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

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

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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). Activities[3] 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; Ponomariov 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 knowledge[5]. 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 Ponomariov and Boardman (2012) grouped this mode into medium relational intensity. We disagree with conclusion of Ponomariov 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 (Urze, 2011).

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

**Table 1.** Indicator and classification of relational intensity activity

| Degree of Relational Intensity | Indicator | Activity |
|---|---|---|
| Low | • Mainly transfer of explicit knowledge<br>• Low level of personal interaction | Technology licensing |
| | | Use of publication |
| Medium | • Mainly transfer of tacit knowledge<br>• 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<br>• 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); Ponomariov and Boardman (2012); Merchán-Hernández and Valmaseda-Andia (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

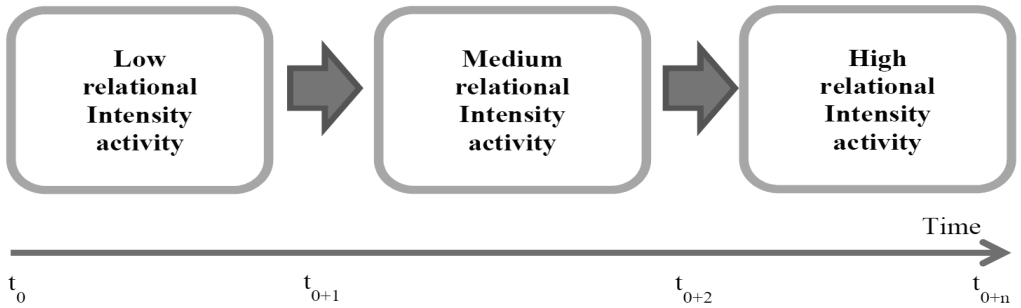
Qualitative case study method was applied to this article due to its ability to answer the why and how questions. This method could provide more detailed explanations of historical evolution of the university-industry collaboration by examining longitudinal changes of important collaborative projects. 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; Shartinger et al., 2002; Camison et al., 2009).

Two different development levels of national systems[6], 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.

**Figure 1.** Analytical framework for identifying development path of UIC activity




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

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).

(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, Japan[7]

The collaboration started when a university professor developed fish sauce having similar characteristic to that of soy sauce. It is the non-alcohol sauce which has domestic patent

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

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) businesses[8]

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 1996-2002[9].

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. Withyachumnarnkul, 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 imports[10]

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 research output of initial phase (high relational intensity). JRC sent a researcher to be a senior visiting*

10 For more information: http://www.lion.co.th/home.php

11 Innovation Group has developed to be a technology leaded 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.

*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 project-based professors searched for university researchers who had interests in working on their

12 Japan for Sustainability website

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: Summarized 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 province.[14]

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. Nopharatant, Interview, June 21, 2015.

*Collaboration between Artith Ventilators and RMUTL 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. Notably, when activity reached the high intensity, the development path reversed to medium relational*

13 For more information: https://aes.ssr.titech.ac.jp/english

14 For more information: http://www.betagro.com/index_th.php

*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 brand.[15]

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 TIT 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 (TIT)

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 business[16]

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 is to protect competitors to use future technologies. It does not aim to commercialize discovered technologies at this time. In addition, this

15 For more information: http://www.artith.com/

16 For more information: http://www.ntt.co.jp/index_e.html

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 training 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 & Resorts.[17]

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, for DPU students, and 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 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 cases

| 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<br>• Informal collaboration arranged by intermediary person (firm advisor) | Knowledge user | Evolutionary (step-by-step)<br>1. Low: Technology licensing<br>2. Medium: Researcher mobility (from university to firm)<br>3. High: Technical consultation and incubation | • Role of intermediary person in building trust<br>• Firm's understanding in the importance of UIC (send one staff to work at the university incubator after finishing the initial phase)<br>• University researcher's interest in industrial research (used to be a company researcher)<br>• Success of initial phase |

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 |
|---|---|---|---|---|
| Case 2: CP and MU | • Academic paper written by university researcher<br>• Capability of firm in foreseeing potential technology<br>• Firm's interest in product development<br>• Direct contact between firm and university researcher | Co-creator of knowledge | Evolutionary (leapfrogging)<br>1. Low: Use of publication<br>2. Medium: -<br>3. 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)<br>• Trust in researcher's capability (firm decided to directly contact university researcher when it read an academic paper)<br>• Success of initial phase |
| Case 3: Lion and CU | • Research (prototype) developed by university and Innovation Group<br>• Informal collaboration arranged by intermediary person (CEO of Innovation Group) | Co-creator of knowledge | Evolutionary (leapfrogging)<br>1. Low: -<br>2. Medium: Student mobility (from university to firm)<br>3. High: Joint R&D (product development), technology licensing (jointly developed), and technical consultation | • Role of intermediary person in building trust<br>• Mutual interest<br>- Firm is interested in product development while university researcher is interested in conducting industrial research<br>• Trust in researcher's capability (firm's executive was an alumnus of faculty of science, CU)<br>• Success of initial phase |
| Case 4: JR East and Keio | • Research (prototype) developed by Keio University's student<br>• Informal collaboration<br>• (meeting at aparty) | Co-creator of knowledge | Evolutionary (leapfrogging)<br>1. Low: -<br>2. Medium: Research mobility (from firm to university)<br>3. High: Prototype demonstration, joint R&D | • Mutual interest<br>- Firm is interested in product development while university researcher is interested to demonstrate prototype<br>• Capability of firm in foreseeing potential technology<br>• Trust in researcher's capability<br>• Success of initial phase |
| Case 5: Large energy firms (Tokyo gas, Mitsubishi) and Tokodai | • Informal collaboration (Getting to know each other through SRL)<br>• Formal collaboration<br>• (Establishment of AES center) | Co-creator of knowledge | Evolutionary (leapfrogging)<br>1. Low: -<br>2. Medium: Researcher mobility (from firm to university)<br>3. High: Joint R&D | • Role of intermediary body in building trust<br>• Mutual interest<br>- Firm is interested in knowledge creation while university researcher is interested to conduct advanced research<br>• Capability of firm in foreseeing potential technology<br>• 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 6: Betagro and KMUTT | • Close relationship between executives of parties<br>• Informal collaboration (informal meeting between executives of both parties) | Co-creator of knowledge | Evolutionary (leapfrogging)<br>1. Low: -<br>2. Medium: Cooperative education, hire graduate, training for employee<br>3. High: Joint R&D | • Close relationship (trust) between two partners<br>• Mutual interest<br>- Firm needs quality human resources while university aims to develop the skills of students in response to firm's needs<br>• Success of initial phase |
| Case 7: Artith and RMUTL | • Close relationship between firm executive and senior university researcher (used to be classmate)<br>• Informal collaboration<br>• (informal consultation and discussion) | Co-creator of knowledge<br><br>At the beginning firm did not have high technological capability but it needed technological progress and had capability to learn | Evolutionary (leapfrogging)<br>1. Low: -<br>2. Medium: Cooperative education, hire graduate<br>3. High: Joint R&D | • Close relationship (trust) between two partners<br>• Mutual interest<br>- Initial phase: firm was interested in product development while university researcher is interested to conduct industrial research<br>- Intermediate phase to present: firm needs quality human resources while university aims to develop the skills of students in response to firm's needs<br>• Success of initial phase |
| Case 8: NTT and TIT | • Close relationship between firm and head of laboratory (used to work at NTT)<br>• Mutual interest | Co-creator of knowledge | Non-Evolutionary<br>Joint R&D<br><br>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)<br>• Mutual interest<br>- Firm's intention in competitor protection while through patent registration university's interest in advanced research<br>• Success of initial phase |
| Case 9:<br><br>Centara and DPU | • Formal collaboration<br>• (MOU)<br>• Mutual interest | Co-creator of knowledge and knowledge user<br>Both parties co-developed the training programs for the students<br>One of MOU purposes is to train Centara employees | Non-Evolutionary<br>Student mobility | • Commitments of both parties' executives (trust between them)<br>• Mutual interest<br>- Firm needs quality human resources while university aims to develop the skills of students in response to firm's needs<br>• 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) RMUTL'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.
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.

**Figure 2.** Development paths of UIC activity

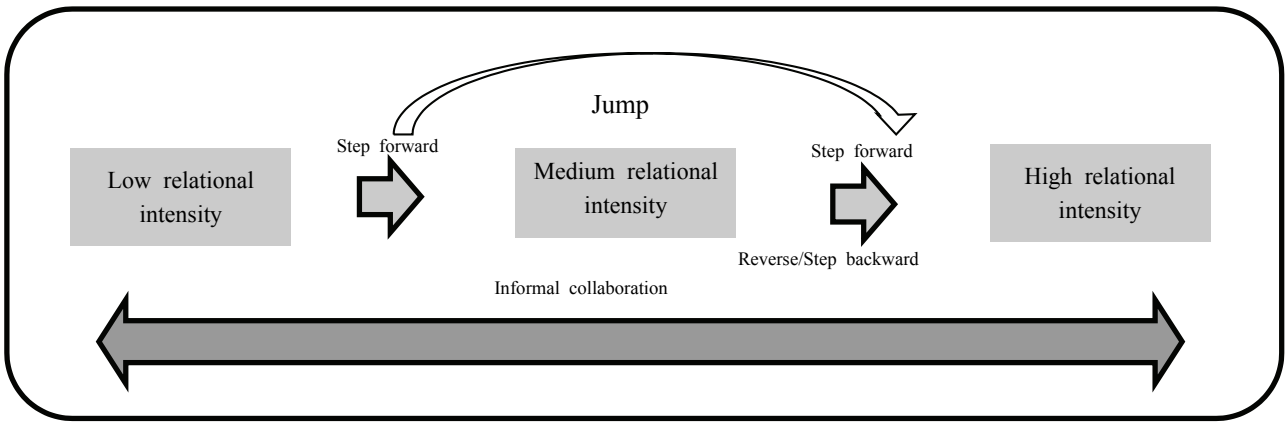


**Table 3.** Factor affecting development path of UIC activity

| 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 | |
| **1. Evolutionary: types of activities changed over time**<br><br>**Factor affecting pattern**<br>Firm needed several types of activities.<br>*Researcher mobility from company to university often happens in Japan but in Thailand, student mobility is much preferable. | 1.1 **Step-by-step** *(low-medium-high)* | Knowledge user | • Push-force<br>- Supply-Push: Research was developed by university researcher<br>- University researcher licensed technology to firm without fee<br>- Firm must work closely with expert<br>• Role of intermediary person or body in building trust<br>- Intermediary person introduces researchers to firms | • Firm's awareness in importance of UIC activities<br>• University researcher's interest to conduct industrial research<br>• Trust between two partners<br>• Success of initial phase |
| | 1.2 **Leapfrogging** *(low-high, medium-high)*<br><br>*(reverse/step backward: high-medium)* | • Co-creator of knowledge<br>- Firm with high technological capability<br>- Firm with need of technological progress | • Pull-Force<br>- Demand-Pull: Firm wanted to improve or develop specific products or processes<br>• Role of intermediary person or body in building trust<br>- Intermediary person introduces researchers to firms and they decide to 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)<br>• Trust built by two partners<br>• Mutual interest<br>- Firm is interested in knowledge creation or product development while university researcher is interested to conduct advanced or industrial research | • High technological capability in foreseeing potential technology<br>• Firm's perception in product development<br>• University researcher's interest to conduct industrial research<br>• Trust between two partners<br>• Success of initial phase |
| **1. Non-evolutionary: types of activities not changed over time**<br><br>**Factor affecting pattern**<br>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<br>• Research topic defined by both parties before collaboration<br>• Trust built by two partners<br>• Mutual interest<br>- R&D: firm's intention in competitor protection while through patent registartion university's interest in advanced research<br>- 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<br>• Trust between two partners<br>• Success of initial phase |

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. 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.

## 6. Limitations and Further Studies

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.

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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