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Author(s)	Siripitakchai, Naparat; Miyazaki, Kumiko
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Description	一般講演要旨

Technology Capacity Building and the University-Industry Linkage of the Thai Hard Disk Drive Industry

Naparat Siripitakchai, Kumiko Miyazaki

Graduate School of Innovation Management, Tokyo Institute of Technology

Abstract — University-Industry Linkage (UIL) is believed to be the important engine to drive the technology capacity in a developing country. The objective of this study is to investigate the types of channels of interaction between universities and firms and to analyze the types of technology capacity building and research network of the Thai HDD industry. The methodology and data are interviews, survey and bibliometric analysis based on the publications from ISI database and the Thai local publications in the HDD technology. The findings show that joint research is the most important channel to strengthen the collaboration in UIL and the technology capacity building in Thai HDD industry is diversified in process related technologies.

Keywords: Technology Capacity Building, University-Industry Linkage (UIL) and Developing Country

1. Introduction

The concept of National Innovation System (NIS) emphasizes that understanding the linkages among the various actors in the public and private sectors involving in innovation is the key to improving technology performance (Freeman, 1987; OECD, 1997). One of the most importance linkages is University-Industry Linkage (UIL) which play a significant role for the technology capacity in a developing country. Underlining the linkages, the actors are interacting through several channels. The variety of interactions among universities and firms can contribute to the wide range of technology and knowledge transfer.

In Thai HDD industry, there have been at least two important sets of UIL initiatives (Brimble and Doner, 2007). The HDD industry is one of the most important electronic industries in the manufacturing sector of Thailand. In 2010, Thailand is the second-largest production base for HDDs after China. However, the Thai HDD industry heavily relies on FDI and Multinational Company (MNC) subsidiaries. Although FDI by MNCs can bring both economic benefits and technological development, it can lead to the harmful effect if the developing countries do not deepen their technological capabilities in the long run.

Therefore, the objective of this study is to investigate the types of channels of interaction based on the degree of importance and degree of engagement in the UIL of the Thai HDD industry. The types of technology capacity building and research network are also analyzed. The findings may contribute to the policy recommendation for firms, universities and government in order to select the proper channels for the different type of actors.

The following section briefly defines the theoretical framework. The methodology is explained in section 3. Results and Findings are shown in section 4. Finally, Section 5 provides conclusion.

2. Theoretical Framework

2.1. Channels of interaction

According to the work of Fernandes et al. (2010); Este and Patel (2007); Inzelt (2004), the types of interaction or the channels of interactions can be classified into two main categories: one-directional channels including traditional channels, service channels and commercial channels and bi-directional channels. In this study, we used the same classification scheme but made some adaption of ad hoc channel grouping and added the particular channels existing in the Thai HDD industry such as technology transfer project from foreign countries and setting up or managing a laboratory at university. The revised categorized channels are one-directional channels, bi-directional channels and creation of physical facilities channels as shown Table 1. The revised list of channels is based on the literature reviews and preliminary interviews with the firms' managers.

We distinguish the creation of physical facilities channels from two types of knowledge and technology flow channels (one-directional and bi-directional). The objective of this channel is to create an embodied structure to strengthen the public, contract and joint research channels.

In this study, in addition to investigating the channels of interaction, we also observed the technology capability building in the UIL of the Thai HDD industry.

Table 1: Channels of interaction between firm and university

Category	Item
One-directional channel (OC)	Meeting
	Conference
	Consultancy service
	Have an internship/ co-op student
	Give or attend a training course at university
	Contract research
	Public research
Bi-directional channel (BC)	Training program for postgraduate at firm
	Technology transfer project from foreign country
	Joint research
Creation of physical facilities channel (CC)	Set up or managing a laboratory at university
	Involved in activities of industry/university cooperative center (I/UCRC)
	University personnel set up SME (firm) to support HDD industry

2.2. Technological capability building

The key capability for development in NIS of developing countries is related to accumulating technological capability. According to Pavitt and Bell (1992), they distinguished production capacity from technological capability. Technological learning (accumulation) is any process that strengthens the production and technology capabilities for generating and managing technical change. Pavitt and Bell (1992) concluded that the technological dynamism of industry is not automatic by-product of trade policy and investment policy in developing production capacity.

Hobday and Rush (2007) illustrated the technological capabilities upgrading in four levels including assembly, process engineering, product development and R&D. In their survey, the technological capabilities upgrading of MNC subsidiaries in Thai was in process engineering in 1990s.

In this study, we proposed that the technology capability upgrading in developing countries should be distinguished in product and process related technologies. In the manufacturing based economy like Thailand, there is the evidence which shows that firms and universities are collaborating on conducting R&D in process related technologies. Product related technologies and basic R&D seems to be less priority.

In the next section, the methodology to analyze the channels of interaction and technology capability building will be explained.

3. Methodology and Data

First of all, we analyzed the HDD industry and underlying technologies based on the firm's technology reports which are available on the firm's website together with the online newsletters. We also analyzed the Thai HDD industry based on the publicly available reports and booklets printed by the National Science Technology Development Agency (NSTDA). Based on these available data and information, we categorized the keywords to do the bibliometric analysis and created the list of questions for the survey.

We conducted a UIL survey together with interviews. The purpose of this survey is to study the channels of interaction in terms of the degree of importance and the degree of engagement. The target respondents are firm employees who have been involved with the activities related to university and academic personnel who are involved with firms in the Thai HDD industry.

The structure of the survey starts from the first section asking about general personal, organizational information. The survey contains numerical questions, multiple-choice questions, 5-point Likert-scale quantitative questions and open-ended qualitative questions. The questions ask about the initial reasons, objective and benefits for collaboration. The questions in the second sections are related to the channels of interaction asking about the frequency of interaction and the degree of importance according to the different types of channel. The data from the survey has been analyzed by using descriptive analysis.

The survey forms were submitted to 20 firm employees and 49 academics. The name list of firm's employees were recommended by the firm's R&D division while the name list of academic personnel and students were recommended by three industry-university cooperative research centers (I/UCRCs) in three universities: KKU; KMUTT; and KMITL.

Secondly, we investigated publications in order to observe research performance at international level from Thomson Reuters ISI database by using specific keywords related to the HDD technologies from 2000-2012 (June). The keywords are based on six categories: magnetic recording, read/write head, media, read channel, nano-fabrication, automation,

and ESD/contamination control. We retrieved 115 publications.

We also performed bibliometric analysis by using the national Data Storage Institute Conference (DST-CON) which is the forum for academia and industry to present their recent research works and exchange ideas in the area of Hard Disk Drive (HDD) and Data Storage Technology (DST). DST-CON, organized by a cooperative HDD group between HDD industry and academic institutes represented by three I/UCRCs. NSTDA is the main organizer of this collaborated activity. Therefore, the publications in this proceeding are directly related to the UIL projects. We retrieved 80 publications from DST-CON in 2011.

The result and finding will be explained in the next section.

4. Results and Findings

4.1. UIL Survey

According to the survey, the respondents were 16 firm employees from 2 HDD makers and 12 academic personnel from 6 universities. The response rates were 80% of firm employees and 22% of academic personnel.

The answers of quantitative questions and interviews are summarized as shown in Table 2. The firm employees tended to start the collaboration with the universities with which they had personal connection. Then the professor suggested connection to other professors or researchers in other universities. The research network still relies on personal connection.

The initial objective of the collaboration was sharing knowledge between firms and universities and finding an alternative solution for production improvement. While the firm has know-how to manage the technology, the university provides know-why as complementary capabilities to firm. The firm would like to leverage their employees' competency to conduct research. The additional funding from government is required for doing research to solve the production problem based on academic knowledge.

The expected benefit is acquiring knowledge, expertise, funding and training employees to acquire capability to conduct research. Sharing knowledge with other interdisciplinary actors can provide new ideas and solution. From this point of view, it shows that the technology transfer from only the parent company is not sufficient for the hi-tech industry. The endogenous technological capacity building is necessary. The management of subsidiaries concern the readiness of firm and local human resources to catch-up with the dynamic development of the industry. The answers show that firms are greatly interested to collaborate with universities.

4.1.1. Channel of interaction from the firms' perspective

More than 90% of the surveyed firm employees have been engaged in consultancy service, having internship or co-op students, meetings, joint research and training program for postgraduates. The least common type of channel is the one in which firm employees help university personnel set up SME (firm) to support HDD industry.

Table 3 shows the perspective of firms to interact with universities. Most of firm employees' answers show that variety of channels is important to strengthen collaboration. The bi-directional channel (BC) such as joint research and one-directional channel (OC) such as contract research are the most important channels. These two channels are supported by the government agency and three I/UCRCs by providing research network and partial funding for university which is engaged in collaborative research. Interestingly, the technology transfer project from foreign country by sending firm employees, academic personnel and government researchers to parent companies seem to be a less important channel even if it is proposed as an important channel in the policy planning phase. Training course is ranked as the least important channel. The transferred and trained knowledge and technology might not match with the demand of firms.

In the case of university personnel setting up SME (firm) to support HDD industry, since the SMEs who would like to deal business with the HDD makers have to pass a list of regulation of firms, the barrier to entry is high for new SMEs.

4.1.2. Channel of interaction from the universities' perspective

More than 70% of academic personnel have been engaged with firms in meetings, joint research, involving the activities of I/UCRCs, setting-up or managing a laboratory at university, conference and consultancy service. The variety of interaction in the case of academic personnel is less than firm employees.

According to Table 3, it also shows the consistent result with those of firm employees about an optimistic perspective of academic personnel to

Table 2: The reasons and objective for collaboration within UIL

	Firms' Perspective	Universities' Perspective
How collaboration started?	The firm employees tend to started the collaboration with the universities which they had personal connection.	The collaboration with firms started from personal connection.
The objective of initial collaboration	To acquire knowledge, expertise, funding and training employees to acquire capability to conduct research	To find new research topic and funding
The expected benefit of initial collaboration	Sharing knowledge with other interdisciplinary actors can provide new ideas and solution.	Acquiring technology transfer from firm and producing graduates with the real industrial experience.

Table 3: Channels of interaction and degree of importance

Type of channel	Item	Firms' Perspective				Universities' Perspective			
		Degree of importance		Moderately and very important		Degree of importance		Moderately and very important	
		Mean	Std. Deviation	N	%	Mean	Std. Deviation	N	%
OC	Meeting	3.69	0.95	15	94%	3.92	0.9	11	92%
	Conference	3.56	0.96	14	88%	3.67	0.98	11	92%
	Consultancy service	3.94	0.77	16	100%	4	0.85	12	100%
	Have an internship/ co-op student	3.94	0.85	15	94%	4	0.85	11	92%
	Give or attend a training course at university	3.25	0.93	14	88%	3.25	1.14	9	75%
	Contract research	4.38	0.72	16	100%	3.58	1	11	92%
	Public research	3.63	0.81	15	94%	3.08	1.08	9	75%
BC	Training program for postgraduate at firm	3.69	0.6	16	100%	3.83	0.83	12	100%
	Technology transfer project from foreign country	3.63	1.02	14	88%	3.58	1.24	9	75%
	Joint research	4.5	0.52	16	100%	4.33	0.65	12	100%
CC	Set up or managing a laboratory at university	3.63	0.96	15	94%	3.33	1.5	7	58%
	Involved in activities of I/UCRC	3.75	0.58	16	100%	3.33	1.23	9	75%
	University personnel set up SME (firm) to support HDD industry	3.56	0.89	14	88%	3.08	1.24	8	67%

interact with firms. The bi-directional channel (BC) such as joint research and one-directional channel (OC) such as consultancy services are the most important channels. The technology transfer project from foreign country and training course are ranked as less important channels. The transferred and trained knowledge and technology might not match with the demand of academic personnel. The channel in which university personnel set up SME (firm) to support HDD industry is the least important channel.

Based on the firm employees and academic personnel's perspectives, the training course is less important than other channels. However, it does not mean that it is not important. The ranking of channel based on the degree of importance is for policy makers to decide and allocate the budget to strengthen the variety of interaction. Moreover, the benefit about training employees to improve their competences may come from several channels including joint research and attending conference.

4.2. Technological capability building in Thai HDD industry

4.2.1. International level

In case of international research performance, we found that there is no publication in read channel technology as shown in Figure 1. In case of Read/Write Head technology, it is not surprising that the number of publications is high because Thailand has been the base of Read/Write Head manufacturing for several decades. The publications in nano-fabrication and automation are not directly related to the HDD industry. This shows that the research activities do not cover all technology areas at international level.

Moreover, the content of the co-publications

between universities and HDD makers are related to both product and process related technologies while university publications are more related to process technology as shown in Figure 2.

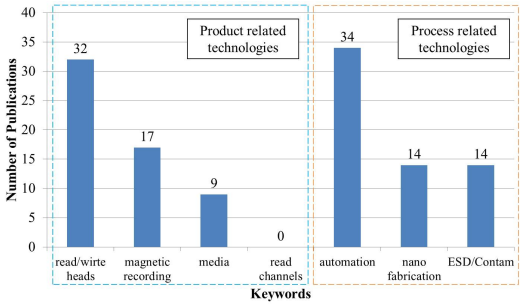

Figure 1: Thai publications classified by groups of keywords from 2000-2012 (complied by author from ISI database)

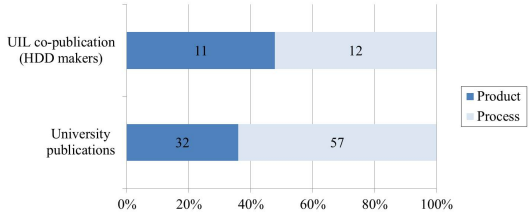

Figure 2: UIL co-publications and university publications as percentages of product and process related technology from 2000-2012 (complied by author from ISI database)

When we analyze the co-publication network we found that there are collaborations between MNCs subsidiaries (HDD makers) and Thai Universities.

4.2.2. National level

After investigating Thai publications from DST-CON, we found that there is no publication in read channel technology which is the same result as shown at the international level as shown in Figure 3. Interestingly, the number of publications in automation is the highest. This shows a clear research direction of current UIL in the Thai HDD industry in process R&D. The content of the co-publications between universities and HDD makers and university publications is more related to process technology as shown in Figure 4.

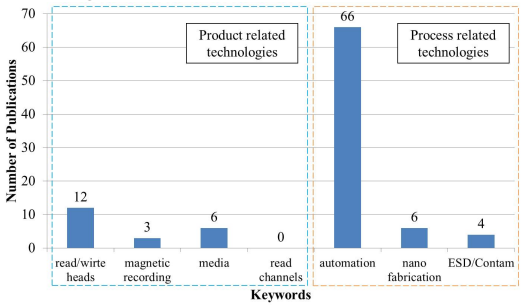

Figure 3: Number of the Thai publications classified by groups of keywords (complied by author from DST-CON2011 proceeding)

The content of the co-publications between universities and HDD makers and university publications is more related to process technology as shown in Figure 4.

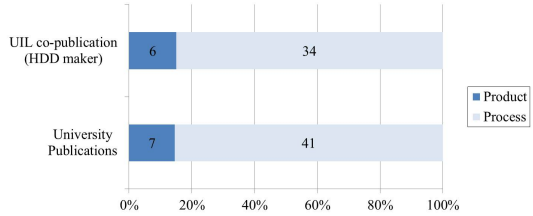

Figure 4: UIL co-publications and university publications as percentages of product and process related technology (complied by author from DST-CON 2011 proceeding)

The co-publication network at national level can give a more broad perspective. Not only the HDD makers but also some suppliers have collaboration with universities in conducting research. Focusing on the UIL in the case of universities and HDD makers and in the case of universities and suppliers, we found that the linkage between HDD makers and Thai Universities is more complex and stronger than the latter.

5. Conclusions

According to this study, firms show great demand for collaboration from universities. The finding is different from the previous study about UIL in Thailand which pointed out that firms do not regard universities as important sources of information and knowledge. On the other hand, Thai universities would like to collaborate with firms in order to complement their knowledge and research in real manufacturing. This aims at reducing the mismatch between research conducted in universities and the required knowledge and technologies within the manufacturing sector. In fact, the transferred technology which universities provide to firms is not the embodied technology such as product and machinery. Universities share the experiences of conducting research and academic problem-solving skill with the firms and this can help provide the R&D capability building in firms.

Joint research is the most important channel to strengthen the collaboration between firms and universities while technology transfer projects from foreign country and attending training course are less important channel for both firm employees and academic personnel. From this point of view, it shows that the technology transfer from only the parent company is not sufficient for the hi-tech industry. The endogenous technological capacity building is

necessary.

The reason joint research is ranked as the most important channel might be because actors can share not only explicit knowledge such as manuals, documents, procedures but also tacit knowledge including know-how and individual experiences. They can share and transfer knowledge while they collaborate in doing research through this channel.

The management of subsidiaries concerns the readiness of firms and local human resources to catch-up with the dynamic development of the industry. To do so, the access to universities' facilities and resources was beneficial for firms in order to improve the firm employees' R&D capability building. On the other hand, academic personnel would like to conduct research to the real situation of manufacturing-dominated economy. However, it is still difficult for university to access the knowledge and technology of firms because of its high confidential level. Therefore, the individually transferred tacit knowledge and technology between firm employee and academic personnel is highly demanded in the collaboration. Interestingly, publications and patents are not the expected result from the collaboration.

Moreover, in this study, it also shows that the type of technology capacity building in Thai HDD industry is diversified in process technology. There is still a lack of R&D in field of product related technologies.

Policy makers should allocate an adequate budget to intensely support the joint research not just focusing on the technology transfer project from foreign countries and training firm employees and academic personnel. The training course should be provided for students who would like to improve their competencies to the level of firm employees and academic advisor in order to participate in the joint research project. The joint project evaluation should be based on mutual discussion among firms, universities and government.

In future work, we would like to further investigate the pattern of interaction including the benefits and barriers to engage within UIL in the hi-tech industry of developing countries.

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