# University-Industry Linkages in Thailand: Successes, Failures, and Lessons Learned for Other Developing Countries

Patarapong Intarakumnerd * and Daniel Schiller

Universities are a critical actor in innovation systems of both developed and developing countries. In the context of developing countries, universities can play an important role as an indigenous knowledge source. Fruitful university-industry linkages (UILs) help local firms to import, modify, and diffuse technology. At the same time, universities can improve their academic capabilities if they interact with the private sector. However, appropriate explanations of UILs in developing countries are still lacking. It is the aim of this paper to identify successes and failures of UILs in Thailand by combining data from company and university surveys. In general, UILs in Thailand are still weak. But determinants for successful projects have been identified which offer the potential to serve as guidelines to improve UILs in the future. The findings of the paper contribute to the debate on the extended role of universities in developing countries for technological change and economic development.

*Keywords*: University-industry linkages, Technological change, Academic capabilities, Developing countries, Thailand

*JEL Classification*: O32, O38

* Corresponding Author, Lecturer, College of Innovation, Thammasat University, Prachan Road, Bangkok 10200, Thailand. (Tel) +66-2-6235055, (Fax) 66-2-6235059, (E-mail) prpu6@hotmail.com; Research Associate, Institute of Economic and Cultural Geography, Leibniz University of Hannover, Germany. (Tel) +49-511-762-3534, (Fax) +49-511-762-3051, (E-mail) schiller@wigeo.uni-hannover.de, respectively.
[**Seoul Journal of Economics** 2009, Vol. 22, No. 4]

## I. Introduction

The concept of innovation systems focuses on the range of actors involved in the process of innovation. In most industries firms are perceived as the central actor. However, there has been a tendency of many scholars writing about innovation to neglect other actors that are necessary to support the innovation process at the firm level. Universities, for example, are a critical actor in both developed and developing countries. They are not only providing training to students who will later work in industry, but are also directly interacting with the private sector on the basis of their research capabilities. It is now widely accepted that universities and public research institutes played a substantial role in the development of many high-technology regions in the U.S. and other developed countries (Bresnahan and Gambardell 2004). The presence of four world-class universities in Boston and San Francisco Bay areas, for example, is partially responsible for their success in the areas of information and communication technology (ICT), and biotechnology. Their students often remained in the area and eventually became entrepreneurs, and the research conducted at their universities, at times, became the seed for new firms (Kenney 1986; Kenney and Burg 1999; Shane 2004; Zucker *et al.* 1998).

In the context of developing countries, universities can play an important role as an indigenous knowledge source: they are a vehicle through which technologies and organizational forms of advanced countries can be absorbed locally, and they have the potential to generate appropriate technological inputs in close cooperation with local firms. Fruitful university-industry linkages (UILs) help local firms to initiate, import, modify and diffuse technology.

There have been remarkable observations that universities around the world are adopting a policy of encouraging entrepreneurship and the university as an institution is moving toward a more entrepreneurial paradigm (Etzkowitz *et al.* 2000; Rappert *et al.* 1999; Shane 2004; Goldfarb and Henrekson 2003). Elaborating on this, Etzkowitz and Leydesdorff (2000) have described the interplay between universities, industries, and governments within a structure of overlapping spheres and 'hybrid' forms of organization as a 'Triple helix.' Nonetheless, the core idea of the 'Triple helix' thesis is that universities should form direct links with industry to capitalise on their knowledge, *e.g.,* by technology licensing. 'Triple helix' relations are thus closely related with the emergence of the entrepreneurial university model and interactions in emerging high-tech industries like biotechnology. However, these concepts are less applicable for some developing countries since they tend to inherit mature industries or labor-intensive parts of the value chain from advanced countries and produce standardized products.

Thus, the efficiency of UILs in developing countries depends on the contributions of universities to the technological and organizational upgrading process in industry. This notion has been incorporated by a recently published framework that brings forth the idea of academic capabilities (Liefner and Schiller 2008). This approach is innovative in its way to relate the functions of universities (*e.g.,* research, teaching, technology transfer, management) to the overall process of technological change and development. A specific focus lies on the notion that it is not sufficient to focus on the monetary returns to universities from UILs. Instead, the development of academic capabilities is expected to require heavy public investments in the early stages of the upgrading process. Academic capability building is a rather challenging task since it has to integrate education, technology, and industrial policy.

Lacking appropriate explanation of UILs in developing countries and the still limited number of comparative studies led to the formation of a research group of academics from Asia, Latin America, and Africa under financial support of the Canadian International Development Research Centre (IDRC). It is the aim of this group to better understand and to compare diverse modes of UILs in each country, which are expected to depend upon several country- and sector-specific factors. The research lasts from late 2007 to early 2009.

Similar to studies in other countries under the IDRC-supported project, our research questions are as follows:

First, we will describe the position of UILs in Thailand and how they evolved over time as a starting point to understand the role of universities for technological change in Thailand.

Second, we will try to explain the reasons for the recent state of UILs and its evolution by examining several determinants. The determinants will be sought in terms of university, firm level, or policy-related factors as well as sectoral differences.

Third, we will explore the question of how UILs could be pursued to a larger extent and more efficiently in the Thai economy and how to reach such improvements starting from the current position. A further aspect is the role of universities to initiate regional economic development in peripheral regions like northern or northeastern Thailand. We expect to draw lessons from the identified successes and failures for other developing countries.

Methodologically, a new questionnaire survey was designed and the same questionnaire has been used for all countries under the IDRC-supported research project. Nonetheless, data from innovation surveys has already been available in the case of Thailand. Even though some questions are omitted or different from the newly designed survey, we use this data to conduct research on Thailand. Further case studies on different types of universities (old and comprehensive universities, autonomous and S&T-oriented universities and regional universities) have been conducted to examine the different patterns of UILs and their underlying reasons.

The following section provides an overview of capabilities of firms and universities in Thailand. Section 3 will analyze the importance of UILs for firms in Thailand based on innovation survey data. Section 4 focuses on empirical evidence of five leading Thai universities on their collaboration with industry. Section 5 provides cases of successful UILs. The final section discusses the results and provides lessons learnt for other developing countries and theoretical implications to existing UIL studies.

## II. Overview of Capabilities of Firms and Universities in Thailand

This section will describe overall situation concerning capabilities of firms and universities in Thailand before analyzing the survey data.

### *A. Overall Capabilities of Firms*

Several studies of Thai firms conducted since the 1980s state that most firms have grown without deepening their technological capabilities in the long run, and their technological learning has been very slow and passive (see Bell and Scott-Kemmis 1985; Chantramonklasri 1985; Thailand Development Research Institute 1989; Dahlman and Brimble 1990; Tiralap 1990; Mukdapitak 1994; Lall 1998). The recent World Bank's study (see Arnold *et al.* 2000) confirms this long-standing feature of Thai firms. Only a small minority of large subsidiaries of transnational corporations (TNCs), large domestic firms and SMEs have capability in R&D, while the majority is still struggling with increasing their design and engineering capability. For a very large number of

SMEs, the key issue is much more concerned with building up more basic operational capabilities, together with craft and technician capabilities for efficient acquisition, assimilation and incremental upgrading of fairly standard technology. The slow technological capability development of Thai firms is quite different from what characterized Japan, Korea, and Taiwan. Firms in these countries moved rather rapidly from mere imitators to innovators.

However, more intense competition in the global market and the economic crisis in 1997 have, to some degree, led to a change in behavior among Thai firms. Several large conglomerates increased their in-house R&D activities rather than solely relying on off-the-shelf foreign technologies. A number of smaller companies increased their technological efforts by collaborating with university R&D groups in order to stay ahead in the market or to enter a more profitable market section. Several locally-owned OEM manufacturers experiencing external pressure especially from foreign customers that adopted global sourcing strategies started to develop products through their own designs and brand names. There were also emerging new start-up firms (less than 50 employees) relying on their own design, engineering or development activities. These companies were managed by entrepreneurs having a strong R&D background, from studying or working abroad. (Thailand Development Research Institute 1998; Arnold *et al.* 2000; Intarakumnerd and Virasa 2002).

### *B. Overall Capabilities of Universities*

Public universities are forming the core of research and graduate teaching in the Thai higher education system. With very few exceptions, private universities are mainly focused on undergraduate teaching. Thus, public funding of universities is the major input indicator to predict outputs that are potentially valuable for UIL. The budget of Thai universities as a whole and for R&D in particular suggests that a critical mass of R&D can at best be reached in a few selected technological fields. R&D expenditures in Thailand in 2002 were just 0.26% of the GDP (IMD 2004), which is rather low in comparison to other catch-up economies at a similar stage of economic development. The share of R&D activities performed by universities has been shrinking constantly from 36% in 1995 to 18% in 2001, and it has been at best constant if inflation is considered between 1997, 1.63 billion Baht, and 2001, 1.95 billion Baht (NRCT 2000, 2004). The figures are in line with funding for the university system as a whole, which has declined as a percentage of GDP and of total government spending since 1997. Its relative position is just improving since 2007 (Budget Bureau, various years). The weak funding base for universities is to a certain degree a result of budget-cuts in the aftermath of the Asian financial crisis (Schiller and Liefner 2007). Besides funding problems the public universities also suffer from bureaucratic red tape and a lack of incentives. Notwithstanding discussions since more than 10 years, the transition of universities into autonomous organizations has just started on a broader scale during the last years.

Publications listed in the Science Citation Index (SCI) are used as an indicator for research outputs in science & technology. These fields are expected to have the highest potential to establish linkages with private companies. The total number of Thai publications grew significantly during the last 10 years from about 500 publications per year until the mid-1990s to well-above 3,000. This development is in line with the change in the Thai innovation system. Comprehensive research in science and technology (S&T) has just started 15 to 20 years ago. If compared to 1st generation newly industrialized countries (NICs), *i.e.,* Korea, Taiwan, Singapore, this expansion is much less impressive. These countries and also China increased their number of publications in an even shorter period of time (Schiller 2006a). By splitting up the publication output by scientific fields, we receive more detailed results for the linkage potential. The world share of Thai publications is still highest in agricultural sciences. Thai universities have established faculties for agro-industry that perform research at the interface between agricultural extension and post-harvest processing. However, a special focus on engineering, as in 1st generation NICs or China, has not been established. Thus, the potential for UILs is expected to be much lower in the modern industrial sector than in traditional sectors (Schiller 2006a). International patents filed by staff from Thai universities are still negligible (Cheamsawat 2004).

An assessment of academic capabilities of Thai universities in a recent paper by Liefner and Schiller (2008, p. 291) found “clear evidence for the weak contribution of local knowledge providers to qualitative growth in Thailand. [...A]cademic capabilities [...] are still low in most cases. [...] Only a few cases of intermediate and advanced academic capabilities have been identified.” Compared with international standards, the research output of Thai universities is still limited. Topics are not selected in accordance with industrial needs. Universities and public research institutes mainly follow a linear approach to innovation: research is done for the private sector, but not in interaction with it (Arnold *et al.* 2000, p. 119; Intarakumnerd *et al.* 2002, p. 1451).

## III. University-Industry Linkages in Thailand: An Analysis of Innovation Surveys

To assess the innovative capabilities and innovation characteristics of firms in Thailand, R&D and innovation surveys have been carried out by the National Science and Technology Development Agency (NSTDA) since the year 1999. R&D surveys were carried out every year, but the innovation surveys were done only in the years 1999, 2001, and 2003.

The survey in 1999 was the first of its kind in Thailand and it covered both R&D and other technological innovation activities only in the manufacturing sector. Since 2002 service sectors are included in the survey to get a more comprehensive understanding of the nature and differences of R&D and innovation activities. The surveys adopted definitions and methodologies used by OECD (namely, Frascati Manual (1993) and Oslo Manual (1997)) and other countries in Asia (namely Singapore, Malaysia, Japan, Taiwan, and Korea) to meet international standards.

The surveys focused on determining the characteristics of firms that carry out R&D and other innovation activities. It also covered the types of R&D and other innovation activities as well as factors, which influence firms' abilities to carry out R&D and other innovation activities. The sampling methodology was developed in order to obtain unbiased estimates of the parameters to be measured — expenditure on R&D/Innovation and total R&D/Innovation personnel in manufacturing and service enterprises. The Business On-Line (BOL) database, with comprehensive information on around 50,000 establishments registered with the Commercial Registration Department, Ministry of Commerce, was used. In addition to the BOL database, other sources of information such as the Board of Investment, the Department of Export Promotion and the Computer Professional Information 2002 were also utilized for the service sector's sampling frame. The population size, sample size, and response rate, percentage of R&D-performing firms, and innovating firms are illustrated in Table 1.

TABLE 1
THAILAND'S INNOVATION SURVEYS: CHARACTERISTICS AND OVERALL RESULTS

| | 1999 | 2001 | 2003 |
|---|---|---|---|
| Size of Population | | | |
| - Manufacturing sector | 13,450 | 14,870 | 16,432 |
| - Service sector | n.a. | 26,162 | 5,221 |
| Total | 13,450 | 41,032 | 21,653 |
| Size of sample | | | |
| - Manufacturing sector | 2,166 | 3,945 | 4,850 |
| - Service sector | n.a. | 2,137 | 1,181 |
| Total | 2,166 | 6,082 | 6,031 |
| Response rate (%) | | | |
| - Manufacturing sector | 47.0% | 36.7% | 42.3% |
| - Service sector | n.a. | 37.3% | 45.0% |
| Total | 47.0% | 36.9% | 42.8% |
| R&D performing firms (%) | | | |
| - Manufacturing sector | 12.7% | 4.4% | 7.2%[1] |
| - Service sector | n.a. | 0.2% | 2.4% |
| Total | 12.7% | 1.7% | 6.0% |
| Innovating firms (%) | | | |
| - Manufacturing sector | 12.9% | 4.7% | 6.4% |
| - Service sector | n.a. | 1.4% | 4.0% |
| Total | 12.9% | 2.6% | 5.8% |

Source: Reports on R&D/Innovation Surveys Year 1999, 2001, 2003 by National Science and Technology Development Agency (NSTDA).

We will examine university-industry linkages in several aspects to assess the relative importance and strength of UILs in Thailand.

## *A. Sources of Information and Knowledge*

Between 1999 and 2003, on the whole, the most important sources of information and knowledge for R&D-performing firms and innovating firms were clients and sources within the company while the universities or higher education institutes and public research institutes were not seen as the major source of information and knowledge for R&D and

[1] The smaller percentage of innovating firms compared to R&D performing firms in 2003 might be unexpected. Nonetheless, this is possible, as not all R&D activities are for innovation. Firms can conduct R&D for problem-solving purpose or just for increasing absorptive capacities in understanding and monitoring new technologies (Cohen and Levinthal 1990). Even R&D activities aimed at creating innovation, many might fail.

TABLE 2
SOURCES OF INFORMATION AND KNOWLEDGE FOR 1999-2003
(0-NOT KNOW, 1-NOT IMPORTANT, 5-VERY IMPORTANT)

| Source of Information | 1999 | | 2001 | | 2003 | |
|---|---|---|---|---|---|---|
| | R&D Firms | Inno Firms | R&D Firms | Inno Firms | R&D Firms | Inno Firms |
| Sources within the enterprise | 3.33 | 2.71 | 4.27 | 4.08 | 2.55 | 3.66 |
| Parent/Associate companies | 2.51 | 2.11 | 3.38 | 3.22 | 1.75 | 2.68 |
| Clients | 3.40 | 2.91 | 4.08 | 3.73 | 2.48 | 3.76 |
| Locally-owned suppliers | 2.58 | 2.18 | 3.39 | 3.05 | 2.00 | 2.97 |
| Foreign-owned suppliers | 2.69 | 2.15 | 3.10 | 3.05 | 1.92 | 2.75 |
| Universities or higher education institutes | 1.99 | 1.64 | 2.46 | 2.13 | 1.56 | 2.03 |
| Government or private Non-profit research institutes | 1.92 | 1.63 | 2.14 | 1.95 | 1.51* / 1.05** | 2.08* / 1.59** |
| Business service providers | 1.65 | 1.54 | 2.18 | 1.95 | 1.20 | 1.79 |
| Technical service providers | 1.97 | 1.80 | 2.59 | 2.39 | 1.44 | 2.24 |
| Competitors | 2.48 | 2.22 | 2.71 | 2.59 | 1.83 | 2.84 |
| Patent disclosures | 1.44 | 1.39 | 2.17 | 2.07 | 1.26 | 1.75 |
| Fairs and exhibitions | 2.40 | 2.11 | 3.12 | 3.10 | 2.00 | 2.85 |
| Professional conference & meeting | 2.47 | 2.09 | 3.16 | 2.68 | 1.88 | 2.70 |
| Specialist literature | 2.73 | 2.23 | 3.25 | 2.73 | 1.92 | 2.69 |
| Internet | 2.42 | 2.04 | 3.54 | 3.45 | 2.32 | 3.34 |

Notes: *Public research institutes
**Private non-profit

innovating firms (see Table 2).

The characteristics of R&D performing firms which regard the university or higher education institute as relatively more important source of information were as follow: a) founded between 6 and 15 years ago, b) 71-100% locally owned, c) having 200 employees or less, and d) being in medical, precision and optical instruments industry for manufacturing sector and telecommunication industry for service sector. For those which regard government/private non-profit research institutes as relatively more important sources of information, their characteristics were a) founded between 6 and 10 years, b) locally owned more than 71%, c) being large firms (> 400 persons), and d) being in medical, precision and optical instruments industry for manufacturing sector and in telecommunication industry for service sector.

For innovating firms which regard the university or higher education institute as relatively more important source of information, their general characteristics were as follow: a) founded more than 15 years ago, b) more than 71% locally owned, c) having more than 400 persons, and d) being in textiles industry for manufacturing sector and telecommunication industry for service sector. For those which regard government/private non-profit research institutes as relatively more important sources of information, their characteristics were a) founded more than 15 years ago, b) 100% locally owned, c) employed between 101 and 400 persons, and d) being in printing and rubber-plastic industry for manufacturing sector and telecommunication industry for service sector.

### *B. External Collaboration of R&D and Innovating Firms*

Overall, R&D-performing firms had intense interaction with customers/buyers, followed by locally-owned suppliers, foreign-owned suppliers and parent/associate companies collaborate while research institutes and universities were relatively less intense (see Figure 1).

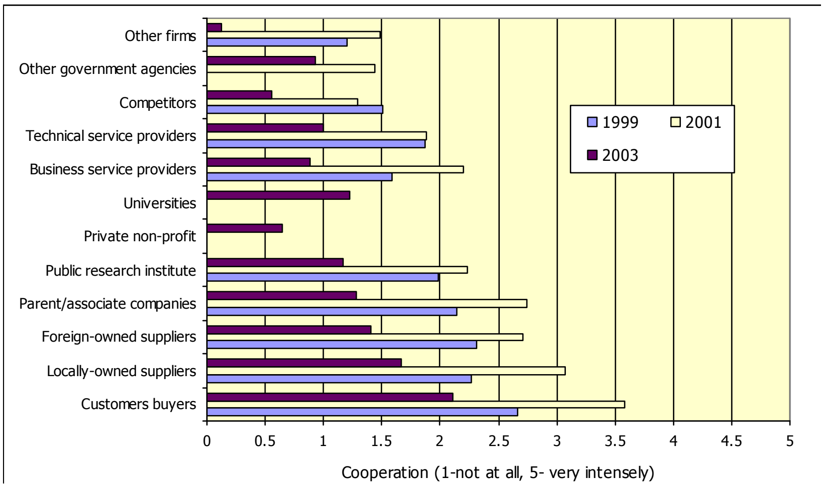
As for firms having product innovation, they had intense interaction mostly with customers/buyers, followed by locally-owned suppliers, foreign-owned suppliers and parent/associate companies collaborate. On the other hand, the research institutes, universities and other government agencies were not seen as the major partners for innovating firms (see Figure 2).

As for firms having process innovation, they had interaction mostly with customers/buyers for product activities, followed by locally-owned suppliers, foreign-owned suppliers and parent/associate companies, while the research institutes, universities and other government agencies were not seen as the major sources (see Figure 3).

### *C. Environment in Thailand for R&D and Innovation*

a) R&D-Performing Firms

Over the period of 1999 and 2003, openness of customers to innovation was seen as positive environment for R&D-performing firms, followed by openness of suppliers to innovation, quality of telecommunications and IT services while technical supports from universities




Note: In the years 1999 and 2001, research institutes and universities are in the same category while public research institutes are separated from universities in the year 2003.

FIGURE 1

EXTERNAL COLLABORATION FOR R&D ACTIVITIES FOR 1999-2003 (0-NOT KNOW, 1-NOT AT ALL, 5-VERY INTENSELY)

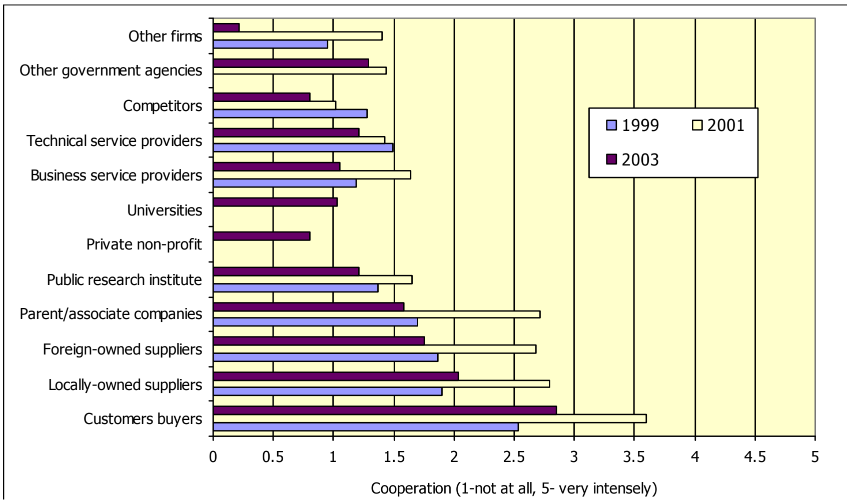



FIGURE 2

EXTERNAL COLLABORATION FOR PRODUCT INNOVATION FOR YEAR 1999-2003 (0-NOT KNOW, 1-NOT AT ALL, 5-VERY INTENSELY)

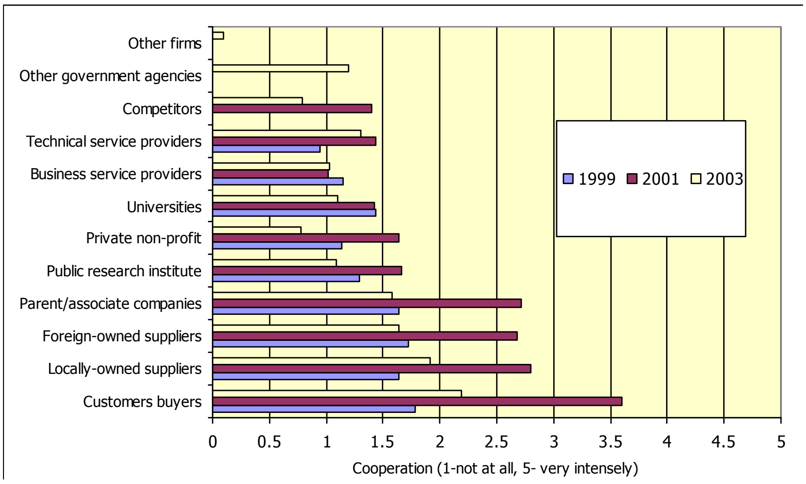



FIGURE 3
EXTERNAL COLLABORATION FOR PROCESS INNOVATION FOR YEAR 1999-2003 (0-NOT KNOW, 1-NOT AT ALL, 5-VERY INTENSELY)

TABLE 3
ENVIRONMENT IN THAILAND FOR R&D ACTIVITIES
(0-NOT KNOW, 1-VERY WEAK, 5-VERY GOOD)

| Year | Availability of government incentives | Availability of manpower in scientific-technical sector | Availability of manpower in business sector | Technological sophistication of local suppliers | Consultancy support services | Local university for technical support |
|---|---|---|---|---|---|---|
| 1999 | 1.77 | 2.27 | 2.29 | 2.23 | 2.05 | 2.18 |
| 2001 | 2.77 | 3.10 | 3.17 | 2.94 | 2.65 | 2.72 |
| 2003 | 1.60 | 1.78 | 1.91 | 1.83 | 1.61 | 1.73 |

| Year | R&D institutions for technical support | Availability of other technical supporting services | Acceptance of failure | Attitude of people towards innovation | Openness of customers to innovation | Openness of suppliers to innovation |
|---|---|---|---|---|---|---|
| 1999 | 2.15 | 2.03 | 2.00 | 2.34 | 3.03 | 2.71 |
| 2001 | 2.66 | 2.79 | 2.40 | 3.12 | 3.39 | 3.19 |
| 2003 | 1.76 | 1.53 | 1.40 | 1.90 | 2.27 | 2.13 |

| Year | Openness of government department & regulatory authorities | Regulatory environment | Intellectual property protection | Quality of telecommunications and IT services | Availability of finance for innovation | Listing requirements on SET stock exchange |
|---|---|---|---|---|---|---|
| 1999 | 2.15 | 1.82 | 2.16 | 2.31 | 2.03 | 1.45 |
| 2001 | 2.87 | 2.53 | 2.64 | 3.40 | 2.40 | 1.67 |
| 2003 | 1.69 | 1.55 | 1.72 | 1.86 | 1.72 | 1.01 |

TABLE 4
ENVIRONMENT IN THAILAND FOR INNOVATION ACTIVITIES
(0-NOT KNOW, 1-VERY WEAK, 5-VERY GOOD)

| Year | Availability of government incentives | Availability of manpower in scientific-technical sector | Availability of manpower in business sector | Technological sophistication of local suppliers | Consultancy support services | Local university for technical support |
|---|---|---|---|---|---|---|
| 1999 | 1.83 | 2.41 | 2.42 | 2.40 | 2.15 | 2.10 |
| 2001 | 2.46 | 3.19 | 3.28 | 3.02 | 2.68 | 2.40 |
| 2003 | 2.17 | 2.51 | 2.66 | 2.60 | 2.37 | 2.36 |

| Year | R&D institutions for technical support | Availability of other technical supporting services | Acceptance of failure | Attitude of people towards innovation | Openness of customers to innovation | Openness of suppliers to innovation |
|---|---|---|---|---|---|---|
| 1999 | 2.03 | 2.10 | 1.96 | 2.62 | 3.17 | 2.86 |
| 2001 | 2.30 | 2.53 | 2.34 | 3.18 | 3.49 | 3.22 |
| 2003 | 2.30 | 2.21 | 1.94 | 2.82 | 3.43 | 3.08 |

| Year | Openness of government department & regulatory authorities | Regulatory environment | Intellectual property protection | Quality of telecom-munications and IT services | Availability of finance for innovation | Listing requirements on SET stock exchange |
|---|---|---|---|---|---|---|
| 1999 | 2.27 | 1.97 | 2.22 | 2.38 | 2.11 | 1.52 |
| 2001 | 2.73 | 2.73 | 2.72 | 3.38 | 2.68 | 1.48 |
| 2003 | 2.39 | 2.18 | 2.46 | 2.74 | 2.47 | 1.40 |

and research institutes were rather weak, especially in the year 2003. Also R&D-performing firms perceived that the situation on availability of manpower in scientific and technical sector worsened (see Table 3).

b) Innovating Firms

From year 1999 to year 2003, openness of customers to innovation and openness of suppliers to innovation were seen as strong factor for supporting R&D and innovation activities while technical supports from universities and research institutes government and university were moderate (Table 4).

Interestingly, comparing with non-R&D and non-innovating firms, R&D-performing firms and innovating firms view the support from universities and public research institutes more positively.

### *D. Sectoral Analysis*

Firms in all industrial sectors viewed inter-firm linkages with

TABLE 5
IMPORTANCE OF SOURCE OF INFORMATION AND KNOWLEDGE BY INDUSTRIAL SECTOR FOR INNOVATING FIRMS IN 2003
(1-NOT IMPORTANT, 5-VERY IMPORTANT)

| Sector | Universities or other higher education institutes | Public research institute |
|---|---|---|
| Food | 2.75 | 2.43 |
| Textiles | 3.25 | 2.50 |
| Wearing | 2.00 | 2.00 |
| Dyeing | 1.00 | 0.75 |
| Wood | 1.33 | 1.33 |
| Paper | 1.75 | 2.00 |
| Printing | 2.67 | 3.00 |
| Petroleum | 1.95 | 1.90 |
| Chemicals | 1.58 | 1.67 |
| Synthetic rubber/Plastic | 1.50 | 3.00 |
| Non-metallic | 1.17 | 1.33 |
| Basic metal | 1.75 | 1.75 |
| Fabricated metal products | 1.80 | 1.90 |
| Machinery | 2.00 | 2.00 |
| Electrical machinery | 1.73 | 2.18 |
| Radio | 1.25 | 2.13 |
| Scientific instrument | 2.13 | 2.38 |
| Motor | 2.08 | 2.23 |
| Other vehicles | 1.00 | 0.75 |
| Furniture | 1.20 | 1.50 |
| Telecommunication | 5.00 | 3.00 |
| Financial | 2.50 | 2.50 |
| Computer | 2.33 | 2.67 |
| R&D | 3.00 | 3.00 |
| Other services | 2.29 | 2.43 |
| Total | 2.03 | 2.08 |

customers, suppliers, and parents/associated firms as more important than UILs. Nonetheless, there are differences among sectors regarding UILs. We will, therefore, analyze the relative importance of university and public research institutes according to perception of firms by examining firms' source of information and knowledge, external collaboration, perception on environment.

a) Source of Information and Knowledge by Industrial Sector

In the manufacturing sector, universities or higher education in-

TABLE 6
EXTERNAL COLLABORATION FOR R&D ACTIVITIES BY INDUSTRIAL SECTOR IN 2003 (1-NOT IMPORTANT, 5-VERY IMPORTANT)

| Sector | Universities or other higher education institutes | Public research institutes |
|---|---|---|
| Food | 1.94 | 1.68 |
| Textiles | 1.33 | 1.67 |
| Dyeing | 1.00 | 0.33 |
| Wood | 1.50 | 1.50 |
| Printing | 2.00 | 2.67 |
| Petroleum | 3.00 | 3.33 |
| Chemicals | 1.25 | 1.20 |
| Synthetic rubber/Plastic | 2.22 | 1.78 |
| Non-metallic | 0.00 | 1.00 |
| Basic metal | 1.67 | 0.33 |
| Fabricated metal product | 3.67 | 2.33 |
| Machinery | 1.44 | 1.78 |
| Electrical machinery | 1.83 | 2.17 |
| Radio | 2.14 | 2.29 |
| Scientific instrument | 0.33 | 0.33 |
| Motor | 2.86 | 2.00 |
| Other vehicles | 1.00 | 1.00 |
| Electrical machinery | 1.20 | 1.60 |
| Telecommunication | 5.00 | 4.00 |
| Financial | 0.00 | 0.00 |
| Computer | 4.00 | 4.00 |
| R&D | 3.50 | 3.50 |
| Other services | 2.00 | 1.50 |
| Total | 1.82 | 1.69 |

stitutes were more important for innovating firms in traditional sectors like food processing or textiles industry while public research institutes were more important for innovating firms in printing and synthetic rubbeinnovating firms in telecommunication considered both universities and public research institutes as important sources of information and knowledge. Not surprisingly, firms providing R&D services consider university and public research institutes as significant sources of knowledge and information (see Table 5).

b) External Collaboration for R&D Activities by Industrial Sector

In manufacturing sector, R&D-performing firms in petroleum industry had collaboration with public research institutes more intensely than those in industries, while R&D-performing firms in fabricated metal

TABLE 7
EXTERNAL COLLABORATION FOR PRODUCT INNOVATION ACTIVITIES BY INDUSTRIAL SECTOR IN 2003
(0-NOT KNOW, 1-NOT AT ALL, 5-VERY INTENSELY)

| Sector | Universities or other higher education institutes | Public research institute |
|---|---|---|
| Food | 1.10 | 1.20 |
| Textiles | 0.50 | 1.50 |
| Wearing | 2.00 | 3.00 |
| Dyeing | 0.75 | 0.25 |
| Wood | 0.33 | 0.33 |
| Printing | 1.50 | 1.75 |
| Petroleum | 1.67 | 2.00 |
| Chemicals | 1.10 | 1.05 |
| Synthetic rubber/Plastic | 1.58 | 1.42 |
| Non-metallic | 0.00 | 1.50 |
| Basic metal | 0.00 | 0.00 |
| Fabricated metal product | 1.00 | 1.00 |
| Machinery | 1.20 | 1.50 |
| Electrical machinery | 4.00 | 5.00 |
| Radio | 0.64 | 0.64 |
| Non-metallic | 1.00 | 1.88 |
| Scientific instrument | 0.50 | 0.63 |
| Motor | 0.77 | 0.69 |
| Other vehicles | 1.00 | 2.25 |
| Furniture | 0.30 | 0.60 |
| Telecommunication | 5.00 | 4.00 |
| Financial | 0.00 | 0.00 |
| Computer | 1.67 | 1.67 |
| R&D | 2.33 | 2.67 |
| Other services | 1.86 | 2.57 |
| Total | 1.03 | 1.21 |

product industry had interaction with universities more intensely than others. In service sector, R&D-performing firms in telecommunication and computer industry had collaboration with public research institutes and universities more intensely than firms other industries (see Table 6).

c) External Collaboration for Product Innovation Activities by Industrial Sector

In manufacturing sector, product-innovating firms in electrical machinery industry had more intense collaboration with public research institutes and universities than firms in other industries. For service

TABLE 8
EXTERNAL COLLABORATION FOR PROCESS INNOVATION ACTIVITIES BY INDUSTRIAL SECTOR IN 2003
(0-NOT KNOW, 1-NOT AT ALL, 5-VERY INTENSELY)

| Sector | Universities or other higher education institutes | Public research institute |
|---|---|---|
| Food | 1.22 | 1.13 |
| Textiles | 0.75 | 0.50 |
| Wearing | 2.00 | 3.00 |
| Dyeing | 0.75 | 0.50 |
| Wood | 1.33 | 1.33 |
| Printing | 1.75 | 2.00 |
| Petroleum | 2.33 | 2.67 |
| Chemicals | 0.67 | 0.48 |
| Rubber | 1.42 | 1.08 |
| Non-metallic | 0.00 | 1.50 |
| Basic metal | 1.00 | 0.50 |
| Fabricated metal product | 2.00 | 1.50 |
| Machinery | 0.90 | 0.90 |
| Electrical machinery | 2.00 | 4.00 |
| Printing | 1.00 | 0.91 |
| Radio | 0.75 | 0.75 |
| Scientific instrument | 0.75 | 0.63 |
| Motor | 1.69 | 1.69 |
| Other vehicles | 0.75 | 2.00 |
| Furniture | 0.70 | 1.20 |
| Total | 1.10 | 1.08 |

sector, product-innovating firms in telecommunication industry had more intense collaboration with public research institutes and universities (see Table 7).

d) External Collaboration for Process Innovation Activities by Industrial Sector

In manufacturing sector,[2] innovating firms in electrical machinery industry had more intense collaboration with public research institutes than firms in other industries, whereas innovating firms in petroleum industry had more intense collaboration with universities than those in

[2] Since it is very difficult to differentiate between product and process innovations in the service sector, the Thai surveys did not have a separate category for process innovation in services.

other industries (see Table 8).

## IV. University-Industry Linkages in Thailand from the University Perspective

The university perspective is covered by case studies of five public universities in Thailand. Public universities are the backbone of higher education in the country. The selection includes contrasting cases of the most important universities in terms of S&T research and education. The five cases cover comprehensive and S&T-oriented universities as well as traditional and autonomous ones. Three universities in Bangkok, Chulalongkorn University (CU), Kasetsart University (KU), King Mongkut's University of Technology Thonburi (KMUTT), are compared with two regional universities, Chiang Mai University in the north (CMU) and Khon Kaen University (KKU) in the northeast. The five universities have been studied comprehensively in 2004 and further follow-up surveys have been completed in 2005 and 2006. To cover the most recent developments especially those related to the management of UILs at autonomous universities, additional interviews with selected university managers, policy makers, and academic experts have been conducted.

The selection of interviewees was based on their experience and involvement with industry. The survey did not aim at measuring the impact of universities by a representative sample of interviews, but at learning about the process of regional involvement of universities in a developing country. However, this method has its limitations, as it might underestimate less successful attempts to work with industry. The large number of interviews conducted with professors who co-operate with private companies ($n=72$) and of identified cooperation projects ($n=136$) from a wide field of disciplines allows descriptive methods of analysis to be applied.

### *A. Impact of Higher Education Reform on UIL in Thailand*

The Thai higher education system underwent several reforms during the last years that have affected the possibility and the need to build closer linkages with industry (Schiller and Liefner 2007, p. 551). The following list covers major determinants for this trend. However, some regulations have a strongly negative impact on the potential for closer university-industry linkages:

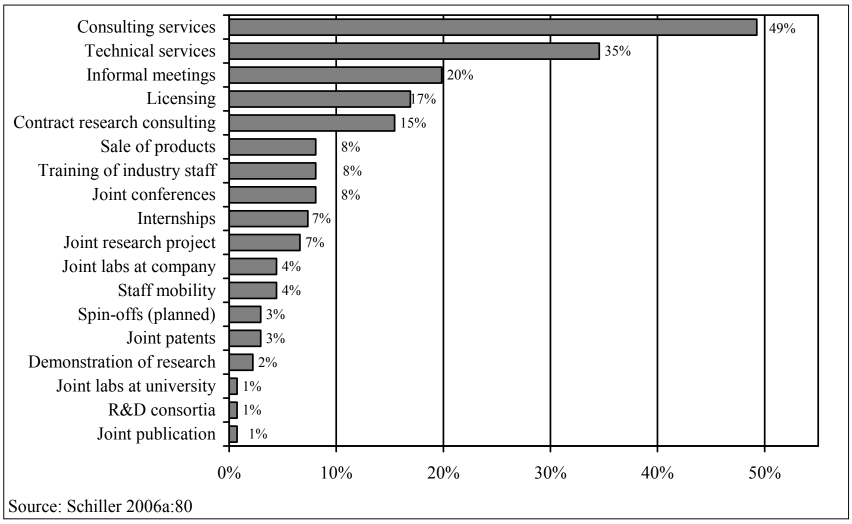
- (+) Stagnant public funding is an incentive to tap all kinds of new income sources.
- (+) Outward orientation is given since basic funding of universities mainly covers teaching expenses.
- (+) The transition of public universities into autonomous agencies eventually encourages additional entrepreneurial activities.
- (±) Research agencies support joint research with industry and commercialization, even though these projects are still quite small and too bureaucratic.
- (±) Technology policy has started to promote cooperative research and development in private companies, but is not yet implemented in a structured way.
- (−) For individual promotion, in particular, the teaching record is more important than excellence in research and academic services.
- (−) There is not enough high quality research which is potentially beneficial for industry.
- (−) Regulations for industrial projects are not fixed at most universities and therefore do not encourage academics to conduct personal projects with official consent.

### *B. UIL Modes*

Former studies on UIL in Thailand found that with interesting exceptions Thai UILs are frail (Brimble and Doner 2007). Even though Withayagiat (1993, p. 41) and Temsiripoj (2003, p. 201) estimate that about 25% of all Thai professors are involved in outreach activities with the private sector, most of these project are on an informal, personal base without tangible or intangible effects for the respective universities (Schiller 2006a). Most projects are limited to consulting and technical services without deeper research involvement and to linear modes of knowledge transfer (Figure 4).

a) Industrial Sectors

Knowledge demand and cooperation patterns differ significantly among the industrial sectors. Most cooperation partners are from manufacturing sectors, but with a strong focus on three sectors. The sectoral division within the UIL sample differs markedly from the total population in manufacturing. Most cooperation partners are from food processing followed by automotives and electronics, and chemical industry and pharmaceutics. All other sectors have a lower share in the sample than




Source: Schiller 2006, p. 80.

FIGURE 4

UIL MODES IN THAILAND (MULTIPLE ANSWERS POSSIBLE), $n=136$

TABLE 9

CHARACTERISTICS OF INDUSTRY PARTNERS OF THAI UNIVERSITIES

| Sector | Sample[1] | Population within the manufacturing sector |
|---|---|---|
| Manufacturing | 100% (72%) | (100%) |
| Food processing | 37% (51%) | (16.0%) |
| Automotives and electronics | 15% (20%) | (13.8%) |
| Chemical industry and pharmaceutics | 14% (19%) | (12.8%) |
| Other manufacturing | 7% (10%) | (57.4%) |
| Services | 18.0% | |
| Cooperative, non-profit organizations | 10.0% | |

| No. of employees ($n=126$) | |
|---|---|
| above 500 | 30% |
| 101 - 500 | 35% |
| below 100 | 35% |

| Main owner ($n=136$) | |
|---|---|
| Thai | 81.6% |
| foreign, thereof | 18.4% |
| abroad | 48.0% |
| within BMR | 36.0% |
| other part of Thailand | 16.0% |

Note: Values in brackets indicate the share within the manufacturing sector.
Source: Own survey, NSO 2001.

in the total population (Table 9). It is expected that the demand is recently highest in traditional industries which are trying to upgrade their production processes and who are using basic technologies in which Thai universities are specialized.

If innovation survey data is aggregated according to the most important sectors in the university survey, food processing has the highest share of innovating firms, followed by automotives and electronics, while chemical industry ranks third. However, innovation activities in food processing are less intensive and often oriented towards minor improvements of production processes. This is supported by the fact that the share of innovative companies, *i.e.,* companies which have a sales share of 25% or more in new products, is lower in food processing than in the other two sectors.

Most partners of Thai universities are SMEs with less than 500 employees. However, the share of large companies among the cooperation partners in the sample is almost one third while the Thai economy in general has a much higher share of SMEs. It is more likely that bigger companies cooperate with universities. Most partners are Thai-owned companies and more than 50% of the remaining foreign partners of Thai universities have a local branch that is responsible for the cooperation.

Table 10 differentiates the UIL modes by industrial sectors. The results are in line with the sectoral differences in industrial innovation activities. The better innovation performance of chemical industries, automotives, and electronics is reflected by more research-oriented university linkages, while food processing is mainly working with universities in small scale consulting projects or services, *e.g.,* testing. Research collaboration and interactive cooperation modes are mainly found in automotives and electronics. Chemical industry and pharmaceutics are using licensing and direct acquisition of products which originated from university research in a linear way. Projects with larger and/or foreign companies are more sophisticated than those with smaller and/or Thai companies.

b) Scientific Fields

A detailed analysis of UIL modes among scientific fields reveals additional factors that differentiate UILs in Thailand (Table 11). From the university perspective, engineering is the scientific field with the most intensive and sophisticated UIL projects. Contract research, joint research, and internships are more relevant in engineering than in the

TABLE 10
UIL MODES IN THAILAND BY INDUSTRIAL SECTOR
(MULTIPLE ANSWERS POSSIBLE), $n$= 136

(Unit: %)

| UIL Mode | Food Processing | Automotives and Electronics | Chemical Industry and Pharmaceutics | Other Manufacturing Industries | Services | Cooperatives, Non-profit Organizations |
|---|---|---|---|---|---|---|
| Consulting | 60 | 30 | 32 | 50 | 58 | 46 |
| Technical services | 48 | 25 | 26 | 60 | 17 | 23 |
| Informal meetings | 26 | 10 | 21 | 20 | 13 | 23 |
| Licensing | 12 | 30 | 37 | 10 | 13 | 0 |
| Contract research | 10 | 30 | 16 | 20 | 13 | 15 |
| Sale of products | 2 | 15 | 5 | 0 | 21 | 8 |
| Training of industry staff | 6 | 5 | 5 | 10 | 17 | 8 |
| Internships | 8 | 10 | 11 | 0 | 4 | 8 |
| Joint research projects | 2 | 30 | 11 | 0 | 0 | 0 |
| Joint labs at company | 6 | 0 | 5 | 0 | 4 | 8 |
| Staff mobility | 2 | 5 | 21 | 0 | 0 | 0 |
| Spin-offs (planned) | 2 | 10 | 0 | 0 | 4 | 0 |

Source: Own survey

TABLE 11
UIL MODES IN THAILAND BY SCIENTIFIC FIELD
(MULTIPLE ANSWERS POSSIBLE), $n$= 136

(Unit: %)

| UIL Mode | Engineering | Natural Science | Agricultural Science | Life Science, Medicine | Other |
|---|---|---|---|---|---|
| Consulting | 52 | 34 | 64 | 35 | 56 |
| Technical services | 46 | 21 | 50 | 24 | 13 |
| Informal meetings | 13 | 24 | 21 | 24 | 25 |
| Licensing | 7 | 10 | 14 | 65 | 13 |
| Contract research | 24 | 24 | 4 | 6 | 6 |
| Sale of products | 2 | 14 | 11 | 18 | 0 |
| Training of industry staff | 7 | 3 | 11 | 6 | 19 |
| Internships | 15 | 3 | 7 | 0 | 0 |
| Joint research projects | 13 | 7 | 0 | 6 | 0 |
| Joint labs at company | 7 | 10 | 0 | 0 | 0 |
| Staff mobility | 7 | 3 | 0 | 12 | 0 |
| Spin-offs (planned) | 2 | 3 | 0 | 12 | 0 |

Source: Own survey

other fields. The interactive nature of projects in this field are providing good starting points for further cooperation in the future, *e.g.,* joint research projects may result from internship programs.

UILs in agricultural science are as intensive, but by far more dominated by consulting and technical services. The potential to provide more sophisticated services is limited by the structure of the agro-industrial sector which is dominated by SMEs and cooperatives. However, the contribution of local universities is crucial in this industry since these companies have a demand for adapted technologies and are in general not capable to absorb knowledge from international sources.

Cooperation in natural science and life science is less intensive, but especially in life science advanced UIL modes like licensing or (planned) spin-off activities are indicating a higher scientific level of UILs in these fields. However, licensing activities in life sciences are conducted at the expense of interactive UIL modes. Joint projects or internship programs are less important than in engineering. In many projects difficulties arose because companies were incapable to introduce the licensed technology into the market. Therefore, licensing fees are not paid and in several cases the licenses have been returned to the universities after some years.

c) Regional Analysis

The regional scope of UIL projects differs markedly among the three regions. All universities have a majority of their UILs with partners in the same region (Table 12). Regional patterns for Bangkok universities show a concentration on Bangkok and the BMR, whereas companies from the ESR are underrepresented in the sample. KU's linkages are more decentralized because of its traditional agricultural focus. KKU's UIL activities are almost completely limited to the northeastern region. Nevertheless, KKU has been chosen by Seagate to set-up a joint research lab, which is one of the most sophisticated UIL projects in Thailand (see case study below). In contrast, CMU is the only university in the sample that has established several linkages with partners abroad in order to compensate for missing industrial partners in their regional innovation system. The regional universities have not been able to get access to firms or government agencies in Bangkok to a significant degree.

The fragmentation of innovation systems in developing countries often results in a regional and technological mismatch between knowledge production and needs. Excellent university departments at regional

TABLE 12
REGIONAL SCOPE OF UILs IN THAILAND, $n$= 136

(Unit: %)

| | EBR+ | Thereof | | | Northeast | North | Other Thai Regions | Abroad |
|---|---|---|---|---|---|---|---|---|
| | | BKK | BMR | ESR | | | | |
| Universities | 73 | 27 | 41 | 5 | 2 | 3 | 18 | 3 |
| In Bangkok | | | | | | | | |
| CU | 80 | 20 | 53 | 7 | 0 | 0 | 13 | 7 |
| KU | 66 | 32 | 34 | 0 | 4 | 6 | 22 | 2 |
| KMUTT | 83 | 22 | 48 | 13 | 0 | 0 | 13 | 4 |
| KKU (Northeast) | 10 | 10 | 0 | 0 | 85 | 0 | 5 | 0 |
| CMU (North) | 18 | 14 | 4 | 0 | 0 | 50 | 0 | 32 |

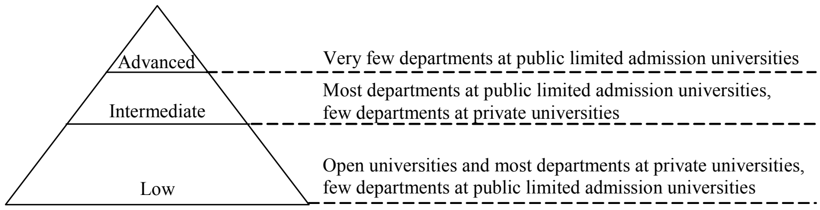
Note: EBR+ - Extended Bangkok Region, BKK - Bangkok, BMR - Bangkok Metropolitan Region (incl. Ayutthaya), ESR - Eastern Seaboard Region.
Source: Own data.

universities do not find counterparts at the regional level and have to look for partners in the economic centre or abroad. On the other hand, technologically advanced companies may not find capable university partners within a particular country. Hence, knowledge transfers with large local or foreign-owned companies often occur from companies to universities, whereas local SMEs or cooperatives are lacking basic absorptive capacities for any kind of UIL (Schiller 2006b, p. 501).

Thai universities' industrial linkages are strongest in the food-processing sector. Except for CU, these companies are cooperation partners in more than one-third of the projects at each university. Other important sectors are automotive and petrochemical companies which are more important partners for Bangkok universities (CU and KMUTT). The background of industrial partners differs at the two regional universities. A quarter of all partners of KKU are local cooperatives, whereas CMU has established overseas contacts with pharmaceutical or chemical companies (*e.g.,* Boehringer, Dow Chemicals).

### *C. Academic Capabilities for UILs*

A concept that explains the weak position of UILs in developing countries like Thailand is provided by the academic capability framework. Academic capabilities are defined as the set of functional skills and organizational ability of a country's higher education institutions to carry out their extended role in the process of technological upgrad-




Source: Liefner and Schiller 2008, p. 287.

FIGURE 5
ACADEMIC CAPABILITIES OF THAI UNIVERSITIES

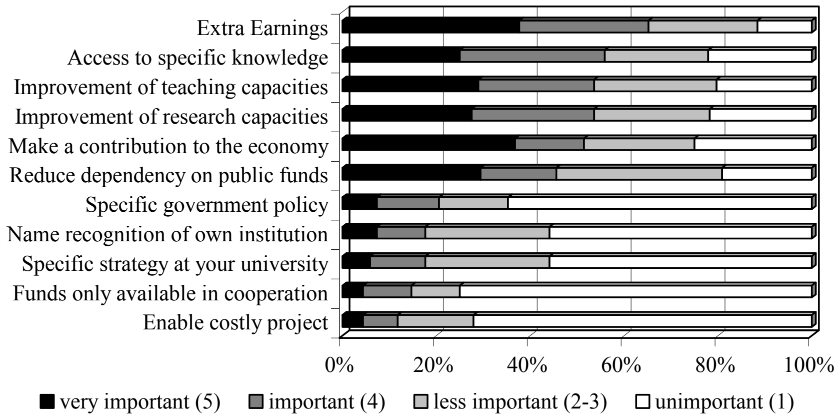
ing and learning. The extent of academic capabilities can be measured by the complexity of sub-sets of functional and organizational capabilities (Liefner and Schiller 2008, p. 281).

Academic capabilities of a country are strongly linked to its company-based technological capabilities, as inputs from universities are crucial for technologically advanced business activities. Highly qualified graduates bring new knowledge into their companies and, thus, are a necessary element in upgrading strategies. University research may set a basis for innovation and direct problem-solving assistance to companies. These close links between higher education, public research, and business are at the core of the well-established concept of interactive innovation processes, and need not be readdressed here.

Academic capabilities of departments at Thai universities are still low in most cases (Figure 5). This finding strongly supports the theoretical proposition that an independent role and direct involvement of universities and other local knowledge providers in economic development and technological upgrading has only just emerged. The results of Liefner and Schiller (2008) are in line with the findings from the innovation survey. However, a few cases of intermediate and advanced academic capabilities have been identified and discussed in the paper. The success factors of some of these cases will be illustrated by the case studies below.

## *D. Incentives and Barriers for UIL*

An analysis of why university researchers in Thailand are working with industry and which barriers occur during the cooperation is a good indication for the effects of the yet low level of academic capabil-




Source: based on own survey

FIGURE 6
INCENTIVES OF INDIVIDUAL PROFESSORS FOR UILS AT THAI UNIVERSITIES

ities. If academic capabilities are still low it is very likely that synergies between UILs and research activities are low and that they are not embedded in a long-term strategy to improve these capabilities. Typical limitations that would hint at a mismatch between research at universities and industrial needs would be a low cooperation propensity in industry which is already documented by the innovation survey. Professors at Thai universities most often mentioned limitations on the industry side, *e.g.,* industrial partners are not willing to cooperate or not available in the respective field of research. This is a clear indication of a mismatch between the work of universities and companies, limited knowledge about potential partners, and a lack of trust and communication.

The empirical results support the proposition that academic capabilities are in general not high enough to ensure intense and successful UILs. Additional individual earnings are the most important reason for UILs. Increasing the budget of the institution to become independent from public funds or to enable costly projects are far less important even though public funding decreases (Figure 6). It is a common feature of higher education systems in developing countries with low incomes in the public sector that researchers are using UILs to increase their personal income (World Bank 2000).

## V. Outstanding Cases of Successful UILs in Thailand

An important result of the survey at different universities is that there are promising cases in some industrial sectors and at certain universities which will be introduced in the following section. These projects have the potential to showcase how to upgrade academic capabilities and UILs in the Thai innovation system on a broader scale. We will highlight the case of a cluster initiative in the hard disk drive (HDD) industry and the transition towards autonomy and entrepreneurialism that took place at King Mongkut's University of Technology Thonburi. Both cases contain elements of best-practices for academic capability building. They illustrate appropriate mechanisms to improve the efficiency of UILs and to cope with typical limitations in developing countries.

### *A. Sectoral Case Study: HDD Cluster*

Recent papers on UILs in Thailand have highlighted sectoral case studies for hard disk drives, agro-industry, automotive, textiles/apparel, and petrochemicals (Brimble and Doner 2007; Schiller 2006a). Cooperation in the textile industry is still very weak as shown by the university survey and does not serve as a case of best practice. Approaches in the automotive and agro-industry are much more intense, but they are either dependent on isolated activities of individual companies (*e.g.,* Toyota) or limited to non-profit services for agricultural cooperatives. Therefore, we will focus on the hard disk drive industry where a cluster initiative led by a government agency and joint by several multinational companies and local universities has been formed, and we will briefly compare this case with a project in the petrochemical industry where a university has established linkages to several large Thai companies.

Hard disk drive production is part of the microelectronics industry which contributes about 30% to the total value of Thai exports. The industry is dominated by global players, *e.g.,* Seagate, Maxtor, Fujitsu. The presence of multinational companies could (in theory) provide a basis for substantial spillovers to local suppliers and knowledge providers such as universities. On the one hand, suppliers have to upgrade their technological capabilities and they are sometimes directly supported by multinational companies. On the other hand, multinational companies require highly-qualified engineers for their production facilities.

Therefore, supporting programs at local universities, *e.g.,* in electrical engineering, would be a strategy to increase the quality of local labor with fitting qualifications for a certain industry.

In Thailand, a company-driven initiative by Seagate and a joint initiative by the global HDD industry association (IDEMA) which has been supported by the National Electronics and Computer Technology Center (NECTEC) are fairly advanced examples of UILs. To our knowledge, there are no other cases which have reached a similar intensity yet. However, both cases have not yet attracted broader attention by policy makers. Evidence from interviews in the industry by Brimble and Doner (2007) provide evidence for the yet apathetic approach of the Thai government to the industry.

Seagate, the largest private employer in Thailand with major plants in the city of Nakhon Ratchasima (which is half way between Bangkok and the northeastern city of Khon Kaen) has set up a joint training program with five Thai universities. The closest cooperation has emerged at two universities which are close to the production sites, *i.e.,* a cooperative training program at Suranaree University of Technology and a joint R&D center at KKU.

At KKU a long-term personal contact between a leading engineer at the company and the UK-trained head of the electrical engineering department has resulted in the endowment of a multi-million Baht lab in 2003. Since then the joint lab has been used to improve the quality of Seagate's production of sophisticated read-write heads and to train staff and students with clean room equipment that is build in accordance with the original assembly line. Research projects are co-funded by the company and carried out jointly with their technicians. Major benefits for the university are training of young scientists with state-of-the-art equipment, while findings of many projects have also resulted in international publications. Seagate's main benefits are the acquired skills of graduates from the lab, who can start to work at Seagate's facilities right away (Schiller 2006a, pp. 85-86).

Seagate reports satisfaction with its university R&D centers. However, no public official has come to talk seriously with Seagate about its experience with the R&D center and about the possibility of expanding this model. Seagate itself recently set up a similar center at Suranaree University of Technology (Brimble and Doner 2007).

The collective action of companies, universities (*c.f.* Asian Institute of Technology and KMUTT), and the government was launched by the preparation of the HDD industry cluster study in 2003 which was used to identify the need for joint projects in the industry. Since the study was financed by NSTDA it marked an exception from the former passive attitude of the government towards the industry. Since then, the Ministry of Industry and the Board of Investment supported the industry, *e.g.,* by special incentive packages. Recently, the initiative includes several cluster strengthening components, such as improving engineering training, defining common operational problems, and developing visual inspection software (Brimble and Doner 2007).

The HDD industry case provides several insights into the challenge to establish more sophisticated UILs in developing countries: first, universities need basic academic capabilities in terms of research excellence, promising students, and organizational openness towards outreach. At KKU, a personal contact ensured the receptivity on the university side. Second, isolated action of a single multinational company is a feasible way to promote closer UIL, however the full potential is rather used if cluster initiatives are formed on the basis of common interest. Third, collective action is often connected with consensus building and incentives initiated by the government. Thus, policy makers have to take an active role in providing the prerequisites for closer UILs. However, the configuration of UILs is contingent on industrial sectors and scientific fields. A transfer of successful models from one sector to another is therefore difficult, but the government should take a more active role in encouraging more activities of this kind by promoting existing models of best practice in Thailand.

KMUTT has set-up the Chemical Engineering Practice School (ChEPS) in cooperation with large petrochemical companies in Thailand and with funding from different government agencies and alumni foundations. Students are spending a term at a practice site in the two-year master program. During their internship they are conducting a small research project which is jointly planned and supervised by company staff and a site director from the university. Since the university is showing its commitment by sending a member of its staff, ideas from the student projects are eventually transformed into contract or joint research activities between the companies and the university. Cooperative education is used in this project to initiate trust-building and to improve the intensity of UILs.

### *B. University Case Study: King Mongkut's University of Technology Thonburi*

A major effort of higher education reform in Thailand is the transition of public universities from the bureaucracy to autonomy. The autonomy of financial, personnel, and academic affairs provides the opportunity for university managers to implement innovative outreach strategies and to make their universities more entrepreneurial. However, only KMUTT completed the transition towards an autonomous university in 1998 and three universities have been newly founded as autonomous ones. Other public universities became autonomous in 2007, but it is much too early to assess the impact on UILs yet. A detailed description of the history of university autonomy, its barriers, and lessons learnt at KMUTT can be found in Kirtikara (2004).

For the case of KMUTT, it is concludes that autonomy has been beneficial for its UIL strategy, but much potential is still unused. The overall level of entrepreneurialism is still at an early stage. The incorporation has been subsequently followed up by new initiatives which benefited to a certain degree from autonomy. For example, new programs and schools in emerging fields have been set up more flexibly, staff from different departments has been able to cooperate, and newly established intermediaries have been equipped with additional resources.

However, many of the initiatives would have been possible without autonomy. For instance, the employment of staff by the university is also possible at other universities, but with less clear regulations. Above that, some initiatives even existed before the incorporation, *e.g.,* the pilot plant facilities; its success has been mainly based on the effort of an individual professor. To identify the additional impact of autonomy, a case-by-case approach would be necessary which is clearly beyond the scope of this paper.

On a more general level it has been elaborated that the attitude of university staff is crucial for the transition towards an entrepreneurial model. In this regard, greater flexibility of KMUTT is noticed by its stakeholders. Its relatively low age, the S&T focus, and the determination among its top administrators have been conducive for these initial steps. Nevertheless, the full potential that arose from autonomy is not yet realized and many of the new initiatives are insufficiently coordinated or lack a critical mass.

A strengthened integration of autonomy with enhanced UIL is the most important issue on the pathway of KMUTT towards an entrepreneurial university. Even though some examples of best practice for Thailand have been found, the university has not yet taken enough advantage of the new opportunities. The financial contribution of the private sector is still quite low — even the intermediaries receive less than half of their income from industrial projects. There is still a lack of technologically advanced and formalized UIL projects. In contrast to other areas in which the university management is taking a leading role, the formulation of a more comprehensive outreach strategy is still missing. Efficient individual incentives and proper regulations for UIL remain to be implemented to tap into the manifold informal arrangements between faculty members and companies. A possible trade-off between autonomy and sustainable entrepreneurship even arises from the need to develop own sources of income within a short-time. These pressures could undermine the strategic deepening of UIL since more effort is put on fast money from tuition or consulting.

Virasa (2008) has analysed the technology transfer and commercialization system at Mahidol University (MU), the top university in terms of publications with a focus on natural science, life science, and medicine. MU was the first university that set up a company to invest in university spin-offs. STANG Holding was founded in 2004. Virasa's (2008) results show that the university's venture fund by STANG Holding is under-utilised. In the past four years, only three technical service companies were established by the venture fund. Most of the companies' activities are still operated by university staff and it is difficult to sell and commercialize MU products due to high risk aversion towards business start-ups, a lack of marketing ability, and the modest size of the current venture capital fund.

## VI. Discussion and Conclusion

From the innovation surveys, it is obvious that in general university-industry linkages in Thailand are weak. Firms do not regard university and public research institutes as important sources of information and knowledge. They do not collaborate intensely with local universities and public research institutes. They also perceive that technical supports from local universities and public research institutes are relatively weak. Thus, most UIL projects are limited to consulting and technical services. More advanced projects are just occurring in some outstanding cases. Inter-firm relationship with customers, suppliers and parents/associated companies are much more important both in terms of sources of knowledge and actual collaboration in innovation projects.

However, there are interesting aspects if firms that perform R&D are analyzed separately or if different industrial sectors are compared:

- R&D performing firms and innovating firms have stronger UILs than non-R&D-performing firms and innovating firms. The former perceive universities and public research institutes as relatively more important sources of knowledge and they view the supports from universities and public research institutes in more positive light.
- R&D performing firms and innovating firms in science-based industry, requiring more sophisticated level of science and technology capabilities for their R&D and innovation activities, such as petroleum/petrochemical, electrical machinery, telecommunication, computer and R&D services have more intense collaboration with local universities and public research institutes than those in resource-based and labour-intensive industries. However, the food processing industry is using universities quite intensely as a knowledge source and to improve production processes.
- Firms that cooperate with industry are mostly locally-owned. Older companies are more likely linking-up with universities than very young start-ups which contradicts the university spin-off hypothesis that is valid for high-tech regions of industrialized countries. In Thailand, SMEs are only cooperating with universities in very limited cases since most of them do not carry out any technology-intensive activities such as R&D, design, advanced engineering.[3] Joint innovation activities are more likely to occur with larger local companies in traditional sectors. Within the public research sector, universities are a more important knowledge source than government research institutes.

Though, the surveys generally points out relatively weak UILs, the university interviews illustrate further interesting facts:

[3] In more advanced countries where firms are in higher positions of global value chains, small firms in these countries perform those technology-intensive activities, therefore, it is not surprising if they collaborate more with universities and public research institutes.

- Thai universities are not homogenous in scope and quality. The results discussed above are representative for most public and autonomous universities. However, most open and private universities do not carry out any research and have a strong focus on social sciences and humanities which further limits the cooperation potential of these universities.
- Academic capabilities of Thai universities are not yet advanced enough to supply in-depth collaboration with high-tech industries. Interactions with low-tech sectors like food processing and agriculture are more intense than with more advanced industries like electronics or chemical industry. UILs with the former sectors are almost completely limited to services and do not comprise any deeper research activities. However, this kind of collaboration is an appropriate starting point to change the attitude at universities and to build trust among the partners.
- The demand for UILs from the industry is still quite low. Many local companies do not carry out any R&D activities and thus do not need technological inputs from universities. Multinational companies in Thailand are acquiring most of their knowledge via their parent companies. However, there are exceptions as shown for the HDD case or in other sectors like the petrochemical industry where several local companies are working together with KMUTT.
- Economic activities in Thailand are heavily concentrated around Bangkok and the adjacent Eastern Seaboard Region. The peripheral regions are dominated by agricultural activities and some related industries or by the tourist industry in the south. Therefore, the potential to cooperate with industry is even lower for universities in the periphery. In our sample, KKU and CMU coped with this challenges in two different ways: (i) outstanding departments have formed linkages with companies around Bangkok or in other countries, (ii) many departments are closely working together with local SMEs or agricultural cooperative. These projects are very different from UILs in high-tech sectors. But in the absence of other knowledge providers, regional universities are thus having the potential to foster regional development in a unique way.

A major shortcoming is that success stories are in general not pushed ahead systematically by the respective universities or government agencies. Since the efficiency of organizational change in Thai higher education is still doubtful, most likely, the variety of universities with very different levels of research and teaching will be a continuing feature of the Thai higher education system.

Fundamental problems such as a lack of graduate students, research equipment, and relevant research results are not yet addressed by efficient incentives. Higher education policy is in general weakly implemented and often diluted during the political process. There is too little public funding for universities to satisfy extended demands. As for technological capabilities, public policies and start-up financing are also needed to initiate academic capability building. Thus, only a few successful departments at public universities have as yet achieved advanced academic capabilities.

The results of the innovation surveys and case studies are also in line with the recent study done by Brimble and Doner (2007). The study points out that public officials and firm managers recognize the importance of UILs for meeting challenges faced by Thai producers. But with interesting exceptions, Thai UILs are frail. This is due to protection and low levels of innovation resulting in few private sector efforts to link up with universities; rigid structures and weak incentives in the Thai universities discouraging ties with business; and generally fragmented Thai bureaucracy.

Nonetheless, universities have been under pressure since the Thaksin government (2001-2006) and the Budget Bureau encouraged them to increase their revenues, hence reducing their reliance on the national budget. They have been forced to become more relevant to industrial needs in order to earn extra incomes. In the year 2007, several leading Thai public universities attained autonomous status. The idea is to take them out of the bureaucratic system and its red tape, and let them enjoy more freedom financially. Most of their budget is now supplied by the government, but they are expected to generate more income from other sources, especially from the private sector. Therefore, they have to conduct research and other activities, which are more relevant to industry. Recently, universities have generally tried to increase industry sponsorships and to forge links with industry through collaborative R&D and training activities.

Lessons that could be learnt from the (yet not very successful) case of UILs in Thailand for other developing countries are as follows:

- Governments should not pull back funding for higher education too early since it is detrimental for the strengthening of local knowledge sources. Even if entrepreneurial activities are a potential source of income, they have to be founded on relevant academic capabilities. Since these capabilities are mainly (semi) public goods, they have to be developed by public funding.

- Universities have to offer support and incentives to their researchers for UILs. Without these support measures researchers will most likely perform their entrepreneurial activities outside the university system and universities will not benefit. UILs that are carried out under the umbrella of the university are more likely to be maintained and deepened over a longer period of time.
- Comparatively stronger interactions between universities and the private sector in traditional industries are a good starting point for UIL activities. However, lessons learnt from these early interactions have to be translated in policies to promote further interaction in emerging high-tech sectors to support structural change and upgrading during the catch-up process.
- Private firms, especially SMEs as illustrated by the survey results, might not see the benefit of UIL or do not know how to start collaborating with universities, government intervention to correct this type of market and institutional failures is necessary. Government agencies can act as intermediary providing necessary information and bringing the two parties together. Matching government grants encouraging promising individual UIL projects might be desirable, especially those involved by SMEs.

Based on the empirical findings for Thailand, some suggestions for extending existing theoretical approaches are possible. (i) The literature on technological upgrading in developing countries is mainly focused on exogenous knowledge inputs, *e.g., via* multinational companies. However, local knowledge providers are becoming more important at a certain level of economic development and the contribution of university research and teaching should be even more explicitly acknowledged in the literature on technological catch-up. (ii) The analysis of UILs in developed countries is often limited to formal research collaboration *via* patent licensing or spin-off companies. It is necessary to broaden this view and to cover more informal modes, *e.g.,* consulting and technical services, and UIL in teaching. These modes are especially relevant in developing countries because they fit better with the absorptive capacities of firms and academic capabilities of universities in most cases. Besides that, these modes can serve as starting points to build trust and to deepen relationships between science and industry in yet fragmented innovation systems. (iii) The sectoral focus of innovation systems and UIL studies should also be extended beyond high-tech industries. Endogenous potentials for innovation and UILs in developing countries are to a large part found in so-called low-tech sectors, *e.g.*, food processing.

*(Received 27 February 2009; Revised 21 October 2009)*

## References

Arnold, E., Technopolis, Bell, M., SPRU, Bessant, J., CENTRIM, Brimble, P., and Brooker Group. *Enhancing Policy and Institutional Support for Industrial Technology Development in Thailand: The Overall Policy Framework and the Development of the Industrial Innovation System.* Washington, D.C.: World Bank, 2000.

Bell, M., and Scott-Kemmis, D. Technological Capacity and Technical Change. Draft Working Paper No. 1, 2, 4, and 6, Report on Technology Transfer in Manufacturing Industry in Thailand, UK: Science Policy Research Unit, University of Sussex, 1985.

Bresnahan, T., and Gambardella, A. (eds.). *Building High-Tech Regions.* Cambridge: Cambridge University Press, 2004.

Brimble, P., Doner, R. "University-Industry Linkages and Economic Development: The Case of Thailand." *World Development* 35 (No. 6 2007): 1021-36.

Budget Bureau. *Thailand Budget in Brief.* Bangkok, Various Years.

Chantramonklasri, N. Technological Responses to Rising Energy Prices: A Study of Technological Capability and Technological Change Efforts in Energy-Intensive Manufacturing Industries in Thailand. Unpublished D. Phil. Thesis, Brighton, UK: Science Policy Research Unit, University of Sussex, 1985.

Cheamsawat, N. *Commercialization of R&D Works: From University Shelves to Markets.* Bangkok: King Mongkut's University of Technology Thonburi, 2004.

Cohen, W., and Levinthal, D. Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly,* 35 (No. 1 1990): 128-52.

Dahlman, C., and Brimble, P. Technology Strategy and Policy for Industrial Competitiveness: A Case Study of Thailand. Paper Prepared for the World Bank, April 1990, U.S.: World Bank, 1990.

Etzkowitz, H., Wester, A., Gebhardt, C., and Terra, B. "The Future of the University and the University of the Future: Evolution of the Ivory Tower to Entrepreneurial Paradigm." *Research Policy* 29 (No. 2 2000): 313-30.

Etzkowitz, H., and Leydesdorff, L. "The Dynamics of Innovation: From National Systems and 'Mode 2' to a Triple Helix of University-Industry-Government Relations." *Research Policy* 29 (No. 2 2000): 109-24.

Goldfarb, B., and Henrekson, M. "Bottom-up versus Top-down Policies towards the Commercialization of University Intellectual Property." *Research Policy* 32 (No. 4 2003): 639-58.

IMD. *World Competitiveness Yearbook.* Lausanne: International Institute for Management Development, 2004.

Intarakumnerd, P., Chairatana, P., and Tangchitpiboon, T. "National Innovation System in Less Successful Developing Countries: The Case of Thailand." *Research Policy* 31 (No. 8 2002): 1445-58.

Intarakumnerd, P., and Virasa, T. Taxonomy of Government Policies and Measures in Supporting Technological Capability Development of Latecomer Firms. A Paper Presented at the 6$^{th}$ International Conference on Technology Policy and Innovation, Kansai, Japan, August 2002.

Kenney, M. *Biotechnology: The University Industrial Complex.* New Haven: Yale University Press, 1986.

Kenney, M., and von Burg, U. "Technology and Path Dependence: The Divergence between Silicon Valley and Route 128." *Industrial and Corporate Change* 8 (No. 1 1999): 67-103.

Kirtikara, K. *Transition from a University Under the Bureaucratic System To an Autonomous University: Reflections on Concepts and Experience of King Mongkut's University of Technology Thonburi.* Bangkok: Office of the Education Council, 2004.

Lall, S. Thailand's Manufacturing Competitiveness: A Preliminary Overview. Unpublished Paper for Conference on Thailand's Dynamic Economic Recovery and Competitiveness, Papers for Session 4, Bangkok, May 20-21, 1998.

Liefner, I., and Schiller, D. "Academic Capabilities in Developing Countries — A Conceptual Framework with Empirical Illustrations from Thailand." *Research Policy* 37 (No. 2 2008): 276-93.

Mukdapitak, Y. The Technology Strategies of Thai Firms. Unpublished

D. Phil. Thesis, Brighton, UK: Science Policy Research Unit, University of Sussex, 1994.

NRCT. *National Survey on R&D Expenditure and Personnel of Thailand 1987-1996.* Bangkok: National Research Council of Thailand, 2000.

NRCT. *Thailand's 2001 Research and Development Indicators.* Bangkok: National Research Council of Thailand, 2004.

Rappert, B., Webster, A., and Charles, D. "Making Sense of Diversity and Reluctance: Academic-Industrial Relations and Intellectual Property." *Research Policy* 28 (No. 8 1999): 873-90.

Schiller, D. "The Potential to Upgrade the Thai Innovation System by University-Industry Linkages." *Asian Journal of Technology Innovation* 14 (No. 2 2006a): 67-91.

__________. "Nascent Innovation Systems in Developing Countries: University Responses to Regional Needs in Thailand." *Industry and Innovation* 13 (No. 4 2006b): 481-504.

Schiller, D., and Liefner, I. "Higher Education Funding Reform and University–Industry Links in Developing Countries: The case of Thailand." *Higher Education* 54 (No.4 2007): 543-56.

Shane, S. A. *Academic Entrepreneurship: University Spin-offs and Wealth Creation.* Aldershot: Edward Elgar, 2004.

Temsiripoj, W. Academic-Industry Links in Thailand and the UK: A Comparative Analysis. Unpublished Doctoral Dissertation, University of Manchester, 2003.

Thailand Development Research Institute. The Development of Thailand's Technology Capability in Industry. Reports Volumes 2-5, Bangkok, Thailand, 1989.

__________. Effective Mechanisms for Supporting Private Sector Technology Development and Needs for Establishing Technology Development Financing Corporation. A Report Submitted to National Science and Technology Development Agency, Bangkok, Thailand, 1998.

Tiralap, A. The Economics of the Process of Technological Change of the Firm: The Case of the Electronics Industry in Thailand. Unpublished D. Phil. Thesis, Brighton, UK: Science Policy Research Unit, University of Sussex, 1990.

Virasa, T. University Technology Transfer and Commercialization in the Emergence of an Innovation-Driven Economy: The Case of Mahidol University, Thailand. College of Management, Mahidol University, Mimeograph, 2008.

Withayagiat, S. "Private Sector and Higher Education in Thailand." In C. Stoltenberg *et al.* (eds.), *University-Industry Partnership*. APEC Follow-Up Conference Proceedings, Kansas: Center of East Asian Studie, pp. 39-46, 1993.

World Bank. *Higher Education in Developing Countries*. Washington: World Bank, 2000.

Zucker, L., Darby, M., and Brewer, M. "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises." *American Economic Review* 88 (No. 1 1998): 290-306.