Deficiencies of University-Industry Joint Research for Photovoltaic Technology Transfer in Thailand

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ABSTRACT

University-industry joint research is a major source of technology transfer that could increase the knowledge and capabilities of both parties. However, experience has shown that during the past five years, there has been very little number of U-I joint researches for photovoltaic technology transfer (UIJRPTT) in Thailand. This paper aims to answer the question of why there is limited number of the UIJRPTT in Thailand. The factors driving and barriers impeding the UIJRPTT were investigated to answer the question. The understanding of the factors will be a valuable contribution for the policy makers from the university, the industry as well as the government agencies concerned in supporting and solving the problems related to the UIJRPTT.

Keywords: Technology transfer, U-I joint research, Photovoltaic technology, Barriers to technology transfer, Factors affecting U-I joint research

1. Introduction

Both university and photovoltaic industry in Thailand valued the university-industry (U-I) joint research as a source of technology transfer that could increase their knowledge and capabilities. However, experiences revealed that during the past five years (2004-2008), the university and industry conducted little number of official U-I joint projects and there was no record of patents related to photovoltaic technology registered under the U-I joint research project. The question is why there is little number of the U-I joint research for photovoltaic technology transfer (UIJRPTT) in Thailand and how to improve the situation. This paper aimed to answer the question by identifying determinant factors and barriers of the UIJRPTT. The author hypothesized three groups of factors: characteristics of university, characteristics of industry and transfer context and organizational structure as factors affecting the growth of the UIJRPTT in Thailand. By collecting the quantitative and qualitative data through the questionnaire survey and interview, the justification and analyzing those factors were conducted to answer the question.

2. Literature Review

Existing studies in U-I collaboration and technology transfer investigated factors and barriers affecting and impeding the growth, effectiveness and successful of the U-I collaboration, joint research and technology transfer by analyzing the university-government-firm context through economic, organization, culture, and management theories. For the purpose of this study, based on existing studies, the author developed three categories of factors influencing the growth of the U-I joint research for photovoltaic technology transfers in Thailand. Those included: characteristic of university, characteristic of industry, and transfer context and organizational structure.

2.2.1 Characteristics of University

Several studies explore how characteristics of university affect the formation and growth of the U-I joint research and technology transfer (BHEF, 2001; Casey, 2004; Fontana et al, 2006; Siegel, et al. 2004; Szulanski, 1996, 2000). The interest of characteristics of university was involved with the university reliable knowledge and technical source. The university with strong knowledge base and capabilities are attractive to the industry to conduct the joint research for technology transfer. With capabilities, university can explore and exploit tacit knowledge in developing technology and innovation. Szulanski (1996) emphasizes lack of perceived reliability of the transfer source affect the technology transfer in the initial stage. Some studies (e.g. BHEF, 2001; and Siegel et al, 2004) find that motivation of university staffs affect their intention to conduct the joint research for technology transfer. They may perceive inadequate rewards for sharing. They may be unwilling to commit time and resources to the transfer. The potential impact on faculty and students to work with the industry may also raise concern and hinder faculty lecturers and students from their own academic works, inappropriate involving in confidential research, and restriction on publication. Some studies find that difficulties in negotiating and managing collaboration of the university affect the growth of the U-I joint research for technology transfer (BHEF, 2001, Heide et al, 2002). Those difficulties include loss of academic freedom, lack of structure to find partners, risks on fund, communication skill and lack of management consistency.

2.2.2 Characteristics of Industry

Growth of U-I joint research depends on the characteristics of industry. Szulanski (2000) and Giuliani and Arza (2009) stated that firms with strong knowledge base are capable in searching and exploiting knowledge and those with higher knowledge and R&D intensity will collaborate more with university. Low level of technical knowledge and absorptive capacity of firms may impede technology transfer (Miesing et al, 2006). The motivation to learn new thing to develop innovative product and process development and the attitude of firms on value of research collaboration are also important in constituting the appreciation and the relationship. However, BHEF (2001) and Levy and Samuels (1992) also state that management concern affect the decision to conduct the U-I joint research. Those include the level of corporate concern and support for research collaborations which depends on cost, time to complete, and the risk of losing control of proprietary information. Firms are either not always predisposed to see universities as a source of relevant ideas as many do not believe that university researchers have valuable insights.

2.2.3 Transfer Context and Organizational Structure

Previous research has shown that transfer context organizational structure affects the growth of the U-I joint research for technology transfer. In the Thai context, TDRI (1992) and Manaiyapong (2004) state that inadequate infrastructure such as inadequate supply of technical human resources, lack of linkages with S&T communities as well as inadequate technical services are the barriers of the U-I joint research. Moreover, according to Santoro and Gopalakrishnan (2001), lack of communication channels between university and industry, lack of multiple levels of communication within the organizations and between faculty and staffs at the university affect the U-I joint research for technology transfer. Communication skills are also needed to communicate needs and expectation between the two sides (Casey, 2004). Inappropriate confidentiality and intellectual property management may also be the barriers (BHEF, 2001; Casey, 2004). The university concerns that the ability of faculty researchers to discuss their work and to publish their results will be at risk whereas, at the same time, industry needs to protect the value of their investment. In the transfer context, some studies find that cultural differences and trust affect the growth of the U-I collaboration. There is the distinction between university and industry such as non-profit educational and bureaucratic institutions vs. profit and flexible companies. This leads to cultural differences and impede the process of negotiation and cooperation (BHEF, 2001; Casey, 2004). Lack of trust may also occur in the area of legal issues and contract negotiation and can be exacerbated by the departure

of key personnel in establishing the relationship of both firm and research center (Casey, 2004, Santoro and Gopalakrishnan, 2001).

On the basis of these findings, the author formulated the following hypotheses:

Hypothesis 1: Characteristics of university, characteristics of industry and transfer context and organization structure are the factors that affect the growth of the UIJRPTT in Thailand.

Hypothesis 2: Reliability of knowledge and technical source, lack of motivation, difficulties in negotiating and managing collaboration, and potential impact on faculty and students to work with industry are the factors derived from characteristics of university that may affect the growth of the UIJRPTT.

Hypothesis 3: Technical knowledge and absorptive capacity, lack of motivation, attitude of industry and management barriers are the factors derived from characteristics of industry that may affect the growth of UIJRPTT.

Hypothesis 4: Inadequate technical and information service, lack of communication channels, lack of trust, cultural difference, inadequate infrastructure and inappropriate confidentiality and intellectual property management are the factors derived from transfer context and organizational structure that may affect the growth of UIJRPTT.

4. Methodology

The study was based on data collected from two major groups who had direct background related to photovoltaic technology research, and technology transfer. The first group was faculty members and researchers from the photovoltaic technology related laboratories/faculties and administrative officers of research and technology transfer office from eight universities including 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). The second group was CEOs, head of department and engineers and technicians from five photovoltaic firms namely: Solartron, Bangkok Solar, Thai Agency Engineering, Ekarat Solar and Sharp Thebnakorn.

The research instruments designed to gain the qualitative and quantitative data consisted of interviews and questionnaire surveys. To gain the qualitative data, 63 interviewees were interviewed. Among those, the number of interviewees from the university and industry were 45 and 18 respectively, accounting for 71% and 29%. The questioning issues related to strategy of photovoltaic firms and university on R&D and photovoltaic technology within the context of globalization and competitiveness, why industry and university conducted small number of joint research, to what extent the mentioned cause affecting the decision making of the universities and industry in conducting joint research, and how to increase the U-I joint research for photovoltaic technology transfer. The qualitative data were summarized and analyzed to identify determinants of growth of the UIJRPTT in different levels. The questionnaire survey was conducted with a number of respondents to acquire the quantitative data. Out of the 150 survey respondents, 96 were the university respondents (64%) and 54 were the industry respondents (36%). The respondents were requested to indicate five Likert scale on the item statement which related to the hypothesized factor variables they treated the differences between 'strongly disagree = 1' and 'strongly agree = 5'. The collection of data was carried out during June-October 2009. The detail of characteristics of the respondents was shown in Table 1.

5. Results

5.1 Respondents Perspectives on UIJRPTT

The UIJRPTT was not progressive as evidenced by the survey results. Only two universities namely SERT, and the KMUTT reported their cooperation with the industry. The joint research projects between SERT and the photovoltaic firms during 2005-2008, covered: (1) *sponsored research*: grid connected system, solar water pumping and other applications; (2) *consortia*: research and test of solar cell and module equipment; and (3) *exchange of research materials*: solar cell applications for agricultural-purposed engines. The joint research project between KMUTT and photovoltaic firms during 2005-2008 were *consortia* with Thai photovoltaic firm mostly in module and system testing. The other projects were sponsored by the government organization by which the results could indirectly benefit the industry. Those included: (1) projects sponsored by DEDE in solar pumping system prototypes, development of testing and standardization of PV system, development of the photovoltaic standard development and testing facilities, testing and evaluation of the Vanadium Redox flow batteries, potential of installing PV grid-connected system on roof areas of government building, possible impacts of grid-connected system (PV rooftop) on local distribution-grids; and (2) projects sponsored by EPPO in evaluation of electricity generation by solar cell technology, field current-voltage measurement of PV arrays.

Despite low level of U-I cooperation, more than 90% of the survey respondents stated that the UIJRPTT was essential for the development of photovoltaic technology and beneficial to both parties. The university respondents stated that the UIJRPTT could help faculty members and students learn and enhance their knowledge on industrial production, technology scale and complexity, solutions on real world problems as well as allow the university research and knowledge to commercialization. The faculty members could also be granted fund, and use it as extra income and salary for students to work in the research projects. The industry respondents viewed the UIJRPTT was essential in terms of gaining new information, ideas and knowledge that would be beneficial to the improvement of photovoltaic efficiency and cost reduction, the development of new products and product credibility. The industry could use fund which mostly supported by the government to work with the university in the area they were interested and could not conduct research in their in house R&D. Both sides expressed their willingness to collaborate and work in research and development. Table 2 shows the area and research theme that the university offered to work with the industry and that in the interest of the industry.

5.2 Determinants of Growth of UIJRPTT

Using the data from the interviews, this section empirically verified the importance of certain hypothesized factors as determinants that facilitated or hindered the technology development of the university and industry. The data from the interviews offered insights on various factors accumulations determining the growth of the UIJRPTT in Thailand as followed:

Technological Efforts: *Government roles and policy supports* were stated by the university and industry respondents as a major determinant of their technological efforts. The governmental role in implementing R&D strategy and appropriate funding in renewable energy and photovoltaic technology could expand the roles of the university and public research institutes in working with the industry. The role as market facilitator and developer by implementing policies support for domestic market expansion could affect the growth of the UIJRPTT. As the market grew, the production would increase and through learning and scales economy, the cost would reduce. The cost reduction would lead to more income and profit which could further to increase of R&D investment. One manufacturer stated that in principle the company set 1% of income for R&D project each year. However, the government role and policy support in R&D related to renewable energy and photovoltaic technology were criticized as lack of clear vision and the funding program was scattered and not compliment for long term R&D. The government roles as market facilitator and developer were criticized as lack of full political support for legitimization of photovoltaic industry and technology and lack of continuity

for larger market development program. The government lacked of long term public commitment in building awareness on the importance of photovoltaic technology and technology specific subsidies such as adders was viewed failing to cover the cost of investment. The low support could lead to low motivation of both university and industry to make decision in conducting the U-I joint research.

Technological Adoption: *Source of technology transfer of the industry* such as turn key projects, licensing of know-how and import of technology from the mother company impeded the demand for adopting the new technology from domestic sources. The industry viewed that with machinery and know-how from turn key projects and licensing, the new technology was completely transferred and ready for industrial production of cells and modules with credibility. For the supply side, the *university capability in building up new technology* was in question. Due to the fact that the research work in developing new cell technology was in the early stage, the university could not provide technology for the industry to adopt the new technology for commercialization. Moreover, the photovoltaic cell technology which conducted in the university laboratory such as quantum dot solar cell, dye sensitized solar cell and CIGS were considered not applicable to the industry silicon crystalline and amorphous thin film technology. Therefore, the possibility for the U-I joint research for technological adoption was very low.

Technological Adaptation*:* All joint research between the university and industry reported by the respondents and annual publications were in the technological adaptation such as testing of modules, solar applications and BOS system efficiency improvement. The university attribute that was considered facilitating the UIJRPTT for adaptation included: possibility to pool experts from various faculty members, ownership of the equipment and facilities necessary for research works, and sources of funds from public organizations and university credibility and capabilities. Despite such favorable attributes, the respondents from the university and industry viewed that *limited faculty time, university capabilities and credibility*, and *geographical proximity* could impede the decision of the university and the industry in conducting the UIJRPTT. Firm attributes facilitated the collaboration and level of interaction between the manufacturer and the university. The industry's *skilled labor and capable engineers, entrepreneur spirit of the owner who was ready to invest and taking risks, industrial scale equipment and facilities* was viewed facilitating the UIJRPTT. However, the respondents viewed that *in-house R&D, fear of trade secrecy leakage, and limited fund* mattered decision of the university and the industry in conducting the UIJRPTT. In terms of cell development, most firms indicated that they needed knowledge and technology for increasing the efficiency of cell and module, and production process. However, the knowledge of university faculty was not high enough to help them due to the fact that their research focus was not relevant to silicon photovoltaic cell and amorphous thin film. The industry respondents viewed that this was partly because some faculty members realized that silicon photovoltaic cell and amorphous thin film was a mature technology and they could not catch up the technology abroad. Conducting such research did not allow them to publish any new knowledge. They turned to conduct other emerging technologies such as CIGS, CdTe, and DSC where there were more rooms for new knowledge to be published. Moreover, the *equipment in laboratory* to conduct the silicon photovoltaic cell was too expensive to conduct the research in the university. For the transfer and organization context attributes, participants revealed that there was a weak linkage, *insufficient and inefficient communication channels* between the university and the industry which led to loss of opportunities for university and industry to talk and set research question in need of the industry. Some respondents viewed that the university and industry were living in the different world. *Difficulties in practical incentive and bureaucratic system* such as the university prioritization in academic paper which affected to academic career path and university international ranking rather than research for commercialization and inconsistency policies due to changing of bureaucratic and organization structure affected the motivation of the academicians in conducting researches.

Drive for Creation: Some university respondents cited that key driver for developing technology was to own the technology and obtain the patents which could further lead to the financial benefit due to cost effectiveness and technology leadership. However, *deficiencies in skilled resources* particularly researchers, *lack of equipment, lack of funds* for big and long term project, and *early*

staged research results were indicated. It was also viewed that the basic research in laying the understanding of phenomena and knowledge and creating the new technology did not matched with the industry's core business in silicon based solar cell and selling of modules and applications with simple usages. For the industry, inventions and fundamental research were considered important to their competitiveness; however, there were several factors to be carefully considered. Those included: *time consuming, benefit and cost of investment in research, and economic value of investment***.** Research investment, for the industry, involved large sunken costs which could and could not increase returns. Moreover, as far as the role of external market was concerned, it was doubtful that new invention and technology would work for them due to reliability on technology and source of origin. The manufacturer acknowledged that funding the fundamental research was high and could not bring out profit. It was also viewed that, currently, the associated competitive pressure for the change of the technology was still in the early stages and it was not enough to force the industry to upgrade and change the technology.

5.3 Barriers and Conflicts

A linkage between the university and industry was mostly stated as informal and personal base. However, barriers and conflicts related to organization context could occur before and after the establishment of their collaboration. From the questionnaire results, overall respondents identified barriers to growth of the UIJRPTT, as shown in Table 3, included: (1) industry management barrier (i.e. low level of corporate support due to high investment cost and time consuming) which was considered to be the most potential barrier with the mean value of 3.67; (2) lack of communication channel (3.66); (3) inadequate infrastructure (i.e. inadequate supply of technical human resources, lack of S&T linkage)(3.57); (4) difficulties with negotiating and managing collaboration (3.55); (5) cultural differences (i.e. profit and non profit organization, bureaucratic and entrepreneur)(3.41); (6) inappropriate confidentiality and intellectual property management (3.43); (7) concern on potential impact on faculty and students to work with industry (3.32); (8) university lack of motivation (3.20); (9) lack of trust (3.14); (10) university's inadequate technical and information service (3.14); and (11) industry's technical knowledge and absorptive capacity (3.02). It was obvious that the most potential barriers involved with the transfer and organization context with the mean value of 3.39, followed by characteristics of industry (3.11) and characteristics of university (3.08).

As stated in Table 3, the comparison between university and industry perspectives using Levene's test show no significant difference for most variables at the confidence level of 95% except university lack of motivation and university's inadequate technical and information service. Thus, the equal variance estimates were interpreted for most variables. Regarding the t-value and two-tail significance, there was no significant difference in all variables except variable titled university lack of motivation, indicating that there was no difference of perspectives between the university and industry respondents. The university viewed that industry management barriers (3.66) was the most potential barriers, followed by lack of communication channel (3.61), and inadequate infrastructure (3.52). While the industry viewed that lack of communication channel (3.75) was the most potential barriers, followed by industry management barriers (3.68) and inadequate infrastructure (3.66).

Conflicts from different perceptions most cited by the interviewee were: (1) conflict in research motivation occurred when the university valued cooperation in the forms of co-funding, sharing ideas and co-working with the university whereas the industry viewed that cooperation could occur when the university could prove successful results, or invent the prototype or finished products; (2) conflict of commitment occurred when the industry hiring university consultant to work for them which was cheaper than conducting U-I joint research. The university was not content with the role of academic consultant privately. They viewed that the university would lose benefit it should gain by rules. Academic also felt guilty of being consultant, as they viewed that it took their times of teaching and taking care of students; and (3) conflict in time existed as university viewed that they could wait for trial and errors until the researcher could prove the experiment results but the industry could not wait and extend the projects duration. The extension and unpunctuality could lead to loss of opportunities in selling the products and expanding marketing.

6. Discussion

From the research results, the answer for the question of why there was little number of UIJRPTT in Thailand depended on various factors. The interview results highlighted the importance of determinants in technology development. Those included: (1) the government's roles and support policy in the university and industry technological efforts; (2), the industry source of technology transfer and university capabilities in building up new technology in technological adoption; (3) university faculty time, capabilities and credibility, close geographical proximity, firm attributes and limitation of fund in adapting technology from UIJRPTT; (4) university inadequacy infrastructure and industry economic value perception in technology creation; and (5) transfer and organization context in determining the growth of the UIJRPTT. While the questionnaire results indicated the potential barriers to the UIJRPTT viewed by the respondents which included factors related to characteristics of university and industry and the transfer and organization context. Twelve out of fourteen of the items rated influencing negative impact to the UIJRPTT formulation. This revealed that there were gaps perceived by the respondents in the three factors which could impede the formulation and growth of the UIJRPTT. The results validated the significant focus of technology transfer literature and U-I collaboration (BHEF, 2001; Casey, 2004; Szulanski, 1996,2000; TDRI, 992).

Based on the interview and questionnaire results, it was obvious that government influence was determined to be the one of the important predictor of the growth of UIJRPTT. Especially if the government could create the favorable environment to the photovoltaic technology transfer, there would more likely that the university and industry would step into working together. The critical roles of government that determined the UIJIRPTT was in line with the research work on the innovation system in Thailand such as Monaiyapong (2004) and Brimble and Doner (2007). They state that the government is the key player in supporting activities and tasks of the university and industry as well as their own government agencies. However, according to the results, the government policies and fragmented Thai bureaucracy could hinder U-I linkage and university-industry-government linkages. It was found that the photovoltaic technology was lack of the legitimacy from the government to prioritize it as key technology. As a result, this could affect to insufficiency of support policies and strategies to encourage the R&D, market development and financial funding and credits which were essential to the UIJRPTT.

The interview results confirmed that appropriate university characteristics were essential to the UIJRPTT. University should have capabilities and credibility, faculty time, close geographical proximity as well as the willingness to transfer their knowledge and to create robust bonds of relationship with the industry. The questionnaire results confirmed that difficulties with negotiating and managing collaboration, potential impact on faculty and students to work with industry and lack of motivation were potential barriers to the UIJRPTT growth. Therefore the university should consider the measure to build up capabilities of the university faculty and staffs, and create favorable environment to facilitate the work faculty and staffs as well as to improve the joint research management and motivation system. Moreover, as far as the capability of the university was viewed as important factor for technology adoption, adaptation and creation, the limited UIJRPTT situation could continue as the results showed that, despite the university faculty had the willingness to work with the industry, the university capability gaps and problems still remain. Those included: university research related to cell development was in the early stage, there was no integration of knowledge in research that could benefit the industry commercialization, lack of equipments, specialists, and fund to conduct big scale research. They could be the root cause of limited UIJRPTT.

The results confirmed that industry characteristics could directly promote and hinder the growth of the UIJRPTT. Achieving collaboration for photovoltaic technology transfer would be more likely to occur when the industry had a strong knowledge base and management initiatives and practices that could stimulate the process of U-I collaboration. Industry source of technology transfer, firm attributes and limitation of fund which included credit constraints and skilled labor and capable engineer, entrepreneur spirits, and equipment were determined as determinant of the UIJRPTT in various technology development levels. However, supported by the questionnaire results, management barrier was either viewed as the most potential barriers to the growth of UIJRPTT. From the interview results, such perspective could be well explained by stating that, in the real situation, the

industry did not much value the importance of the UIJRPTT due to the fact that the profits and income gained from big scale research did not cover the high investment cost, and they still had the perception that import technology was easier, faster and more reliable and in house R&D was cheaper and could keep trade secret.

The results confirmed that the relationship building for UIJRPTT was essential for achieving the growth of the UIJRPTT. Transfer and organization context which included communication, difficulties in practice and bureaucratic system and conflict of interest were confirmed in this research as the determinants of the growth of the UIJRPTT. The results revealed the weak linkages of the university and industry and limited circles in the governmental venues. The mismatch of the university technology and the industry need also reflected the deficiency of communication between the two partners. The questionnaire results also indicated clearly on the roles of transfer and organization context as the most important factor that could impede the growth of UIJRPTT. Without appropriate mechanism such as adequate infrastructure, IPR management, technical and information service, communication channels, cultural difference understanding and trust, the growth and success of UIJRPTT could not occur.

Moreover, as far as the conflict of interest was concerned, BHEF (2001) stated that there was conflict of interest in financial, commitment as anything that might interfere with the faculty full time duties The conflicts stated in this study expanded the nature of conflict from the study of BHEF (2001) by revealing the attitude of working between university and industry as university needed the industry to work with them since the beginning of the project whereas the industry needed the proven technology. The conflict in commitment and time that may arise from the organizational culture difference as the industry expected that the commitment and time frame of the UIJRPTT should be as stated in the contract.

7. Conclusion

The purpose of this paper is to answer why there is little number of U-I joint research for photovoltaic technology transfer in Thailand. From the research results, the answer depended on various factors. The interviews highlighted the importance of the government's roles and support policy in driving the technological efforts and university and industry organization capabilities and economic value perception in facilitating and impeding technological adoption, adaptation and innovation creation through the U-I joint research for photovoltaic technology transfer. The questionnaire results indicated barriers to the U-I joint research for photovoltaic technology transfer including factors related to characteristics of university and industry and the transfer and organization context. Table 4 presents the detail of the hypothesized sub-factors that were supported by the results of the study.

The study results could contribute to all policy makers and stakeholders to understand the impact of managerial and policy implications from national, university and firm level as well as characteristics of the university and industry and the transfer and organization context to the growth of the UIJRPTT. The recommendation to improve the current situation was to strengthen the government, university, and industry roles. The government was recommended to consider the benefit and cost of the photovoltaic technology and industry for their legitimacy. If so, the government strategy on renewable energy and photovoltaic technology and market development should be more streamline, long term and concrete focus. For the current situation, the government, university and industry should work together in more active role in promoting technological projects and human resources development related photovoltaic technology. Funding for such projects and development should be increased and more focused. The university support for photovoltaic technology development and U-I joint projects should be equipped with long term plan of human resources development plan. Communication effectiveness between the university and industry should be strengthened. Role and efficiency of the TTO office should be strengthened to facilitate close relationship and interaction between the university and industry.

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Table 1 Characteristic of questionnaire respondents

Industry	Number	%	University	Number	%	Overall %
Total (n)	**54**	**100**	**Total (n)**	**96**	**100**	**100**
Gender			**Gender**			
Male	43	79.62	Male	35	36.45	52
Female	11	20.37	Female	61	63.55	48
Position			**Position**			
Installation Engineer	3	5.55	Assoc. Prof.	4	4.16	
Design Engineer	2	3.70	Assist. Prof.	5	5.20	
Engineer	26	48.14	Lecturer	12	12.5	
Head of Dept.	14	25.92	Head of Office	2	2.08	
Scientist/technician	9	16.66	Administrator	37	38.54	
			Tenure/non tenured Researcher and PhD. students	36	37.50	
Years of working with company			**Years of working with university**			
Less than 1 year	3	5.55	Less than 1 year	11	11.45	9.33
1-3 years	29	53.70	1-3 years	25	26.04	36
4-8 years	21	38.88	4-8 years	27	28.12	32
8-12 years			8-12 years	7	7.29	4.66
12-15 years			12-15 years	8	8.33	5.33
More than 15 years			More than 15 years	13	13.54	8.66
No information	1	1.85	More than 25 year	5	5.20	4
UIJR necessary	46	85.18	**UIJR necessary**	92	95.83	92
No necessary	4	7.40	No necessary	1	1.04	3.33
No response	4	7.40	No response	3	3.125	4.66
Researches involved with PV			**Researches involved with PV**			
never	38	70.37	never	54	56.25	61.33
1-3 projects	7	12.96	1-3 projects	35	36.45	28
More than 3 projects	7	12.96	More than 3 projects	7	7.29	9.33
No response	2	3.70				1.33

Table 2 Area and research theme the university offered and the industry needed

University Offer	Industry Need
• New generation of solar cell such as dye sensitized, CIGS, and quantum dot solar cell (but the development was still in early stage); • Quality and qualification of the photovoltaic cells and modules that affect their duration less than 25 years; • Improvement of EVA quality; • Solar electricity cogeneration system; • BOS and Photovoltaic system installment with less cost and higher efficiency; • Solar water pumping; • Solar cooling system; • Solar lighting; • Solar mix system for drying; • Testing; • Inverter and battery improvement; • Training and building public awareness.	• Improvement of amorphous and silicon based crystalline photovoltaic cell and module efficiency; • Improvement of BOS; • Improvement of efficiency in solar farm and grid connected system; • Design of junction box for plug and play of the module for roof top and large scale; • New products and design of photovoltaic module applications that responded to the market and customer needs; • Testing with international accepted standard; • Improvement of packaging; • Access of experience and personal contacts with the key domestic and oversea knowledge source.

Table 3 Mean value of factor and variables in comparison

Code	Description	Overall (n=150)		University (n=96)		Industry (n=54)		Levene's Test	t-value Sig. (2-tailed)
		Mean	S.D.	Mean	S.D	Mean	S.D		
C1	**Characteristics of University**	**3.08**	**1.07**	**3.01**	**1.11**	**3.22**	**0.98**		
C1.1	Reliable of knowledge and technology source	2.28	1.14	2.18	1.16	2.44	1.09	.926	-1.326 (.187)
C1.2	Lack of motivation	3.20	1.06	3.02	1.15	3.51	0.81	.016	-2.801 (.006)
C1.3	Difficulties with negotiating and managing collaboration	3.55	1.07	3.51	1.09	3.62	1.05	.468	-.649 (.517)
C1.4	Potential impact on faculty and students to work with industry	3.32	1.02	3.33	1.05	3.31	0.98	.274	.106 (.916)
C2	**Characteristics of Industry**	**3.11**	**1.10**	**3.10**	**1.05**	**3.13**	**1.18**		
C2.1	Technical knowledge and absorptive capacity	3.02	1.13	2.90	1.05	3.22	1.25	.227	-1.642 (.103)
C2.2	Lack of motivation	2.88	1.16	2.90	1.11	2.85	1.25	.222	.274 (.784)
C2.3	Attitude of industry	2.90	1.10	2.97	1.04	2.77	1.20	.222	1.070 (.286)

Code	Description	Overall (n=150)		University (n=96)		Industry (n=54)		Levene's Test	t-value Sig. (2-tailed)
		Mean	S.D.	Mean	S.D	Mean	S.D		
C2.4	Management barrier	3.67	1.02	3.66	1.03	3.68	1.02	.785	-.106 (.916)
C3	**Transfer Context and Organizational Structure**	**3.39**	**1.09**	**3.34**	**1.13**	**3.46**	**1.01**		
C3.1	University's Inadequate technical and information service	3.14	1.12	3.06	1.18	3.27	1.01	.027	-1.122 (.264)
C3.2	Lack of communication channels	3.66	1.01	3.61	1.02	3.75	0.98	.648	-.838 (.404)
C3.3	Lack of trust	3.14	1.18	3.07	1.18	3.27	1.18	.961	-1.013 (.313)
C3.4	Cultural differences	3.41	1.12	3.47	1.19	3.29	0.98	.081	.956 (.341)
C3.5	Inadequate infrastructure	3.57	1.01	3.52	1.08	3.66	0.89	.124	-.841 (.402)
C3.6	Inappropriate confidentiality and intellectual property management	3.43	1.10	3.36	1.14	3.55	1.02	.362	-1.019 (.310)

Table 4 Hypothesized factors as barriers and as enabling factors to UIJRPTT

Independent Variables	**Survey Support**	**Interview Support**
Characteristics of University		
Reliability of knowledge and technology source	NO	YES
Lack of motivation	YES	YES
Difficulties in negotiating and managing collaboration	YES	YES
Potential impact on faculty and students	YES	NO
Others: Faculty time	-	YES
Others: Lack of fund	-	YES
Characteristics of Industry		
Technical knowledge and absorptive capacity	NO	NO
Lack of motivation to learn new thing to develop innovative product	NO	NO
Attitude of industry (i.e. viewing that the value of research collaboration is not high enough and viewing that university overvalues their technology)	YES	YES
Management barriers (i.e. low level of corporate support depends on investment cost and time)	YES	YES
Others: Lack of fund	-	YES
Transfer Context and Organizational Structure		
Inadequate technical and information service	YES	YES
Lack of communication channels	YES	YES
Lack of trust	YES	NO
Cultural differences (i.e. profit and non profit organization, bureaucratic and entrepreneur)	YES	YES
Inadequate infrastructure (i.e. inadequate supply of technical human resources, lack of S&T network)	YES	YES
Inappropriate confidentiality and intellectual property	YES	YES
Other: Geographical proximity	-	YES
Government Roles and Policy Support	-	YES

YES in Survey support means that the average rating number was above 3.
YES in interview support means the sub factors was cited by interviewees.