

# CHAPTER I

## INTRODUCTION

### Rationale for the Study

#### 1. Introduction

Competitiveness has become a core function of the ability of firms to innovate quickly and efficiently in the context of globalization. The intense competitions, short product life-cycles, increase of costs, have made an individual firm more difficult in generating and applying knowledge and began to realize the importance of technology transfer to enhance their capabilities and performances such as productivity, product quality and diversity, cost saving and market share and entry (Calantone, Lee, and Gross, 1988; Benedetto, Calantone, and Zhang, 2003 as cited in Waroonkun, 2007). In this context, firms in knowledge-intensive industries are searching for research partnerships with universities to be transferred knowledge and technology for developing innovative technologies, meeting the burdens of research and development (R&D) investment and supporting their economic structure (Levy and Samuels, 1992; Phan and Siegel, 2006). This is emphasized by the increase in corporate sponsorships in research at universities in many developed countries and in developing countries including Thailand.

Various forms and approaches of technology transfer under the university-industry (U-I) collaboration including joint research recently appear to play more roles in developing technology and innovation for economic rents. Various scientific progresses and discoveries occurred in many research fields are the result of the technology transfer under the U-I joint research (BHEF, 2001). According to Link and Tassef (1989), from the U-I joint research, the industry can acquire knowledge from the university and gain benefit through access to students and professors; access to technology for problem solving; access to university facilities and obtain state-of-the-art information; prestige; economical use of resources; and support of technical excellence. University researchers benefit from joint research and cooperation with the industry through access of scientific and technical areas where industry has special

expertise and find the opportunity to expose students to practical problems; use of earmarked government funds; and potential employment for graduates. The university is also influenced by the industry in terms of setting goals and process for talents training and system of scientific and technological innovation (Tomiura, 1998).

Number of the U-I joint research for technology transfer is higher in developed countries. However, it is still in question as little in developing countries. There is a large amount of literatures related to the U-I collaboration and technology transfer particularly in the developed country contexts but it is not obvious that the recommended models or frameworks from those studies are suitable for the developing countries like Thailand. In addition, the study on the integrated U-I joint research and technology transfer related to the renewable energy particularly photovoltaic technology, currently, has received little studies. There are important areas that have been rarely systematically explored in the field of U-I collaboration and technology transfer such as what factors affect the growth and the effective U-I joint research for photovoltaic technology transfer (UIJRPTT) and how to improve the situation. The identification and uncovering of the barriers and factors influencing and impeding the growth and effective of UIJRPTT in Thailand can provide empirical evidences for the literatures and shed greater light on what can be done to improve the unprogressive UIJRPTT situation in Thailand and other developing countries.

## **2. The Thai Context**

In Thailand, overall U-I joint research for technology transfer is increasing but the proportion is reported not high and structurally diverse. This is because the research commercialization in Thailand is just starting and potentials for comprehensive links with the private sector are still weak (Schiller and Liefner, 2007). Most U-I joint research projects in Thailand reported merely involve informal and personal contacts. The university's technological services either do not include detailed research (Inzelt, 2004).

However, the increasing trend of the U-I joint research can be drawn from the fact that Thai universities realize that the linkage, relationship and research cooperation with the industries can enhance their academic performances and social responsibility roles in enhancing the capabilities of the country. After the education reform, which is the result of the proclamation of the constitution in 1997 and the

National Education Act in 1999, many universities set their goals to be “research-based university” which is relevant to the practice of education standard and quality assessment aiming the Thai universities and faculty members to conduct more researches. By conducting U-I joint research, the university are allowed to upgrade unique academic profile, improve academic quality and be granted more research funding (e.g. from research agencies) particularly when many of universities are becoming “autonomous university”.

The government plays an important role as technology facilitator and supporter for more research and joint research activities between university and industry and technology transfer. In terms of photovoltaic technology development, although there has been no specific strategy for the support of photovoltaic technology development, the government has funded basic research and development (R&D) in the university at a reasonable level. Despite none of the university established major research center for photovoltaic in Thailand, many universities namely Chulalongkorn University (CU), Kasetsart University (KU), Khon Kane University (KKU), King Mongkut’s University of Technology Ladkrabang (KMITL), King Mongkut’s University of Technology Thonburi (KMUTT), Mahidol University (MU), Naresuan University (NU), and Silpakorn University (SU) established laboratories and research groups conducting researches related to photovoltaic technology development. There are a four other universities with small groups of people conducting photovoltaic researches. The Semiconductor Device Research Laboratory (SDRL) under the Department of Engineering at CU started silicon based photovoltaic research since 1979 and amorphous photovoltaic technology in 1988. The School of Renewable Energy Technology (SERT), NU, was established in 1995 (the former name is Solar Energy Research and Training Center). The Semiconductor Physics Research Laboratory (SPRL) under the Department of Physic, Faculty of Science, in CU, as well as the Renewable Energy Applications Laboratory (REAL) in the Department of Electrical Engineering at KMUTL and the Center for Alternative Energy (CAE) in MU were later established and operated under the support of the universities and government’s budget. Most university laboratories and research groups are received support from the National Science and Technology Development Agency (NSTDA) and the National Research Council of Thailand (NRCT), Thailand Research Fund

(TRF) as well as the Ministry of Energy, and university grants but must regularly prepare grant applications in order to secure continued funding. The government encourages the collaboration in research work between the university and industry in the criteria of various funds particularly from the TRF. Moreover, the governmental Institute of Solar Energy Technology Development (SOLARTEC), established since 1998 as the Energy Technology Center, and Energy and Clean Technology Center Project, and promoted in 2005 as the core competent organization for photovoltaic technology development and technology transfer under the supervision of NSTDA also works closely with the university and industry in developing and co-conducting research as well as licensing photovoltaic technology.

The government supports the renewable energy market development program by implementing the renewable energy strategic plan and roof top programs in 2003. Followed by the national strategy on renewable energy during the year 2008-2011, the government stressed its ambition to increase mandatory share of renewable energy to 8% in 2008. The government, in the same year, also announced a 15-year renewable energy development plan that detailed incentives and tax break for renewable energy including solar power investment and researches. Viewing the benefits and opportunities from the government policy support and market development, several photovoltaic manufacturers were established in 2003. Today, the industry is a technology-based industry comprising of five major companies. It employs almost 1,000 employees and has been invested around 5,700 million baht in capital goods. The industry mainly imports technology and raw materials for further producing and/or assembling their products for export.

Considering the nature of the industry, in order to be competitive and survive in the global market, the Thai photovoltaic industry needs to reduce cost/MWp, increase its quality and performance of photovoltaic cells and module and further develop innovation. Without technology breakthrough that can bring the steeply down price and cost of photovoltaic products and new innovation of products and process manufacturing to sustain and increase the product efficiency, the industry might not be able to survive in the long term period (Sichanugrist, 2008). This is due to the fact that the efficiency of the current generation of photovoltaic technology has been continuously increasing and its new generation is continuously developed with

much higher efficiency. Moreover, due to the financial crisis in the U.S. and European countries started in 2008-2009, the industry has been affected by the diminishing demand of the international market and it is expected that the price of photovoltaic cells and modules will be lower within short and long term period which will lead to more competitions among the photovoltaic industries. Therefore, the cooperation with the Thai university may be another way for the Thai photovoltaic industry to work on its technology development for its growth and competitiveness in the global market.

From the mentioned contexts, the U-I joint research for photovoltaic technology transfer should have been significantly increasing. However, in fact, during the past five years, experience revealed that the UIJRPTT rarely occurred. Moreover, from investigation of patent search, no registered patent between Thai university and photovoltaic industry was found. The U-I joint research activities related to photovoltaic industry in Thailand are few and some are only the supporting roles of some universities such as CU and KMUTT under the joint research project between the industry and SOLARTEC in the field of thin film silicon solar cell and dye-sensitized solar cell (SOLARTEC, 2009a, 2009b). This fact raises two fundamental questions related to the limited growth of U-I joint research and the effective UIJRPTT in Thailand. The first concerns with the value significance of the U-I joint research. Is U-I joint research not an efficient and productive mean of generative photovoltaic technology that can create economic and intellectual value? Does the practice of UIJRPTT have any impact on the ability of Thai firms to compete in the global competitive markets and of university to achieve the goal for research-based university? How to make university and industry value joint research significance and cooperate more? The second question concerns the functioning of the UIJRPTT and how to improve the effective UIJRPTT.

### **3. Past and Existing Studies**

Past and existing literatures involving U-I collaboration and technology transfer explain why there is limited number of U-I collaboration and some indicate barriers and factors for effective U-I collaboration and technology transfer. Samli (1985) identifies five barriers to successful technology transfer: culture, economy, people, business and government. Saad, Cicmil, and Greenwood (2002) state that the transferee's knowledge and technical capabilities, the economic, social, cultural,

institutional and political environment influence forms and effectiveness of technology transfer. TDRI (1992) states that inadequate supply of technical human resources, inadequate technical information service, inadequate technical services, tax structure, linkage to S&T communities and attitude of entrepreneurs affecting the technology transfer process in Thailand. Phan and Siegel (2006) state that effective technology transfer through U-I joint research relating to institutional factor (university policies, shared values, incentive system), organizational factor (skill deficiencies in technology transfer offices, structural design, information flows, legal form) and individual factor (professional ethics, personal goals and attitudes, skills-knowledge experience). Santoro and Gopalakrishnan (2001) state that the U-I relationship that facilitates technology transfer comes from the relationship-oriented factors such as trust, geographic proximity, effective communication, and university policies for intellectual property rights (IPR), patents and licenses.

For the purpose of this research, based on theoretical perspectives and existing studies from technology transfer and U-I collaboration which were reviewed in detail in Chapter II, the author identified three hypothesized groups of factors including *characteristics of university*, *characteristic of industry* and *transfer context and organizational structure* as factors affecting growth and acting as barriers of the UIJRPTT in Thailand. Three enabling factors were also developed by hypothesizing that they may likely influence the effective UIJRPTT. Those hypothesized factors included *characteristics and the perspectives of the university*, *characteristics and perspectives of industry* and *joint research mechanism*. The performance and interrelationship of the factors were hypothesized that they may significantly contribute to the degree of growth and economic and quality performance which hypothesized as the outcome factor of the effective UIJRPTT defined in this research. The detail of justification of factors and variables were illustrated and identified in the following chapters.

### **Purpose of the Study**

The objectives of this research were: (1) to identify and analyze the factors affecting growth and effectiveness of UIJRPTT in Thailand; and (2) to develop a model for effective UIJRPTT. The author employed the mix research approach in

analyzing the qualitative and quantitative data collected by the questionnaire survey and in-depth interview with professionals in the Thai university and the photovoltaic industry as well as the information collection from reliable source.

Drawn from the research objectives, three questions were addressed with an assumption that joint research is beneficial to both university and industry and the relationship between the Thai university and the photovoltaic industry were complementarily promoted the organizations concerned.

**First Question:** Why there is little number of U-I joint research for photovoltaic technology transfer in Thailand?

The first question concerned with the factors that hindered the growth of the UIJRPTT under the existing theoretical studies. More questions included: How do Thai universities and photovoltaic industry view U-I joint research? What are the factors that influence them to and not to conduct the UIJRPTT? What are the most negative influential factors as barriers to the growth of the U-I joint research? To what extent those factors affect the decision making of universities and industry?

**Second Question:** What are the factors affecting the effective U-I joint research for photovoltaic technology transfer in Thailand?

The second question considered the perspectives of the universities and the photovoltaic industry on the factors that influence the effective UIJRPTT. More questions included: What are the most influential factors that affect the effective UIJRPTT? What model for the effective UIJRPTT should be? To what extent those factors affect the effective UIJRPTT?

**Third Question:** How to increase the effective U-I joint research for photovoltaic technology transfer?

It did not mean that the factors that hindered the growth and effectiveness of UIJRPTT would not happen. Rather, this research tried to address practical suggestions for overcoming the barriers and facilitate the UIJRPTT. The thesis looked for and described the characteristics and perspectives of the university and industry and mechanism of joint research cooperation that enabled the university, the industry and the government to avoid the difficulties and make the U-I joint research effective for all parties in the Thai context.

### **Significance of the Study**

The significance of the study could be identified in two aspects. First, the study and analysis of the factors that affected growth and effectiveness of the UIJRPTT in Thailand would allow the university and the industry as well as the government organizations concerned evaluate the strength, weakness, opportunity and problems related to the UIJRPTT clearly. This could lead to the formulation of directions and problem solutions to effectively manage and promote the UIJRPTT. The increase in effective UIJRPTT could, as a result, enhance the development of human resources and technology in the field of photovoltaic. The industry would also become less dependent on foreign technology, and be more competitive. That benefit could enhance the renewable energy industry and applications in Thailand. Secondly, in terms of theoretical perspectives, even though a large number of studies addressing the formulation, determinants, and success of the U-I collaboration and technology transfer, limited number of studies has paid attention to the U-I joint research for technology transfer in renewable energy technology particularly the photovoltaic technology and industry in developing countries. Studying this topic could provide more empirical evidences for the relevant academic studies. Moreover, the developed model of effective UIJRPTT which explained the interrelations between the U-I collaboration organization mechanism, technology transferor and transferees characteristics in promoting U-I joint research in developing countries as well as the roles of the government in supporting the emerging technology could extend the confirmation on factors and variables derived from literatures in the U-I joint research, technology transfer and organization management.

### **Scope of the Study**

The scope of this research was limited to the identification and analysis of factors that affected growth and effectiveness of UIJRPTT in Thailand and the development and validation of an effective model of UIJRPTT in the context of the Thai photovoltaic industry and Thai university by which the hypothesized factors derived from past and existing studies related to U-I collaboration and technology transfer. The analysis of the root cause of the factor affecting growth and the formulated UIJRPTT model in this study could help improve the understanding in the

significant factors, the interaction between the factors and the outcomes. Practical suggestions for overcoming the barriers and facilitating the effective UIJRPTT were recommended at the end of this research.

It should be noted that this research only targeted respondents from the relatively small group of Thai photovoltaic industry professionals such as chief executives officers (CEOs), head of departments, process and production engineers, scientists and staffs who have been working in the photovoltaic cells and module manufacturing firms and the university faculty members, researchers and PhD students who have been conducting photovoltaic research, offering courses in various faculties, laboratories, and research groups and administrative officers who have been working in the technology transfer office and research affairs. The period of conducting the research is during March 2009 - January 2010.

### **Definition of Terms**

In this research “university” is defined as the university in Thailand that its faculty and research units engaging in the photovoltaic technology related research. “Industry” is defined as group of industrial firms engaging in manufacturing photovoltaic cells and/or assembling the photovoltaic modules.

The meaning of “U-I joint research” in this thesis is defined as a research relationships and collaboration between university and industry that can be referred in many different interactions. According to the study of BHEF (2001), forms of “U-I joint research” can be identified in five research mechanisms, those are:

1. **Sponsored research:** The most frequent form of research relationship, which involves companies directly funding university research;
2. **Collaborative research:** University-industry research partnerships that are encouraged through partial governmental funding;
3. **Consortia:** Groups of companies and universities engage in various research efforts of common group interest;
4. **Technology licensing:** Licensing of university patents (usually stemming from federally funded research) to companies for commercialization;
5. **Exchange of research materials:** Used to expedite the performance of research and accomplished through material transfer agreements.

“Technology” refers to new and better idea of achieving economic ends (Nihei, 1987), the theoretical and practical knowledge, skills and artifacts that can be used to develop products and services, and the production and delivery system (Williams and Gibson, 1990; Burgelman, Clayton, and Wheelwright, 2004). “Technology transfer” in this research is defined as physical assets, information, both technical and commercial, human skills that are transferred between Thai university and industry in the field of photovoltaic technology.

The “effective U-I joint research for photovoltaic technology transfer (UIJRPTT)” is defined as the U-I joint research in the mentioned forms related to the transfer of photovoltaic technology that can be measured by the greater growth of number of U-I joint research and greater quality and economic performance of the results from the technology transfer under the U-I joint research. The quality performance is defined as the degree to which joint research program and mechanism can help improve innovation in products and process, technology, and better quality of research result. The economic performance is defined as the degree to which joint research program and mechanism can help reduce investment in resources, less time in conducting research, and gain benefits from intellectual property rights.

“Characteristics and perspectives of university” in this thesis refers to the attributes of the university and the perspectives of the professionals in the university, where the research units/faculty are conducting research related to the photovoltaic technology, which can define the effective UIJRPTT. Those characteristics and perspectives include four hypothesized factors namely: (1) capability in receiving and transferring technology in terms of technique and funds; (2) adequate specialists, researchers and students; (3) adequate research tools and equipment and (4) willingness and motivation for teamwork and shared value.

“Characteristics and perspectives of industry” in this thesis refers to the attributes of the photovoltaic industry and the perspectives of the professionals in the photovoltaic industry, that comprise of five manufacturing and assembling photovoltaic firms, which can affect the effective UIJRPTT. Those characteristics and perspectives include four hypothesized factors namely: (1) capability in receiving and transferring technology in terms of technique and funds; (2) willingness and motivation in working with university with shared value; (3) perspectives on

worthiness and value of joint research in terms of economic and intelligence value and (4) understanding cultural differences.

“Joint research mechanism” is defined to system and pathway that relates to the work to promote, support, maintain and develop the joint research and technology transfer between the university and industry which can determine the effective UIJRPTT. The joint research mechanism includes four hypothesized factors which are: (1) communication effectiveness; (2) management of coordination office and joint research program; (3) IP management and (4) incentive system.

### **Thesis Layout**

This thesis is organized as follows. Chapter II provides a review of technology transfer, U-I collaboration, U-I joint research in Thailand, Thai photovoltaic industry and existing models and studies related to technology transfer and U-I collaboration. The relevant factors affecting growth and effectiveness of the UIJRPTT are examined. The conceptual model of effective UIJRPTT is developed. Chapter III, several methodologies are presented. Chapter IV reports the empirical results derived from the quantitative and qualitative methods related to the factors affecting growth and effective UIJRPTT from the model. This chapter report is divided into three major parts. Part One provides background of respondents and their perspectives on the UIJRPTT. Part Two presents the analysis of factor affecting the growth of the UIJRPTT. Part Three presents the statistical results on the factors influencing the effective UIJRPTT and the development of the model of effective UIJRPTT as well as the current status of the factors and confirmation of the factors and suggestions derived from qualitative data. The discussion of the research results was provided at the end of the last two parts. Part Four involves with the effective UIJRPTT model validation process. Chapter V summarizes major findings, and presents the recommendations, as well as the contributions, limitation and future areas of future research.