An Empirical Study of University-Industry Research Cooperation -The Case of Taiwan

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(Prepared for the workshop of the OECD-NIS Focus Group on Innovation Firm and Networks, Rome, 2-3 October, 2000)

Abstract

Taiwan is currently shifting from labor-intensive to knowledge-intensive economy. However, the transformation process is still not very effective. Although she has been placed on the top in the world in some product areas in terms of outputs, the value added and profits from the business operations remain low per se. One of the critical ways to improve the situation is to enhance the level of technological sophistication. To encourage research cooperation between industry and university is thus regarded as the major approach to obtain the objective. Nevertheless, the issue and related practices are new to most of the policy makers and academic researchers in Taiwan. The study is to explore this issue through (1) extensive literature review; (2) Investigation of the major participants in the university-industry research cooperative system; and (3) case studies. The preliminary findings from the study include: (1) For government, it needs to help set up "intermediaries", establish research centers oriented for industrial technologies, and delegate the ownership and rights of research results to universities or companies; (2) As to university, it is better to build a patenting and licensing office in order to enhance the technology transfer performance; (3) For the industrial corporations, they have to better leverage external sources of technologies, to build long-term relationship with universities, and to establish internal competence.
Key Words: university-industry cooperation, research cooperation, technology transfer,

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1. Introduction

Taiwan has been working hard to change the situation from labor-intensive to knowledge-intensive economy. Nevertheless, one can still recognize that its current capabilities for innovation is not solid enough, i.e., its "national innovation system (NIS)" is yet well-

[1] The author would like to thank National Science Council for its financial support. This paper is part of the research results from NSC-87-3011-P-004-001 Project.

constructed. For example, Taiwan is placed on top 3 in the world in computer-related product areas in terms of outputs, but the corporations' profits and value added are not sufficient compared with those in developed economies. In addition, very few new products are originally developed from the firms based in Taiwan.

New technology is critical to the industrial corporations' competitiveness. Companies can develop their technical capabilities and products either based on internal research and development (R&D) or outsourcing. Although it remains necessary to build own internal R&D capacity, the external sources of technologies have become more and more important (Fusfeld & Haklisch, 1987; Sen & Rubenstein, 1989; Berman, 1990; Wu, 1994; etc.). To develop technologies externally can be conducted in several ways, including inter-firm cooperation, industry-research institution cooperation, and university-industry cooperation. Among them, the university-industry research cooperation (UIRC) has been considered a top issue by many scholars regarding the national competitiveness (Rahn et al., 1988; Avveduo & Silvani, 1988; Belanger, 1988; Wainwright, 1988; Sumney, 1989; Chen, 1990; Novozhilov, 1991; Chen, 1994; Wu, 1994). The issue is particularly important in Taiwan from the following two aspects:

(1) Taiwan is currently still in the "investment-driven" stage so that she must pay much attention to upgrading her innovative capabilities in order into move to innovation-driven stage. In fact, because of lack of the aforementioned capabilities, the performance of most corporations in Taiwan are not good compared to those of foreign ones.

(2) In general, high-level of researchers and engineers are not sufficiently available in the industries in Taiwan. For example, there were about 9,072 engineers with doctoral degree in Taiwan in 1994. Among them, 803 people were working in industry, 1979 in research institutions, and 6092 in universities. According to the numbers above, one can find that there are about 70% of researchers and engineers with doctoral degrees are working in universities. Therefore, industrial companies can benefit a lot if they are able to leverage the technical resources of universities.

This paper is to explore the university-industry research cooperation (UIRC) in Taiwan from both micro and macro perspectives based on extensive literature review, in-depth look on UIRC's participative system and two UIRC case studies.

2. Literature Review

2.1 Historical Development

University-industry research cooperation is a new issue in Taiwan, but its related practices have been faced in developed countries for a long time. As Brown (1985) has pointed out that the role of universities in the development of the U.S. industries is long and complex, a few examples may be sufficient to demonstrate. Based on the Morill Act of 1862, the land grant universities were established to educate common citizens in the agricultural and mechanical arts and to provide a crucial link between higher education and economic development. The interactions between the communities and universities were further eased by the Hatch Act of 1887 and Smith Lever Act of 1941, both of which encouraged and initiated experimentation, applied research, and a matching funds concept (Allen et al., 1989).

During the World War and , much of the effort of the U.S. university laboratories was devoted to wartime mission-oriented research. Some examples of the effort are the development of synthetic rubber and man-made polymer, the invention of radar and many other electronics (Brown, 1985). In addition, partly due to Compton's and later Bush's recommendations to then-President Roosevelt, universities were thrust in the 1940s, away

from industrial cooperation and support into a “golden age” of federal funding and basic research (Allen et al., 1989; Geiger, 1986). (Bush also promoted two major concepts: (1) Pure science is best; and (2) Basic research will ultimately improve the consumer’s life.) Consequently, the increased funding of universities research by the U.S. government continued very long after the war. Industry’s investment in university research went down to a prewar investment level. Allen et al. also pointed out that industry from the 1950s until the late 1970s almost became the outsider of university research. From the early 1980s on, the issue of university-industry-industry (U-I) research interaction has regained attention and importance.

2.2 Benefits and Motivations

While collaborations on research between universities and industries have existed for a long time, there has been a marked increase in the number of these relationships in recent years (APCO, 1986; Aaron, 1988; Geisler et al., 1991). Also, in its recent position statement, IRI pointed out: “Since 1986, spending for industrial R&D in the U.S. has been growing less than 5 percent annually. At the same time, industry’s financial support of academic R&D has been growing more than 12 percent annually”. The growth has been based on the promise that university-industry cooperation increases technological innovation and hence, economic development (Berman, 1990).

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Several main reasons, which are claimed to motivate the industry to increase university-industry cooperation, have been provided by Atlan (1990) and Peters and Fusfeld (1982). They are: (1) access to manpower, including well-trained graduates and knowledgeable faculty; (2) access to basic and applied research results from which new products and processes will evolve; (3) solutions to specific problems or professional expertise, not usually found in an individual firm; (4) access to university facilities, not available in the company; (5) assistance in continuing education and training; (6) obtaining prestige or enhancing the company’s image; and (7) being good local citizens or fostering good community relations.

On the other hand, the reasons for universities to seek cooperation with industry appear to be relatively simple. Peters and Fusfeld (1982) have identified several reasons for this interaction: (1) Industry provides a new source of money for university; (2) Industrial money involves less “red tape” than government money; (3) Industrially sponsored research provides student with exposure to real world research problems; (4) Industrially sponsored research provides university researchers a chance to work on an intellectually challenging research programs; (5) Some government funds are available for applied research, based upon a joint effort between university and industry.

Similarly, Barber (1985) has identified three factors which appear to have been most instrumental in stimulating university interest in enhanced university-industry relations. These are: (1)reduced federal support of research; (2) deteriorating university research equipment; and (3) economic benefits to university.

2.3 Types of University-Industry Interactions

As far as the types of university-industry (U-I) interactions are concerned, there has not been a universally accepted classification. Peters and Fusfeld (1982) pointed out that “the U-I interactions can be formal or informal”; “the duration of interaction can be for less than an hour or for more than thirty years”; and “an interaction can be as simple as a telephone call, or as intricate as a ten-year contract”. Stewart and Gibson (1990) classified the U-I interaction into four major categories: classroom, publication, research, and financial linkages.

Eventually, they identified seventy-two linkages by which professionals from industry and academia interface. Regarding the research linkage alone, however, Peters and Fusfeld (1982) provided a detailed categorization. Table 1 lists the major categories which will be briefly described.

Table1. Major Categories of University-Industry Research Interactions

1. General Support
2. Contract Research
3. Research Centers and Institutes
4. Research Consortia
5. Industrial Associate/ Affiliate Programs
6. New Business Incubators and Research Parks

Source: Atlan, 1987

(1) General Support

General support continues to be an integral part of industrial philanthropy. Such support takes the form of monetary gifts and/or equipment donations for teaching and research purposes. One example in this category is IBM's $50-million grant for manufacturing education in 1983.

(2) Contract Research

Atlan (1987) indicated that over 50% of industrial support to universities is provided through contracts for special projects. In general, the contracted agreements to an individual investigator generate strong person-to person interactions that favor technical cooperation (Peters and Fusfeld, 1982). However, the funding for the individual projects is usually reviewed on a year-by-year basis, and thereby subject to discontinuity. Also, contract research may be conducted under a consortium

(3) Research Centers and Institutes

In order to facilitate the procedures of contracting and communicating between researchers and industry, some universities establish research centers focusing on a certain technology. Such centers can provide the environment for the cross-disciplinary approach that industrial problems often require (Atlan, 1987).

(4) Research Consortia

Research consortia can be characterized as specific mission programs organized to ensure that generic or mission-oriented research will be carried out by one or more universities (Peters and Fusfeld, 1982; Atlan, 1987). Typically, participating companies pay a membership fee; the university offers laboratory space and graduate students and faculty researchers. One of such famous consortia is Semiconductor Research Corporation (SRC).

(5) Industrial Associate/Affiliate Programs

Many research universities set up such programs to provide member firms with access to campus research and resources. One of the most well-known examples is MIT's Industrial Liaison Program.

(6) New Business Incubators and Research Parks

Most of research parks and incubators are located on or near the campus and are intended to draw technology-intensive firms into the university environment. Research parks can be

beneficial to both university and industry by facilitating interaction and encouraging them to take advantage of each other's resources. The highly successful Stanford Industrial Park provides an example for this model. Another way for the university to create an environment conducive to the formation and growth of new technological business s through new business incubators. One example is the Incubator Programs at Rensselaer Polytechnic Institute (RPI), which has become a model for university-related incubator center across the U.S. in ten years.

2.4 Obstacles

The healthy university-industry cooperation is desired by, and its benefits are recognized by, both university and industry, but it is also true that there still exist some obstacles and potential risks for the U-I interactions. Table 2 contains a list of major sources of potential risks of U-I relations. These risks will cause obstacles to U-I partnerships.

The major obstacles include: (1) value conflict; (2) information dissemination restrictions; and (3) intellectual property rights (Brodsky, 1979; Peters and Fusfeld, 1982; Krebs, 1984).

Table 2. Major Areas of Potential Risks of University-Industry Partnerships

1. Reduced university autonomy
2. Intermingling of public and private funds
3. Appropriateness of the research
4. Openness and publication
5. Patents and Licenses
6. Conflict of interests
7. Conflicts of commitment

Source: Barber, 1985

2.4.1 Value Conflicts

The university and industry exist for different purposes. The former exists to foster an environment conducive to advancement of knowledge, the free inquiry, and exchange of ideas. Universities regard themselves as responsible to "the public" with their work contributing to some large civic or educational purpose. On the other hand, a company or business activity exists to offer a service or product to society and on this basis, to make a profit which sustains the employment of its personnel, and provides return to those investors, primarily stockholders.

In addition, academic researchers are sometimes described as having a disdain for the profit orientation and for research which is too narrow or market-oriented. By contrast, industrial researchers are said to view their academic colleagues as "ivory tower" types who are excessively theoretical and who care too little for their work's application (Baldwin and Green, 1984).

2.4.2 Information Dissemination Restraints

The faculty and researchers of academe have usually treated knowledge as a freely disseminated outcome of research. In industry, however, new knowledge is properly treated as private property and the result of an investment in research, and thereby should be utilized in the best interests of the company.

Freedom to publish is fundamental to the university. University research, including

research sponsored by industry, is governed by the tradition of free exchange of ideas and prompt transmission of research results.

According to Peters and Fusfeld (1982), however, most universities allow a firm sponsoring research some time to review manuscripts resulting from the sponsored research for comment to ensure that they do not contain company's proprietary information. The pre-publication review allowance, varying from university to university, is usually for one to six months.

2.4.3 Intellectual Property Rights

A large percentage of academic research historically has been funded by U.S. federal government, which retains the ownership of patent arising from federally funded research. As the U.S. government licensing of these patents was almost entirely on a non-exclusive bases, many patents were not developed into commercial goods or services because non-exclusive licenses did not give the industrial firms the required protection to justify the costs of development (Chermside, 1985).

Ditzel (1988) pointed out that in the U-I research interactions one of the key concerns of an industrial firm is whether patent rights will be available to that firm for license on the new technologies or products which may arise under university research it sponsors. According to a roundtable report by National Academy Press (Macomber,1991), industrial firms do always complain about the difficulties in negotiating intellectual property rights and patenting and licensing agreements in U-I partnerships. However, the patent issues are not only critical to industrial firms but also to universities. For a university, the filing of patent applications on the research inventions is essential to attract licensing interest from industrial companies for commercial development and to attract funding for further research relating to the invention. Since many university researchers do not perceive the disclosure of possible patentable inventions as being part of their research mission, most research universities have attempted to structure patent administration programs (e.g., Office of Patent and Licensing) that would not place undue burdens on the academic researchers.

In 1980, the U.S. Congress passed the Patent and Trademark Law Amendment Act (or Public Law 96-517) which allows the university to retain the rights of the inventions and requires universities to share net royalty income from their inventions. However, there still exist some difficulties to both sides in negotiating the licensing agreements. One source of the difficulties, for example, is the definition of an invention "arising" under the research grant (Ditzel, 1988). Companies often request that the definition of an invention "arising" includes all patentable inventions either conceived or reduced to practice under their full or partial funding. But university acceptance of such a provision without limitation could give rise to conflicting obligations on the part of the university. Another difficulty is that the 1980 legislation still restrict and limit the grant of exclusive rights to persons (other than small business) to a period of five to eight years (Bartlett, 1988).

2.5 Research on University-Industry Cooperation in Taiwan

Scholars in Taiwan conducted little research on university-industry research cooperation (UIRC) in the past. Liu (1983) is one of the earliest persons who explored the issue and system of UIRC in Taiwan. However, he did not further study the barriers and performance of the participating organizations involved in UIRC. Chan (1990) discussed the incentives and barriers for U-I interactions by using empirical case studies based on the firms of computer industry in Hsinchu science park. Huang & Liu (1996) explored the U-I technology transfer issues of the U.S. and Japan. Nevertheless, most of the aforementioned researchers studied

UIRC from the technology provider's (i.e., university's) viewpoints instead of recipient's (i.e., industrial) perspectives.

Liaw (1989) tried to build the fundamental models for UIRC, but his analysis mixed up with different types of interactions, including UIRC and industry-research institute cooperation. Therefore, his findings and conclusions can not specifically fit the situation of UIRC. Chou (1992) investigated high-technology industry's, governmental, and university's technology transfer issues, but his research result, similar to Chuo's, did not clearly separate the analysis between U-I and industry-government cooperation.

According to the literature review above, one can find that the range and types of motivation for UIRC in Taiwan is narrower than that in developed countries probably because the UIRC system itself in Taiwan is yet solid.

3. Research Method and Framework

Although a great deal of research on university-industry research interactions has been conducted abroad, little research has been completed in Taiwan. Therefore, the research is somewhat exploratory. Hence, deep case study is one of the appropriate methods (Yin, 1989).

Regarding the U-I cooperative research, two major types – private contract research and government supported contract research, can been found in Taiwan. This study choose two, latter type, completed projects as cases for in-depth analysis. The criteria for the selection include (1) different technology areas: auto-electronic versus material; (2) different number of participants: one single versus more than two. The people being interviewed include project leaders (university professors), industrial researchers, and government officials.

The research framework for the study is shown on figure 1.

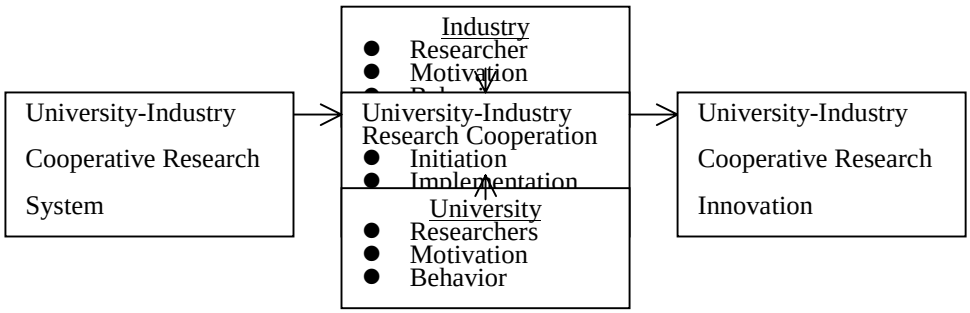

Figure 1. The Research Framework of University-Industry Research Cooperation

4. University-Industry Research Cooperation System in Taiwan

University-industry research cooperation (UIRC) in Taiwan began to be approved by the Ministry of Education in the early 1980s. Before that time, universities were not allowed to actively cooperate with industry. Nevertheless, there remained two formal organizations: Taiwan University's Tjing-Ling Industrial Research Institute (TLIRI) and Tze-Chiang Foundation of Science and Technology (TCFST), which have been involved in UIRC since early 1970s. The former one was established in 1973 and was supported by Mr. Tjing-Ling Yen, the former president of Yulong Motor Co., and Mrs. Wu, president of Taiyuan Textile Corporation, with initial funding of 50 million NT$ for research and 30 million NT$ for the building construction of research center. Combined with the faculty members and equipments of Taiwan University, TLIRI offers technical service, training & education, and contract research to industrial corporations. Currently, the annual revenue from the technical service and contract research is around 600 million NT$. The latter, TCFST was setup in 1973 and

was initially supported by Tsing-Hua University Alumni Association. Its main goal is to cooperate with industry for conducting some research and for training the professionals from industry. Until 1997, it has already trained 40 thousand of technical people, and have completed 256 contract research and technical service projects. Basically, these two organizations are quite similar in the operation areas, but one is supervised under the Engineering College of Taiwan University, the other is an independent not-for-profit organization. The other two similar organizations, based on Chao-Tung University and Cheng-Kung University, have just been operating for less than three years. Therefore, their contributions are still not significant yet.

On the other side, the National Science Council (NSC) of Taiwan thought the lack of good U-I interactions could be one of the reasons why Taiwan is always not able to catch up in the emerging technology areas. Therefore, it initiated a "University-Industry Research Cooperation" Program in 1991, and started to implement in February of 1992. Until January of 1998, there have been total 140 companies and 14 universities involved in 84 U-I Cooperative Research Projects. NSC also actively help recruit Chinese researchers overseas, and encourage them to conduct cooperative projects with industrial firms at home, or even invite them to come back Taiwan to be in charge of some mega projects. For the UIRC Program as a whole, the NSC has supported the Program with 1.46 billion NT$. Until January of 1998, there were 91 patents and 27 technologies from the Program being transferred or licensed.

The university incubator program is also a hot topic in Taiwan recently. As we know, new start-ups are always difficult to get through in the early stage because of lack of business operational experiences and knowledge. Through the involvement and residential program in incubators, entrepreneurs can gain advices and required skills, including technology, finance, marketing, business law, taxation, and initial public offering, etc. Once the start-ups become strong, they can choose to leave. In Taiwan, it is mainly the Department of Small & Medium-sized Enterprises (DSME) of the Ministry of Economic Affairs that has been supporting and been helping set up more than 30 incubators in the past 3 years. Most of them are located in university campus (see Table 3 for the partial list) except for a few centers.

Table 3. A Partial List of University Incubators

Incubator Location	Focus Areas
Tjing-Ling Industrial Research Center	Information, electronic, automation
Sihsen University	Multi-media

Yungming University	Medical electronics, biomedical materials
Chiao-Tung University	Computer, electronics, semiconductor
Joint Commerce College	Fine mechanic, power metallurgy
Global Commerce College	Computer, Video & Vision transmission
Chungchen University	Electronic communication, fine mechanics, chemical engineering
Chungshan University	Computer and communication
Kao-Hsiung Science & Technology University	Information, mechanic automation, commercial automation

Source: DSME, MOEA

Based on the discussion above, the major participants in university-industry research cooperation in Taiwan can be identified as shown on Table 4.

Table 4. The Major Participants in University-Industry Research Cooperation

University	Division for Research Cooperation, Professors & Researchers, Incubators
Industry	R&D Division, Researchers, Planning Division
Government	National Science Council, Ministry of Economic Affairs, Ministry of Education
Intermediary	TSFST, Se-Yuan Foundation, Cheng-Kung R&D Foundation

5.UIRC Case Studies

The section describes two UIRC projects sponsored by National Science Council based on initiation, implementation and results transfer stages respectively.

5.1 Case □ -□ Advanced Erasable CD□ Project

5.1.1 Background

Following the fast development of emerging opto-electronic industry, “how to develop and build the competence of the critical components of the industry” has become a very important

issue to both the government agencies and industrial companies. Therefore, the UIRC Advanced Erasable CDproject has attracted so much attention. The original project was conducted from 1993 to 1995. The cooperative partners include professor David Shieh from the Institute of Electro-optical Engineering of Chiao-Tung University and industrial researchers from Princo and CMC Magnetic corporation. After the completion of the three-year project, a continuing project was initiated in 1997 with the expected finishing date in 1999. CMC Magnetic Corporation was established in 1997 and produced the audio tape products. The company completed initial public offering (IPO) in 1991 and became one of the major producers of videotapes. An automatic production line for computer diskette was added later. This made CMC become the largest manufacturer of 3.5“ diskette products in the world. It successfully produced and marketed CD-R in December of 1996 and transformed itself from a magnetic memory media to a CD-oriented media company. The other industrial company, Princo, was established in Hsinchu Science Park in 1983. Its major products are related to film technology whose areas include CD-R, MD diskette, CD-RW, LD, and tools for surface processing.

5.1.2 Planning and Initiation Stage

The project leader is professor Shieh who came back Taiwan in 1992. Before that, he worked at IBM in the U.S. He presented a paper in a conference where he met with the participants from the Princo and CMC Magnetic corporation. Meanwhile, the National Science Council of Taiwan was promoting research cooperation between university and industry and thus initiated the Advanced Erasable CD(AECD) project. The budget for the three-year project is 34 million NT$. Princo and CMC Magnetic need to invest respectively 1 million NT$ of matching fund which accounts for about 18% of the total. Although the professor Shieh is quite famous and has a lot of experiences, both corporations still hesitated to join the project initially and regarded 1 million NT$ as a big load. Nevertheless, they were persuaded and eventually accepted to join the project through the professor Shieh’s continuous effort. For the continuing project, the initiation and contract process seems to be smoother than earlier one because of the leader’s experience and satisfactory results from the former project.

5.1.3 Implementation and Cooperation Stage

According to NSC’s stipulation, the UIRC project require 3-5 persons of participating company to go to university campus to join research. However, it did not elaborate detailed cooperative activities. The company side thinks it will encounter a big problem if it follows the rule. This is true even for a large company like Acer Peripheral Corporation. Both sides set a regular meeting on Wednesday. Basically, the companies try their best to send engineers to attend the meetings held in campus. However, whether the university research group members can frequently visit company depends on the corporation’s attitude to U-I interactions. Some firms, such as Princo and CMC Magnetic, look the issue from the perspectives of trade secret and hence they do not welcome university researchers to visit. However, the company like Acer Peripheral takes an open way so that it welcome graduate students to visit and consequently it has quite good communication with university researchers and professors. Just one year after the project started, Acer has planned to setup a new business division for developing the related product. On the other hand, CMC Magnetic changed the participating researcher several times because of the business requirement and dispatch another engineers to join the project. However, the new comer always can’t perform well in knowledge acquisition and communication because he is not familiar with the project.

5.1.4 Results Transfer Stage

Following the completion of the AECD project, 3 patent applications have been filed. In fact, one of them has been approved. In the mean time, more than 20 papers resulted from the project have been published. Also, 6 graduate students, participating the project, graduated and entered the industry, thus helped transfer the related technology and knowledge to industrial firms. Princo has had a good interaction with the university during the cooperative period and thus it can easily recognize which research results are worthy to further explore. On the other hand, CMC Magnetic encountered a hard time in absorbing and transferring technology because of its frequent change in participating researchers. In addition, some companies, without participating the project before, tried to license the results because the results' licensing is not exclusive. However, they were frustrated because of the system for licensing application, such as royalty fee, is not satisfactory.

5.2 Case □ -□ Phenol Resin Material□ Project

5.2.1 Background

The Phenol Resin Material (PRM) cooperative research project is conducted by the Graduate Institute of Chemical Engineering of Tsing-Hua University and Yuching Corporation. Yuching was established in 1977 and has become a global company with four major business divisions-environment protection, semiconductors, architectural material, and petrochemical products. Among them, the semiconductor division provides a few semiconductor manufacturing firms with the necessary specific gas and chemicals utilized in production process. The objective of the cooperative project is to develop phenol resin material which is a type of architectural material and is new to Yuching.

5.2.2 Planning and Initiation Stage

The cooperative research project was conducted from the August of 1992 to July of 1995. Prior to joining the project, the researchers of Yuching have already known the cooperative project leader-professor Ma at Tsing-Hua University. Because of the previous long-term relationship, both sides know each other quite well in the technological capability and research strength areas. Generally, Yuching's researchers always goes to Tsing-Hua University to ask for assistance whenever they encounter some kinds of problems. Therefore, it seems to be natural for Yuching to consider further cooperation with professor Ma once the National Science Council initiated the U-I cooperation and promised with supporting fund. In fact, Yuching itself has some connection with foreign companies and mentions that it can even easily acquire the technologies and the results which the project expected to obtain. However, Yuching still decides to invest and participate the PRM project. The major purposes are to develop the resin material with lower cost and to build its own technological competence through the cooperation and learning process. For the university side, professor Ma hopes his research can be applied to real world and his research team can gain practical experiences from this project. In addition, his research teams and graduate students can take the opportunities to better understand what the industry really demands and thus can adjust their research directions.

5.2.3 Implementation and Cooperation Stage

During the project conduction period, Yuching itself has 6 engineers and 4 researchers

participate the project. On the other hand, Tsing-Hua involves with 6 graduate students. They meet with each other about every two or three weeks. Most of the meetings were held at Tsing-Hua university campus. Sometimes, the university's research team visits Yuching's production line and R&D department for better understanding the real problems. In general, both sides appreciate very much about the process of communication and cooperation.

5.2.4 Result Transfer Stage

The completion of the PRM project results in one patent application. Although the ownership of the results' intellectual property belongs to National Science Council, Yuching is still offered an exclusive licensing for 3 years because itself invests more than 20% of total project budget. Consequently, it has earlier opportunities to explore the commercial potential than other competitors. The project is considered to be successful in terms of technological perspectives, but some improvement must be done in dying and tooling in order for Yuching to penetrate the consumer's market. Nevertheless, the product still has great potential and market in the areas engineering and transportational construction. As far as the effectiveness and performance of the cooperative research project is concerned, Yuching's researchers think they not only successful developed the final product with lower cost, but also learn a lot about the technical knowledge. Meanwhile, they take the chance to know more experts and scholars working in the related areas. When Yuching faces any problem in the future, it will be able to identify suitable experts more quickly to consult with and for help. Nevertheless, they confessed that they had not had seriously considered the related skills and "complementary assets" which are generally required for successful new product launching.

5. Research Findings and Discussions

According to the extensive literature review, the UIRC participant system in Taiwan, and the two UIRC case studies, several preliminary research findings can be drawn. In addition, some implications can be further derived and could be useful for governmental policy-makers, university researchers, and industrial professionals.

6.1 From Governmental and University's Perspectives

(1) Need to Support the Establishment of Intermediary Organization

The university and industry exist for different purposes. The university exists to foster an environment conducive to advancement of knowledge, the free inquiry, and exchange of ideas. On the other hand, a company or business activity exists to offer a service or product to society and on this basis, to make a profit which sustains the employment of its personnel, and provides return to those investors, primarily stockholders. Hence, it is critical to have intermediaries to coordinate the universities and industrial companies. The typical examples of "Linkage Organization" include Wisconsin Alumni Research Foundation (WARF), ARCH of Chicago University, and AUTM in the United States, and Steinbeis' Foundation in Germany. In Taiwan, except Tze-Chiang Foundation of Science and Technology, there is almost no formal linkage organization to help U-I research cooperation and transfer.

(2) Need to Establish University Research Center Oriented for Industrial Technology

In this respect, the most famous case is recognized in the United States where National Science Foundation (NSF) sponsored Engineering Research Center (ERC) and Industry-University Cooperative Research Center (IUCRC). Until 1996, NSF has been supporting over

25 ERCs and 70 IUCRCs. NSF supports the research center for the early stage, normally 5 years, after the center is established. Meanwhile, NSF requires the center to find partners from the industry to cooperate with. It expects the center will be able to support itself once the fund from NSF is terminated. Although there are some research centers in universities in Taiwan, most of them are not oriented for industrial technologies.

(3) Need to Delegate Intellectual Property Rights

Currently, the law in Taiwan still rule that the ownership and rights of the government-sponsored cooperative research results belong to government. To industrial companies, if they can't own the intellectual property rights, then they may lose some competitive advantage. In addition, if looking those more than 600 patents owned by National Science Council, one can find the percentage of the patents having been commercialized is less than 10%. On the other hand, many developed countries have already passed the Act to delegate the ownership and rights of the government-sponsored cooperative research results to either university or even industrial companies so that they are more able to commercialize those patents.

(4) Need for Universities to Setup Patenting & Licensing office

Industrial people always complain about the difficulty in negotiating the contract and intellectual property rights with university. On the other hand, the researchers and faculty members of universities normally lack sufficient time, resources, and capabilities to conduct patent application or research results transfer. Therefore, if universities are able to setup a formal office for patenting and licensing, then the office could take care of the patent application, process of research result transfer and determines the commercial potential of university invention disclosure, and negotiates the process of licensing. Thus the university researchers will not be burdened by the administrative affairs.

6.2 From Industrial Corporations' Perspectives

(1) Need to Better Leverage External Sources of Technologies

Most of the industrial firms do not own all the technologies needed, particularly for the small and medium sized enterprises. Therefore, they should consider better utilizing the external sources of technologies to gain competitive advantage. In fact, in the cases of the U.S. and German, 60% of the companies, which license university research results, are small & medium sized enterprises.

(2) Need to Build a Long-term Relationship with University

In general, industrial companies have a serious time pressure to make short-term profit and thus demand the cooperative research results intensively and quickly. However, it takes time to obtain the cooperative research results from the university research team. Furthermore, only with the long-term relations can participants build good communication and absorptive system which could have significant impact on the performance of UIRC project.

(3) Need to Build Internal Competence

It has been widely recognized that the company's own competence can affect its absorptive

capability in transferring outside technologies. While actively cooperating and communicating with outside organizations, it is very crucial that the company has its own technological capability inside. Otherwise, the result transfer process will not be as smooth and effective as expected.

7. Conclusion

In the early 1980s, the government of Taiwan was able to enact industrial technology policies, to setup research institutes, and to attract Chinese engineers and scholars overseas to come back. Therefore, the high-technology industries were able to arise and some industries are even placed top in the world. Nevertheless, one still can find the industrial firms' innovative capabilities and profitability are still low compared to those in developed countries. Hence, the next step for Taiwan is to strengthen the linkage between the industry and university in order to enhance the level of technological sophistication. However, the issue and related practices are new to universities, government agencies, and industries in Taiwan.
Therefore, all of them need to learn regarding university-industry interactions.

8. Reference

Aaron, Elizabeth (1988 December) "Tapping Into University Technology," High Technology Business, pp.26-32

Allen, Martha L., M. Dayne Aldredge, and Bettye B. Burkhalter (1989) "The Evolution of University and Industry Research Relationships," Engineering Education, Part : April, pp.418—Part α: May/June, pp.476-481

APCO Associates (1986) Research Cooperation Between University and Industry, Washington, D.C.

Atlan, Taylan (1987) "Bring Together Industry and University Engineering Schools," in Getting More Out of R&D and Technology, The Conference Board, Research Report #904

Barber, Albert A. (1985) "University-Industry Research Cooperation," Journal of Society of Research Administrators, pp.19-29

Baldwin, Donald R. and James W. Green (1984 Spring) "University-Industry Relations: A Review of Literature," Journal of Society of Research Administrators, pp.5-17

Bartlett, Joseph W. (1988 November) "Joint Ventures With Industry," High Technology Business, pp.30-32

Berman, Evan M. (1990 Summer) "R&D Consortia: Impact on Competitiveness," Journal of Technology Transfer

Brown, Theodore L. (1985 Fall) "University-Industry Relations: Is There a Conflict? ," Journal of Society of Research Administrators, pp.7-17

Chan, Sinchen, (1990), "The factor_influencing university and industry cooperative performance research", Unpublished thesis, Graduate School of Business Administration,

National Chungchi University, Taiwan

Chermside, Herbert B. (1985 Winter) “Some Ethical Conflicts Affecting University Patent Administration (PART I),” Journal of Society of Research Administrators, pp.23-24

Chuo, Jisu, (1992), “The research of high technology industry, government, and university technology transfer”, Unpublished thesis, Graduate School of Business, National Taiwan University.

Ditzel, Roger G. (1988 Summer) “Patent Rights at the University/Industry Interface,” Journal of Society of Research Administrators, pp.221-228

Geiger, R. (1986) To Advance Knowledge: Growth of American Research Universities 1900-1940, Oxford University Press, Press, England

Geisler, Elizer, Antonio Furino, and Thomas J. Kiresuk (1991 May) “Toward a Conceptual Model of Cooperative Research: Patterns of Development and Success in University-Industry Alliances,” IEEE Transactions on Engineering Management, vol. EM-38, no.2, pp.136-145

Huang, Jien & Liu, Paul (1996) IPR law and Its managemnet, Whiti Publisher Chinese Taipei

Krebs, Robert E. (1984 Sprint) “A Dilemma – Scholarship vs. Entrepreneurship,” Journal of Society of Research Administrators, pp.19-28

Lauo, Jinlong, (1983) “The research of industry and university cooperative models” incited from Liaw, Jidir (1989) Industry, government, and university cooperative research, Unpublished thesis, Graduate School of Business Administration, National Chungshan University, Taiwan

Liaw, Jih-Der (1988) “An Empirical Study of the Cooperative Research Among Industry, University, and Government,” Unpublished Master Thesis, National Chungshan University, Taiwan

Liu, Jinlung (1983) A Study of Models for Cooperation Between Industrial Firms and Academic Institutions, Chinese Taipei

Macomber, John D. (1991 February) Industrial Perspectives on Innovation and Interactions with Universities, Government-University-Industry Research Roundtable, National Academy Press, Washington, D.C.

Peters, Lois S. and Herbert I. Fusfeld (1982) University-Industry Research Relationships, National Science Foundation

Stewart, G. Hutchinson and David Gibson (1990) “University and Industry Linkages: The Austin, Texas, Study,” in Frederick Williams and David V. Gibson (ed.) Technology Transfer: A Communication Perspective, pp.109-131, Sage Publications, Inc., California

Wu, Ching-Song, (1992), “R&D consortia and Industry Development”, the First Symposium on Industry Management conference, Funjung University, Taiwan

Wu, Feng-Shang (1994), “Technological Cooperation: Model and Trend”, the Third Symposium on Industrial Management, Funjung University, Taiwan