolve time, i.e. whether they evolve from low to medium and to high relational activity (see analytical framework in Figure 1). We also examine factors affecting the evolution of development paths.

Japanese Cases

1. Collaboration between Muroji and Fukui Prefectural University (FPU)

2. Collaboration between a Group of Large Energy Firms and Advanced Energy Systems for Sustainability (AES) Center at Tokyo Institute of Technology (TIT)

3. Collaboration between JR East Consultants Company and Keio University (Keio)

4. Collaboration between Nippon Telegraph and Telephone Corporation and Precision and Intelligence Laboratory, Koyama Laboratory Photonics Integration System Research Center, Tokyo Institute of Technology (TIT)

5. Collaboration between a nano carbon firm and Toyota Technological Institute (TTI)

Thai Cases

1. Collaboration between Lion Corporation (Thailand) and Chulalongkorn University (CU)

⁶ (a) Economic development; Japan is classified as a high income country whereas Thailand is upper middle income country (World Bank database) and (b) the capabilities of key actors in triple helix concept are different, for example, Japanese firms became more innovative, invested in R&D and relied less on importation of foreign technologies (Goto and Odagiri, 1996) whereas in Thailand, only small minority of large subsidiaries of Transnational companies (TNCs), large domestic firms and SMEs have capability in R&D (Intarakumnerd and Leclerc, 2010).

2. Collaboration between Artith Ventilators and Rajamangala University of Technology Lanna (RMUTL)

3. Collaboration between Betagro and King Mongkut University of Technology Thonburi (KMUTT)

4. Collaboration between CP Group and CENTEX SHRIMP at Mahidol University (MU)

5. Collaboration between Centara and Dhurakij Pundit University (DPU)

6. Collaboration between a local brewery entrepreneur and Rajamangala University of Technology Thanyaburi (RMUTT)

7. Collaboration between Local Community and RMUTL

4. Case Analysis

Two common development patterns were found from different national systems of innovation. For evolutionary cases, type of activity has evolved over time when technology was transferred to firm, or there were several types of firm's needs or requests. For non-evolutionary cases, type of activity has not been changed over time when both partners set fixed specific goals and collaborative patterns. There are also non-starter cases.

4.1 Evolutionary Cases: Type of Activity Changed Over Time

In these cases, two development paths were found; step-by-step path and leapfrog path. Step-by-step path develops from low to medium and finally to the high relational intensity activity. Leapfrogging path often starts with low and jumps to high relational intensity activity or starts with medium and finally develops to high relational intensity activity. Often, both development paths have informal collaboration as the starting point (Table 2).

- Step-by-Step Path

Step-by-step path occurs due to supply-push force which is characterized as when universities transfer academic inventions developed by their expertise via the sale, transfer or licensing of intellectual property to existing firms or new ventures, for example academic spin-offs (OECD, 2012).

Muroji and FPU case can be classified as a supply-push model in which FPU conducted the academic research i.e., non-alcohol soy sauce then transferred the technology to Muroji for production. At the beginning, this case required the intermediary person to match supply to demand. Due to the research independently developed by university, when transferring technology, the university researcher must spend time at the firm for providing technical advice on implementation of the downstream research activities. Development path started from technology licensing (low relational intensity) to researcher mobility (medium relational intensity) and move to technical advice (high relational intensity). Result of the collaboration is product innovation (non-alcohol soy sauce) which brought to domestic and overseas market. Apart from success of initial phase, the firm realizes importance of UIC activities and the FPU researcher is interested in conducting industrial research; therefore, they have continued working together. The firm has rented a space in incubation at FPU. Interestingly, discovered knowledge has been spilled over to other prefectures because this project does not start with a specific need of the firm (Case 1).

Case 1: Collaboration between Muroji and Fukui Prefectural University (FPU)

Muroji Co., Ltd. is the oldest Japanese soy sauce brewery in the world. For more than 440 years, this firm has been making soy-sauce in Fukui, Japan⁷

The collaboration started when a university professor developed fish sauce having similar characteristic to that

⁷ For more information: <http://www.muroji.co.jp/history.html>

of soy sauce. It is the non-alcohol sauce which has domestic patent already and in the process of international patenting. Muroji's advisor learned about this. He then arranged a meeting between Muroji and the professor. Without licensing fee, this professor transferred his own technology (ingredient and production process). He also provided technical consultation and allowed the company to access his laboratory.

With a contract, he spent almost every day advising the firm at the initial stage. When the firms' staff could learn how to produce sauce, he reduced his time to only one day per week. To sell this product, a biotechnology venture company was established by a coordinator of fish sauce project who was familiar with the professor. Altogether, the professor spent approximately 4-5 years to commercialize academic research.

The university provided one building to the professor to use as the incubation rented by the firm for its R&D activities. From time to time, three partners had meetings and then they decided to expand market to China. Currently, the firm engages more in selling its products to overseas. The collaboration between the firm and professor continued. In August, 2015, the university set up the high-volume production facilities in the incubation which is used by the firm.

Source: T. Utagawa, Interview, December 18, 2014.

• Leapfrogging Path

Leapfrogging path occurs because of demand-pull force, technological capabilities of firms, role of intermediary persons or organizations in building trust, and mutual trust.

Demand-Pull Force

A demand-pull force is a model which universities are solicited by industrial actors to find solutions to production and innovation problems based on contract research or collaborative R&D (OECD, 2012). Based on six case studies, the collaboration began with demands of firms (Case 2, 3, 4, 5, 6 and 7).

Technological Capability of Firm

Our study is similar to Jarrahi and Kangavari (2012). Technological capability of firm influences the development paths. The effectiveness of knowledge flow depends on capabilities of knowledge user and creator.

In case of high-technology firms, these firms perceived the importance of product development. They clearly identified their research topics and foresaw potential technologies. After both parties had the meetings and discussion, they quickly started working together (Case 2, 3 and 4). In case 5 and 6, though the firms' size was large and they had high technological capabilities, they could not decide on their research topics. In that light, they sent their researchers to be visiting professors or university students to explore the opportunities for future collaborative research.

In contrast, in case 7 the firm did not have high technological capabilities but it incrementally upgraded technological capability in product improvement. At the beginning the firm and its partnering university used existing knowledge by testing and benchmarking their prototypes against high-quality products. The collaboration started with a mobility of a junior university researcher to the firm. After the success of the initial phase, that university researcher and company engineers continued conducting joint R&D activity through cooperative education program.

Role of Intermediary Organization in Building Trust and Trust Built by Two Partners

UIC often happens due to intermediary organizations because two parties need a bridging mechanism to get information about technologies and to build trust (Case 3 and 5). In contrast, in some cases, two partners have close relationship (such as through being former classmates and former colleagues), which means that trust has already been embedded in the relationship. In these cases, starting the collaboration can easily happen (Case 6-7). The

findings are in the line with the study of Jarrahi and Kangavari (2012). They identified that both knowledge recipient's capability and trust are the factors affecting knowledge flow which makes UIC activities further develop.

Mutual Interest

Mutual interest between the two partners is a driver to shape the development paths. When both of them are interested in the same issues, the collaboration could be started immediately (Case 2, 3, 4, 5, 6, and 7).

The starting point of collaboration between CP Group and CENTEX SHRIMP at Mahidol University (MU) was when CP read an academic paper on shrimp's brain co-written by MU professor. Then, CP decided to directly contact and invited him to be a consultant of shrimp center. Joint R&D projects were conducted. Also, public research institute such as NSTDA involved in this collaboration. Until now, this relationship among CENTEX, NSTDA and CP has developed for more than 25 years. It became much closer like being in the same organization facilitating knowledge exchange. The development path of this case is not step-by-step. It started from use of publication (low relational intensity activity) and jumped to high relational intensity activities (consultation and joint R&D). Jumping occurred because, at that time, CP had high capability enough to see the potential of a new technology and it trusted in MU professor's ability (Case 2).

Case 2: Collaboration between CP Group and CENTEX SHRIMP at Mahidol University (MU) The Charoen Pokphand Group (CP) is a transnational conglomerate that consists of three core businesses that operate in the agribusiness and food, retail and distribution, and the telecommunications industries with investment in 16 countries. Charoen Pokphand Foods Public Company Limited (CPF) operates in both the

livestock (swine, broilers, layers, and ducks) and aquaculture (shrimp and fish) businesses⁸

The collaboration between CP and MU researchers started in 1989. When CP read an academic paper on shrimp's brain co-written by university professor, CP decided to directly contact and invited him to be a consultant of shrimp center at Mahachai, Nakornpathom province. This collaboration was formal. At that time, CP is one of a very few of Thai firms having high technological capabilities. Its R&D facilities in shrimp research were more advanced than university's facilities. In 1993, MU's researchers started to conduct a research on DNA probe and PCR for shrimp disease diagnostic. Then in 1994, university professor introduced a close system for shrimp farming. One to two years later (1995-1996), CP used PCR for shrimp disease diagnostic and this method had widely used in the period of year 1996-2002⁹.

In 2001, the professor and his colleagues established Center of Excellence for Shrimp Molecular Biology and Biotechnology or CENTEX SHRIMP at MU, with a support from National Science and Technology Development Agency (NSTDA). There were almost sixty staffs consisting of CENTEX researchers, NSTDA researchers, assistant researchers, master students, doctoral students and foreign post-doctoral students. The relationship among CENTEX, NSTDA and CP became much closer like being in the same organization which facilitates exchange of knowledge. Examples of joint research outputs are DNA probes for shrimp viruses and RT-PCR diagnostic detection for yellow head virus. Besides, training programs for other firms have been organized and several foreign companies have commissioned R&D projects to CENTEX.

Downstream development happened during year 2007-2008, when NSTDA supported the establishment of Shrimp Genetic Improvement Center in collaboration with MU and Prince Sonkla University (PSU) in southern Thailand. After seven years, the center could breed shrimp

⁸ For more information: <http://www.cpthailand.com/>

⁹ Shrimp center website

with disease resistance. The shrimps were later sold to PSU, which in turn, further bred and sold the shrimps to farmers in 2014.
Source: B. Withyachunnarnkul, Interview, February 14, 2015.

CU's researchers discovered new knowledge but it was in stage of prototype which had potential to apply to detergent. Lion's executive well understood technology and saw its potential to apply to its product. Therefore, the executive decided to jointly conduct R&D and allow university researchers to conduct research in firm's laboratory. Then, prototype was developed and licensed to Lion for mass production. Technical consultation was also provided. This case illustrates leapfrogging pattern of collaboration. Informal meeting was arranged to propose the research outputs at the initial stage. Then, the research was conducted in firm's laboratory. This means that university researchers moved to work at firm. It is a medium relational intensity activity (research mobility). During the collaboration process, various activities, namely, technology licensing, technical consultation and training program were used simultaneously. Finally, activity evolved to high intensity i.e., joint R&D (Case 3).

Case 3: Collaboration between Lion Corporation (Thailand) and Chulalongkorn University (CU) Lion Corporation is established in 1967 to produce powder detergent and shampoo in Thailand to substitute Japanese imports¹⁰. Before Lion and CU collaborated with each other, another company, Innovation Group (Thailand)¹¹ provided two R&D grants to CU's Faculty of Science (chemistry). One project was carried out by a university researcher. Six months after the project started, the university researcher discovered a method of generating Silver Nano from silver nitrate which could stop the growth

of bio-organisms in wet condition and could apply in detergent.

Then, CEO of Innovation Group (Thailand) invited the Managing Director (MD) of Lion Corporation to visit the research laboratory. It is just happened that the MD was an alumnus of faculty of science. After demonstrating the biocidal property of nanosilver to him, Lion decided to join the research project and allowed it to be conducted in Lion's laboratory (Chunhasawasdikul, 2010). During the stage of product development, the researchers developed low-cost silver raw material which can substitute imports. Low-cost and less complicated production process was also designed. Then, prototype was developed and applied for an invention patent. It was then licensed to Lion for mass production. Together with technology licensing, CU's researchers provided technical consultation on process of production and quality control and organized training courses for staffs. Finally, the new product, Pao Silver Nano, was brought to the market. This whole process took about one year. Besides, they continued working together on developing liquid detergent and softener.

Source: S. Ekasit, Interview, February 17, 2015 and Chunhasawasdikul (2010).

At a party, Keio professor met with President of East-JR and President of JRC. University professor proposed his ideas to the two presidents, for example, instead of using human voices, a variety of vibrational energy in railways can be converted to power electronic. This led to a collaborative two-month experiment in power generating floor technology at the Marunouchi North ticket gate in Tokyo station. Another idea about supplying electrical power for escalators was initiated. To transform this idea to reality, a company researcher was sent to university. The starting point of this case was a social network at the party (low relational intensity) and then it evolved to experiment

¹⁰ For more information: <http://www.lion.co.th/home.php>

¹¹ Innovation Group has developed to be a technology led polymer organization through the "Inspiration of Technology". The group is servicing a wide range of rubber and polymer products to automotive, electronic, electric applicant and general rubber industries. Innovation Group committed to provide technology services and technology solutions to customers.

research output of initial phase (high relational intensity). JRC sent a researcher to be a senior visiting researcher at Keio and then started doing a new joint R&D project which was a further development of initial phase. This shows reverse step from high to medium relational intensity activity (Case 4).

Case 4: Collaboration between JR East Consultants Company and Keio University (Keio)

JR East Consultants Company (JRC) was founded in 1989 as a general consulting firm in the field of railway technology. JRC is a subsidiary of the East Japan Railway Company (JR-East), which is one of the largest passenger railway companies in the world.

In 2004, Professor Yoshiyasu Takefuji, Keio professor met with President of East-JR and President of JRC at a party. Professor Takefuji proposed his ideas to them, for example, instead of using human voices, a variety of vibrational energy in railways can be converted to power electronic. This idea is based on the research by Professor Takefuji's student (since 2003)¹²

He successfully increased the power generating efficiency (co-developed with Kyocera) and durability by combining elements of piezo-electricity and resonance phenomena, and brought the technology to the level of experimental practical application. This led to a collaborative two-month experiment in power generating floor technology in October 2006 at the Marunouchi North ticket gate in Tokyo station. Then, they had another plan to supply electrical power for escalators and lights with the electricity generating floor. To transform this idea to reality, JRC sent a researcher to be a senior visiting researcher at Keio University. The collaborative project aims at using human energy to operate escalators and thereby create an environmentally friendly source of energy at train stations. Apart from this project, Keio University continues to do several projects with JRC such as transverse wave speaker.

Source: Summarize from Keio University website and Keio Research Institute at SFC website.

In case of AES center and large energy firms, those firms sent their researchers to be project-based professors and work with existing university professors to create collaborative research projects. Normally, AES organizes seminar and site visits to companies to observe their technologies and project-based professors invite university researchers to join their collaborative projects. To sum up, collaboration between Tokyo Institute of Technology (TIT) and firms started with the activities introduced by SRL's activities. SRL acted as an intermediary. After establishment of AES center, TIT and firms directly collaborated with each other. Collaborative activity then developed to personnel exchange. Several firms sent their researchers to be visiting researchers or visiting professors. In this case, collaborating firms have high technological capabilities to work on an equal footing with university professors. Finally, the joint R&D, a high relational intensity activity, was formed (Case 5).

Case 5: Collaboration between a Group of Large Energy Firms and Advanced Energy Systems for Sustainability (AES) Center at Tokyo Institute of Technology (TIT)

The Future Energy Vision Study Group under TIT, formed in 2005, initially included only faculty members. It later connected with the activities of Solutions Research Laboratory (SRL), a firms' networked laboratory closely collaborating with large energy companies such as Tokyo Gas and Mitsubishi. Over time, the group expanded to include a large number of companies and evolved to be current Advanced Energy Systems for Sustainability (AES) Center under TIT.¹³

AES collaborated with R&D units of large firms like Tokyo Gas, Mitsubishi and Toshiba on energy and environment issues. Also, several firms sent their researchers to join the university as project-based professors and work with existing university professors. To create collaborative research projects, AES organizes evening closed and opened seminar and site visits to companies to observe their technologies. Meanwhile, those

¹² Japan for Sustainability website

project-based professors searched for university researchers who had interests in working on their collaborative projects. After working for TIT for a few years, these project-based professors started to feel more like a part of TIT than corporate employees (AES center, 2013). At present, AES center has expanded its network to over fifty corporations including firms in overseas in order to be a global hub for next-generation energy research. Examples of collaborative R&D projects are Smart Power Network Project, Nuclear Fuel Cycle Project and Marine Biomass Project. Source: Summarize from AES center website and AES Center (2013).

Executives of Betagro and KMUTT organized occasionally informal discussions leading to Food Engineering Practice School Program (FEPS) for Master's Degree in 2006. This program has a main purpose to train the students to apply their knowledge to solve problems in a real situation. The development path of this case is classified as leapfrogging pattern starting from medium (student mobility) to high relational intensity (joint R&D). Because this firm has the technological capability to do R&D activities, it is interested in continuing collaborating with universities. When collaboration reached the high intensity, the evolution path reversed to medium relational intensity (student mobility) in order to start doing new R&D projects (Case 6).

Case 6: Collaboration between Betagro and King Mongkut University of Technology Thonburi (KMUTT)
Founded in 1967, the Betagro Group began as a single entity, Betagro Company Limited, to produce and distribute animal feed. Its headquarters were originally located in Pom Prab, Bangkok, and its first feed mill in Prapadaeng, Samut Prakan province¹⁴. Executives of both parties had informal discussion

about how to stimulate collaboration between university and industry. Initially, the executive of Betagro suggested KMUTT setting up a consultation service center but KMUTT's executives did not agree. They thought that KMUTT is a university; therefore, it should mainly focus on producing human resources rather than providing consultation service. As a result, they initiated Food Engineering Practice School Program (FEPS) for Master's Degree in 2006 which aims to train the students to apply their knowledge to solve problems in a real situation before pursuing their research work. From 2006 to present, KMUTT has sent approximately six master students to Betagro every semester. Betagro proposed several research topics and assigned the staff members to be co-supervisors. KMUTT has to select some topics which are feasible for the students' theses. In every semester, the executives of both parties join the students' presentations. In this case, the key actor who plays a role in strengthening the relationship is the executives of both university and firm, instead of FEPS' alumni. Source: M. Nopharstant, Interview, June 21, 2015.

Collaboration between Artith Ventilators and RMUTT began with personal relationship between the firm owner and a university professor. At that time, the firm owner wanted to obtain an international standard guarantee for export products. He then consulted his friend who was a university professor. This senior professor sent a junior university researcher to work at firm. Finally, products could be exported to overseas and two parties have continued working together by organizing a cooperative education program. The development process of this case is classified as leapfrogging pattern starting from personal contact and jumping into high relational intensity i.e., joint R&D. Because this firm has technological capability to do R&D activities, it is interested to continue collaborating with universities.

¹³ For more information: <https://aes.vit.ac.jp/english>

¹⁴ For more information: http://www.betagro.com/index_th.php

Notably, when activity reached the high intensity, the development path reversed to medium relational intensity (student mobility) in order to start doing new joint R&D projects (Case 7).

Case 7: Collaboration between Artith Ventilators and Rajamangala University of Technology Lanna (RMUTL)

Artith was established in 1984 as the first company in Thailand producing 12-inch diameter turbine ventilator under its own brand¹⁵

The collaboration between RMUTL and Artith started with personal relationship between the firm owner and a university professor. At that time, the firm owner wanted to obtain an international standard guarantee from Air Movement and Control Association (AMCA) in order to export products to overseas. He then consulted his friend who was a university professor. This senior professor sent his former Ph.D. student to work at firm.

Together with the firm's engineers, university researcher who is a former Ph.D. student of senior professor set up a laboratory and built prototypes. This laboratory was used to test and benchmark prototypes against high-quality products. Four years later, the products have been guaranteed by AMCA and could be exported to overseas markets. A generation passed, this firm owner's son continued to develop its products. He needed students to work as assistant researchers. The professor therefore sent his students to this firm through a cooperative education program (on-site work for one year). An example of a new product from a cooperative education program is CNC automation. After the projects finished, the company hired 50% of interns as permanent staff.

Source: N. Moonpa, Interview, February 10, 2015.

4.2 Non-Evolutionary Cases: Type of Activity Not Changing over Time

Types of activities have not been changed over time when both supply and demand side have a fixed specific need. Research topics and collaborative

patterns were clearly set by both parties at the beginning to respond to a specific need of firm and objectives of collaboration. The collaboration has been continued owing to commitment of both parties' executives and success of initial phase (Table 2). This result seems to be consistent with the conclusion of Ring and Van de Ven (1994). The development of relationship is a repetitive sequence of each stage.

NTT and IIT have collaborated through joint R&D projects. Due to personal connection and reputation of its university professors, NTT provides R&D grants to this laboratory by defining clear research topics every year. The two parties plan to jointly apply for patents which may not be utilized (Case 8).

Case 8: Collaboration between Nippon Telegraph and Telephone Corporation and Precision and Intelligence Laboratory, Koyama Laboratory Photonics Integration System Research Center, Tokyo Institute of Technology (IIT)

The Nippon Telegraph and Telephone Corporation (NTT) is a Japanese telecommunications company founded in 1985. It operates in five business segments; 1) domestic intra-prefectural communication services and incidental services, 2) domestic inter-prefectural and international communication services and incidental services, 3) mobile phones services, and the related services, 4) system integration and network system services, and 5) real estate business, finance business, construction and power business, system development business, as well as advanced technology development business¹⁶

A professor overseeing Precision and Intelligence laboratory used to work at NTT. Every year, NTT provides R&D grants to his laboratory together with defined research topics. Main target of collaboration is to jointly apply for patents every year. In fact, some patents may not be used but NTT still continues providing R&D grants. This is because NTT's objective for patent application

¹⁵ For more information: <http://www.artith.com/>

¹⁶ For more information: http://www.ntt.co.jp/index_e.html

is to protect competitors to use future technologies. It does not aim to commercialize discovered technologies at this time. In addition, this laboratory specializes in relating technologies. It has advanced R&D facilities and equipment with skillful researchers. For discussions and consultations, NTT and this laboratory have regular meetings every two months. Example of discovered technologies is an optical device used in data center or computer server.
Source: X. Gu, Interview, July 5, 2015.

Centara Hotels and Resorts and DPU have an agreement to develop training programs for Centara staff, to offer a training program for DPU students, and to provide trainings for the public. They have continuing human resource development collaboration in various programs without changing to other modes of collaboration (Case 9).

Case 9: Collaboration between Centara and Dhurakij Pundit University (DPU)
The Central Group founded Central Plaza Hotel Public Company Limited to handle the launch of its own hotel, shopping mall, or convention center in the expanding Ladprao area in Bangkok. The hotel was opened in 1983, and in 2007 the hotel company was rebranded to Centara Hotels & Resorts¹⁷
Centara Hotels & Resorts (Centara) signed a Memorandum of Understanding (MoU) with DPU

in 2012 with an aim to develop state-of-the-art training programs for Centara staff, to offer a training program for DPU students, and to provide training for the public.

At the beginning, Centara accepted a number of students from DPU to do an internship at various Centara properties. A majority of DPU students came from the Faculty of Tourism and Hospitality and DPU International College (DPUIC). Based on the interviews with the internship supervisors at Centara, DPU students performed well during the internship.

After that, from 2013, Centara and DPU jointly developed the Management Development Program (MDP) which aims to equip Centara's managers and supervisors with managerial skills. This one-year program started with theoretical components taught in English at DPUIC, followed by a real-time management at Centara whereby each trainee is assigned with managerial-level projects. Finally, the participants are trained at the DPU's partner, Swiss College of Hospitality Management Lenk (SHML).

Recently, Centara and DPU introduced a new project, Centara Academy in 2014. It aims to enhance the skills of graduates from high school and polytechnic school. Taught in Thai language, this three-month program was initiated by the Faculty of Tourism & Hospitality at DPU. Upon the program completion, students have the advantage of earning credits which can be counted toward their Bachelor degree at DPU.

Source: K. Campiranon, interview, March 7, 2015.

Table 2: Summary of Evolutionary and Non-Evolutionary Case

| Case | Initial Condition | Capability of Firm | Development of UIC Activity (Level of Relational Intensity) | Reason for Starting and Continuing Collaboration |
|---------------------------|--|--------------------|--|--|
| Case 1: Muroji and FPU | Research developed by university researcher Informal collaboration arranged by intermediary person (firm advisor) | Knowledge user | Evolutionary (step-by-step) Low: Technology licensing Medium: Researcher mobility (from university to firm) High: Technical consultation and incubation | Role of intermediary person in building trust Firm's understanding in the importance of UIC (send one staff to work at the university incubator after finishing the |

¹⁷ For more information: <http://www.centarahotelsresorts.com/>

| Case | Initial Condition | Capability of Firm | Development of UIC Activity (Level of Relational Intensity) | Reason for Starting and Continuing Collaboration |
|-----------------------------|---|-------------------------|--|--|
| | | | | initial phase) University researcher's interest in industrial research (used to be a company researcher) Success of initial phase |
| Case 2: CP and MU | Academic paper written by university researcher Capability of firm in foreseeing potential technology Firm's interest in product development Direct contact between firm and university researcher | Co-creator of knowledge | Evolutionary (leapfrogging) Low: Use of publication Medium: - High: Consultation, joint R&D | Capability of firm in foreseeing potential technology and firm's interest in product development (firm read an academic paper of university researcher) Trust in researcher's capability (firm decided to directly contact university researcher when it read an academic paper) Success of initial phase |
| Case 3: Lion and CU | Research (prototype) developed by university and Innovation Group Informal collaboration arranged by intermediary person (CEO of Innovation Group) | Co-creator of knowledge | Evolutionary (leapfrogging) Low: - Medium: Student mobility (from university to firm) High: Joint R&D (product development), technology licensing (jointly developed), and technical consultation | Role of intermediary person in building trust Mutual interest Firm is interested in product development while university researcher is interested to conduct industrial research Trust in researcher's capability (firm's executive was an alumnus of faculty of science, CU) Success of initial phase |
| Case 4: JR East and Keio | Research (prototype) developed by Keio University's student Informal collaboration (meeting at a party) | Co-creator of knowledge | Evolutionary (leapfrogging) Low: - Medium: Research mobility (from firm to university) High: Prototype demonstration, joint R&D | Mutual interest Firm is interested in product development while university researcher is interested to demonstrate prototype Capability of firm in foreseeing potential technology Trust in researcher's capability Success of initial phase |
| Case 5: | Informal collaboration | Co-creator of | Evolutionary (leapfrogging) | Role of intermediary body in |

| Case | Initial Condition | Capability of Firm | Development of UIC Activity (Level of Relational Intensity) | Reason for Starting and Continuing Collaboration |
|--|--|--|--|--|
| Large energy firms (Tokyo gas, Mitsubishi) and Tokodai | (Getting to know each other through SRL) Formal collaboration (Establishment of AES center) | knowledge | Low: - Medium: Researcher mobility (from firm to university) High: Joint R&D | building trust Mutual interest Firm is interested in knowledge creation while university researcher is interested to conduct advanced research Capability of firm in foreseeing potential technology Success of initial phase |
| Case 6: Betagro and KMUTT | Close relationship between executives of parties Informal collaboration (informal meeting between executives of both parties) | Co-creator of knowledge | Evolutionary (leapfrogging) Low: - Medium: Cooperative education, hire graduate, training for employee High: Joint R&D | Close relationship between two partners (trust between them) Mutual interest Firm needs quality human resources while university aims to develop the skills of students in response to firm's needs Success of initial phase |
| Case 7: Arith and RMUTL | Close relationship between firm executive and senior university researcher (used to be classmate) Informal collaboration (informal consultation and discussion) | Co-creator of knowledge At the beginning firm did not have high technological capability but it needed technological progress and had capability to learn | Evolutionary (leapfrogging) Low: - Medium: Cooperative education, hire graduate High: Joint R&D | Close relationship between two partners (trust between them) Mutual interest Initial phase: firm was interested in product development while university researcher is interested to conduct industrial research Intermediate phase to present: firm needs quality human resources while university aims to develop the skills of students in response to firm's needs Success of initial phase |
| Case 8: NTT and TIT | Close relationship between firm and head of laboratory (used to work at NTT) Mutual interest | Co-creator of knowledge | Non-Evolutionary Joint R&D The firm aim to conduct future technologies and jointly apply for patents in order to protect competitors | Close relationship between two partners (trust between two partners) Mutual interest Firm's intention in competitor protection while through patent registration university's interest in advanced research Success of initial phase |

| Case | Initial Condition | Capability of Firm | Development of UIC Activity (Level of Relational Intensity) | Reason for Starting and Continuing Collaboration |
|-------------------------|---|---|---|---|
| Case 9: Centara and DPU | Formal collaboration (MOU) Mutual interest | Co-creator of knowledge and knowledge user Both parties co-developed the training programs for the students One of MOU purposes is to train Centara employees | Non-Evolutionary Student mobility | Commitments of both parties' executives (trust between them) Mutual interest Firm needs quality human resources while university aims to develop the skills of students in response to firm's needs Success of initial phase |

4.3 Non-Starter Cases

This kind of cases is characterized as when the collaboration stopped at one-shot event. We found the four following reasons;

- 1) In case of nano carbon firm and TTI, firm had technological capabilities to collaborate with university, because it is a technology-based firm. The collaboration between firm and university could not be evolved because university researchers and company researchers were not interested in continue working (Case 10).
- 2) RMUTT's professor provided technical consultation on liquor fermentation to a micro enterprise which was a knowledge user. The firm used knowledge generated by the university professor. This case could not be evolved because a new partner emerged (Case 11). A role of existing partner is taken by a new partner.
- 3) RMUTT's university researchers assisted the community to set up machinery maintenance service center (with a support from local government) and trained technicians (with a support of Ministry of Science and

Technology). However, this case could not evolve because government support was terminated too early and community lacked a good management system to continue (Case 12).

Case 10: Collaboration between a nano carbon firm and Toyota Technological Institute (TTI)
A small carbon nanotube firm, established in Nagoya, produces carbon materials. It faced a problem on how to manipulate and control nanotube efficiently. University professors and this company developed a problem in to a research project proposal and applied for R&D grants from Japan Science and Technology Agency. This agency provided R&D grants for three years. After that, two parties carried out a joint research project and used R&D facilities at TTI. The result of this project was a technology which could pick one material to attach to another type of material efficiently. Researchers applied for a patent. Until now, two parties have not continued working together yet.
Source: M. Yoshimura, Interview, January 28, 2015.

Case 11: Collaboration between a local brewery entrepreneur and Rajamangala University of Technology Thanyaburi (RMUTT)

A RMUTT's professor knew a local brewery entrepreneur because of his friend. The relationship between them started with informal collaboration and could develop very well because the location of firm was close to the university and they had similar educational background (graduating in the same field). This professor provided an advice on how to make liquor not rancid in the fermentation. He sent students to make fermentation buckets for brewing liquor and gave fungus leavening to the entrepreneur. However, when this firm met a new business partner, this project was terminated. A new partner ordered this firm to produce liquor by using its own fungus leavening.

Source: C. Charoenchai, Interview, February 19, 2015.

Case 12: Collaboration between Local Community and RMUTL

After a science caravan festival at Longkhod District in Chiang Mai was over, Ministry of Science and Technology (MOST) and RMUTL invited community leaders to discuss and identify their problems. Longkhod District is an agricultural community which plants potatoes, longan, and mango. The selected issue was to establish Agricultural Machinery Maintenance Service Center, because this kind of center only existed in the central region far from this district. In order to set up the center, local government invested in infrastructure and equipment, whereas MOST supported for training of ten

technicians. However, the support from MOST was terminated within one year. After that, this service center stopped operating because it lacked of a good management system. Those technicians in the center resigned. Most of them opened small service centers in the community instead.

Source: N. Moonpa, Interview, February 10, 2015.

5. Conclusion

Key findings of case analysis partially contribute to the understanding of UIC as described below.

- 1) This article found different development paths of UIC activities and factors influencing those paths. Even two different national systems, two common development patterns were found. First, for evolutionary cases having changing types of collaboration overtime. Two development paths are either step-by-step or leapfrogging. How paths evolve depends on push and pull forces, technological capability of firms, trust built by intermediaries and two partners, and mutual interest. Interestingly, reverse or backward path may occur in leapfrogging cases when two parties want to explore new collaborative topics and send their researchers or students to work with their counterparts. Second, non-evolutionary cases i.e., type of activity has not changed over time, occurred when two partners have fixed specific goals. Different evolutionary paths and factors influencing them are summarized in Figure 2 and Table 3 respectively.

Figure 2: Development Paths of UIC Activity

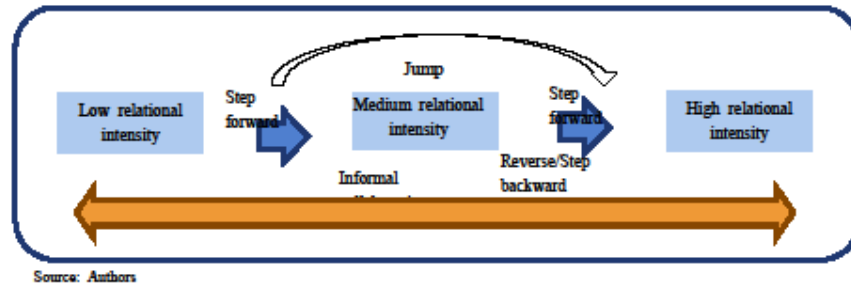


Table 3: Factor Affecting Development Path of UIC Activity

| Development Pattern | Development Path | Factor Affecting Development Path | | Why Two parties Start and Continue Working Together |
|---|--|--|---|---|
| | | Collaborating Firm's Technological and Learning Capability | Initial Condition of Collaboration | |
| Evolutionary: types of activities changed over time Factor affecting pattern Firm needed several types of activities. *Researcher mobility from company to university often happens in Japan but in Thailand, student mobility is much preferable. | Step-by-step (low-medium-high) | Knowledge user | Push-force Supply-Push: Research was developed by university researcher University researcher licensed technology to firm without fee Firm must work closely with expert Role of intermediary person or body in building trust Intermediary person introduces researchers to firms | Firm's awareness in importance of UIC activities University researcher's interest to conduct industrial research Trust between two partners Success of initial phase |
| | Leapfrogging (low-high, medium-high) (reverse/step backward: high-medium) | Co-creator of knowledge Firm with high technological capability Firm with need of technological progress | Pull-Force Demand-Pull: Firm wanted to improve or develop specific products or processes Role of intermediary person or body in building trust Intermediary person introduces researchers to firms and they decide to | High technological capability in foreseeing potential technology Firm's perception in product development University researcher's interest to conduct industrial research |

| Development Pattern | Development Path | Factor Affecting Development Path | | Why Two parties Start and Continue Working Together |
|---|-------------------|--|--|--|
| | | Collaborating Firm's Technological and Learning Capability | Initial Condition of Collaboration | |
| | | | work together. Then, they send researchers to explore research topics. When they need to explore new areas, another group of researchers are sent (step back from high to medium) Trust built by two partners Mutual interest Firm is interested in knowledge creation or product development while university researcher is interested to conduct advanced or industrial research | Trust between two partners Success of initial phase |
| Non-evolutionary: types of activities not changed over time Factor affecting pattern Type of activity was not changed because objectives and collaborative patterns were clearly set by both parties. | Use one only mode | Either co-creator of knowledge or knowledge user | Response to a specific need of firm Research topic defined by both parties before collaboration Trust built by two partners Mutual interest R&D: firm's intention in competitor protection while through patent registration university's interest in advanced research Education: firm needs quality human resources while university aims to develop the skills of students in response to firm's needs | Commitment of both parties' executives Trust between two partners Success of initial phase |

Source: Authors

- 2) In non-starter cases, activities have been terminated or not developed further due to following reasons; (a) soft institutional failure or failure in social values when partners are not interested to continue working, (b) capabilities failure when firms cannot maintain operating projects and (c) hard institution failure when government support is early terminated, and (d) a role of existing partner is taken by a new partner.
- 3) Our analysis disagrees with Shartinger et al. (2002). Leapfrogging path could occur. Use of medium and high relational intensity activity may take shorter time and may not need to proceed in order.
- 4) Types of activities may not change overtime if both parties define a fixed specific goal and collaborative pattern.
- 5) Mobility of people and informal interaction seem to be predominant activities for Japanese and Thai case. It can be a stepping stone to build relationship between two organizations.

6. Limitation and Further Study

The authors are aware that the case studies were not given by both parties; university and industry. The reason for not interviewing firms is that those case studies emerged from the field work exploring collaboration with the industry by different types of universities. In addition, the factors affecting the development paths were not explicitly hypothesized and tested by the interviewees but they were inductively derived from analysis of the case studies by the authors.

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However, human mobility in the Thai cases is mobility of students while researcher mobility from companies to universities frequently happened in the Japanese cases.

Understanding whether and how university-industry collaboration evolves overtime and factors underlying these evolutions can be very useful for drawing effective government interventions. For example, technology capabilities of prospective collaborating firms and attitude for cooperation of entrepreneurs should be evaluated before initiating collaborative projects. Intermediary persons and organizations as catalysts for initiating and deepening collaboration should be encouraged. Government supports should last long enough to sustain and deepen collaboration. Mobility of students and researchers as platform for building trust between university and industry should be promoted. Informal university-industry interaction in the form of forums and meetings should be initiated as a starting point for more substantial formal collaboration.

We, therefore, suggest that the following aspects identified by our study should be tested in further studies with larger sample size.

Two development paths of university and industry collaboration: a) step-by-step and b) leapfrogging.

Factors affecting the development paths of university and industry collaboration: a) firm's technological capability, b) push-pull force, c) role of intermediaries, d) trust, and e) mutual interest.

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