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The Potential to Upgrade the Thai Innovation System by University-industry Linkages

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Summary

This paper discusses the potential to upgrade the Thai innovation system by university-industry linkages. Our results are structured into three parts. First, the identification of potentials for university-industry linkages (UIL) within the Thai innovation system shows that there is a wide gap between absorptive capacities of private companies and knowledge production of universities. Second, we present survey results for individual departments at Thai universities showing that UIL are mostly limited to consulting and technical services, hampered by mutual distrust, and maintained to receive an extra personal income. Third, case studies on four typical modes of UIL allow us to discuss various ways to upgrade the Thai IS by UIL in future.

Key Words: knowledge transfer, university-industry linkages, innovation system, developing countries, Southeast Asia, Thailand.

1. Introduction

The application of the innovation system (IS) concept to developing countries brought forth a set of adaptations of the role of its actors and their interactions. Major differences in the analytical approach towards established vs. young and still fragmented IS are 1) a shift from ex-post analysis to an ex-ante approach (system building), 2) emphasis on learning and absorbing knowledge from extra-regional sources, and 3) relevance of country-specific institutional and cultural settings.

Previous research on the innovative performance of Thai manufacturing companies has shown that the Thai IS is representative for a wider set of developing countries that have been less successful in upgrading technological capabilities in line with their economic performance.

Extra-regional knowledge sources (e.g. multinational companies) are less embedded in the Thai IS than in other Asian countries (e.g. Singapore, Malaysia). Knowledge providers from within the IS (e.g. universities and research institutes) have the potential to mitigate this weakness by absorbing knowledge from international networks and transferring appropriate portions to local companies. Since results of Thai innovation surveys reveal weak university-industry linkages (UIL), this endogenous potential is far from being fully tapped.

Therefore, our paper discusses the emerging role that public universities play for upgrading the Thai IS by UIL. Our approach is to analyse direct mechanisms of knowledge transfer via academic services and other kinds of UIL (e.g. consulting, contract and joint research, technical services, licensing etc.). We are using a unique dataset of 136 UIL projects gathered from interviews at five public universities in 2004 which are representative for the Thai higher education system and case study material from especially inspiring projects.

Our results are structured into three parts. First, the identification of potentials for UIL within the Thai IS on a macro-level shows that there is a wide gap between absorptive capacities of private companies and knowledge production of universities. Second, we analyse UIL performance at individual departments on the micro-level. Third, case studies on four typical modes of UIL from the regional innovation systems of Bangkok, the North (Chiang Mai), and the Northeast (Khon Kaen) allows us to discuss various ways to upgrade the Thai IS by UIL in future.

Hence, our paper contributes to the on-going debate on upgrading Asian-style innovation systems by focusing on the emerging role of universities, and by deriving recommendations for innovation policy to strengthen UIL in developing countries.

2. Universities in Innovation Systems of Developing Countries

Today, it is common ground among innovation researchers that the market introduction of new products, production processes, and forms of organisation is the result of an interactive process (Kline and Rosenberg 1986). A process of innovation implies close linkages between different departments within an enterprise, other enterprises, company-oriented service providers, public research institutions, and universities (Nelson 1993, Lundvall and Johnson 1994). Within innovation systems, interactions between these players are guided by both formal and informal rules (Edquist 1997, Freeman 2001). The nature and intensity of the interactions that go on between players crucially influence the innovative performance of the enterprises that belong

to a given innovation system (Nelson 1993).

Cooperative relations between universities and enterprises intensified in recent years, a fact that can be explained by two mutually interactive processes (Bercovitz and Feldman 2006). Universities and other public research institutions were constrained to develop new external sources of funds as public funding for the science system dwindled. Industrial contract research constitutes one optional source of funds (Schmoch 1999). At the same time, enterprises find that the importance of university knowledge is growing because their industrial production is becoming increasingly knowledge-based (OECD 1996). Rapid changes in technology and market conditions call for higher innovation rates and shorter lead times for the development of products and processes. Strategies pursued by enterprises to accelerate innovation processes include outsourcing research and development activities and forming strategic co-operations. Universities and other public institutions may potentially act as partners in this respect.

In recent years, new forms of Mode 2 knowledge production evolved (Gibbons et al. 1994). Mode 2 is characterised by growing diversity in the localisation of research activities and the enhanced importance of interdisciplinary research. Etzkowitz and Leydesdorff (2000) have described the interplay between universities, industries, and governments within a structure of overlapping spheres and hybrid forms of organisation as a triple helix. The triple helix becomes manifest in the establishment of technology-transfer departments at universities, the creation of incubators for technology-based enterprises, and the establishment of science parks. As higher education institutions transform themselves into entrepreneurial universities (Clark 1998), their capability to transfer technology to enterprises increases, which leads to partial superposition of the functions of universities and enterprises in a process of innovation.

However, these concepts have to be modified for the study of innovation systems in developing countries. Innovation systems in countries like Thailand can better be described as "learning systems". The role of universities in learning systems is not to generate new knowledge but to raise the skills of the population - i.e. to build up human capital - and to help absorb ideas from developed countries (Mathews 2001, Viotti 2002). Overall technological development in learning systems, which can only be achieved by the successful absorption of knowledge, is determined by the absorptive capacities of the national firms. A firm can enhance its absorptive capacity by training its personnel, by carrying out research and development (R&D), and by using advanced manufacturing equipment. Thus, an existing absorptive capacity and additional learning efforts reinforce each other mutually (Asheim and Vang 2004, Cohen and Levinthal 1990).

Universities can both help to train personnel and stimulate learning by exposing companies

to new ideas in co-operation projects. But as universities themselves are often not used to carrying out research and to monitoring the latest technological developments in their fields, they themselves need incentives to upgrade their R&D capabilities and to bring their knowledge to bear in UIL. Thus, learning and promoting capability has to involve both industry and academia.

3. University-industry Linkages

Forms of UIL range from ad-hoc consulting services, sponsored research, and technology licensing to the formation of research consortiums (Bercovitz and Feldman 2006). Refusing to classify the isolated exchange of knowledge between individuals as a cooperative relationship, Inzelt (2004) argues that such interaction should be institutionalised to qualify. It is the lack of efficient institutions in developing countries - where legal systems are often weak - which makes it difficult to conduct effective transactions and conclude contracts on research co-operation. Because of this, most of the relations entered into are informal and based on mutual trust (Knack and Keefer 1997). Nevertheless, even the importance of such isolated informal interactions should not be underestimated, as this kind of relationship may form the starting point for the development of more sophisticated cooperative relations.

The low level of R&D activities in Thai enterprises affects their linkage potential. When enterprises do not conduct any R&D of their own and use universities as vicarious research institutions, the development of an effective innovation system with its own technological culture becomes highly improbable (Lall 2002). A number of case studies has demonstrated that corporate technological endeavours may be supported but not substituted by governmental and academic activities (Nelson and Rosenberg 1993).

University-industry co-operation in developing economies cannot be expected to work in the same way as in developed economies. Co-operation may be hampered by technological constraints on the part of both partners. In many cases, universities will not have the ability to supply knowledge that is new to their partners and companies cannot be expected to be willing and/or able to pay universities for their services. The stimulation for absorbing and applying new ideas can be contributed by both partners as universities may be technologically not more or even less advanced than some of their industry partners. This will be particularly relevant for UIL with subsidiaries of multinational companies that have access to superior knowledge. Hence, learning effects can be expected to occur on both sides, and may sometimes be greater on the university side. This process, however, may require government intervention, e.g. through

pecuniary incentives or by setting up regulations that allow UIL to flourish.

Universities in developing countries find themselves in a different position from their peer institutions in industrialised countries. They tend to be under-funded and unable to purchase and apply the latest research equipment. Their faculty and staff tend to be less qualified on average. Thus, developing countries' universities are usually far below the academic standards set by universities in industrialised countries. Consequently, they put more emphasis on undergraduate teaching, which is a very important function in many developing countries that strive to improve the skills of their population. Graduate education and research do not belong to the core activities of many universities in developing countries. Thus, universities themselves have to continuously improve their teaching and research capabilities in order to be able to meet future needs of their societies (World Bank 2000, Altbach 1998).

Apart from the governments' and universities' features outlined above, the government-university relationship itself has a special character in many developing countries. Strong personal and organisational ties between government and universities can hamper a transparent decision-making process that is based on objective criteria. In the case of Thailand, a strong link between the Royal Family and the universities contributes to this situation (Schiller, Liefner 2006).

4. The Data

The empirical research for this project was funded by the German Research Association (DFG) and carried out at the Institute of Economic and Social Geography, University of Hannover, Germany. It is based on interviews with professors and administrators at five universities in Thailand, including three institutions in Bangkok, Chulalongkorn University (CU), Kasetsart University (KU), and King Mongkut's University of Technology Thonburi (KMUTT), as well as two regional universities, Chiang Mai University (CMU), and Khon Kaen University (KKU). The universities selected for the case studies are regarded as outstanding in science and technology research and teaching on a national level. They are therefore expected to possess the highest potential for research commercialisation within Thailand. The regional scope of this paper goes beyond the regional innovation system of Bangkok where about 80% of the manufacturing activities are concentrated. Therefore, it also captures the kinds of relationships that emerge from co-operation with agro-related businesses. Moreover, institutional settings and scientific specialisations of these universities differ markedly, which allows as to analyse their influence on commercialisation behaviour. The large number of interviews conducted with professors who cooperate with private

companies (72) and identified UIL projects (136) from a wide field of disciplines allows descriptive methods of analysis to be applied and gives a first impression of UIL potentials of the national innovation system as a whole. However, at this exploratory stage it is yet to early to limit the analysis to a single sectoral innovation system. The interviews were carried out between June and October 2004. A detailed description of data and methods can be found in Schiller (2006).

5. The Potential for UIL in the Thai Innovation System

This chapter examines the potential for university-industry knowledge transfer in the Thai innovation system on the macro-level. We compare R&D activities of universities and private enterprises to measure the extent to which the two sectors could benefit from each other in terms of new knowledge and technologies. R&D activities in the Thai manufacturing sector have been analysed in various other papers (e.g. Intarakumnerd et al. 2002, 2003, Berger 2005, Revilla Diez and Berger 2005, Schiller 2003). Hence, the discussion in this paper focusses on R&D in the higher education system.

5.1 Research and Development (R&D) in the Thai Innovation System

The financial and human resources used for R&D in the Thai IS are an indicator for the relevance of activities that are potentially promising for UIL. A certain critical mass of endogenous R&D is a prerequisite for intensive and sophisticated co-operation between industry and science. In a first step, we measure the linkage potential by input indicators.

Table 1 splits up R&D expenditures by financing and performing sectors. Compared with government and private R&D activities the share of university R&D is declining constantly. In absolute numbers there is only a small expansion from 1.63 billion Baht in 1997 to 1.95 billion Baht in 2001. As a result, the expansion of public R&D expenditure has been limited to the government sector (research institutes linked to different ministries) and did not strengthen universities R&D capacities significantly. Half of public R&D expenditures is still channelled through the Ministry of Agriculture and Cooperatives and the Ministry of Science and Technology.

Table 1: Thai R&D Expenditure by Financing and Performing Sectors

	share in financing R&D			Share in Performing R&D		
	1995	1997	2001	1995	1997	2001
Government	60%	58%	49%	49%	55%	45%
Universities	20%	25%	10%	36%	34%	18%
Business	17%	11%	34%	15%	11%	37%
Aborad	3%	5%	2%			
Unknown	0%	1%	5%			

Source: own calculations based on NRCT 2000; 2004.

Thai R&D mainly focusses on applied research. In the last few years universities are starting to perform basic research. The spreading shown in table 2 is quite typical for developing countries because they cannot compete with developed countries in basic research due to entry barriers, e.g. high sunk costs (World Bank 2000). The specialisation of the R&D system on application and appropriate technologies along comparative advantages influences the linkage potential positively if it is in line with technological needs of the private companies. Since R&D performing companies mainly conduct experimental development, the absorptive capacity to implement university research is further limited. At this point, we can already conclude that a critical mass of R&D can at best be reached in a few selected technological fields.

Table 2: Thai R&D Performance by Kind of Activity

	Basic research			Applied research			Experimental development		
	1995	1997	2001	1995	1997	2001	1995	1997	2001
Total	20%	14%	16%	63%	72%	42%	17%	14%	42%
Government	23%	14%	20%	63%	75%	61%	14%	11%	19%
Universities	26%	16%	34%	66%	75%	52%	8%	9%	14%
Business	11%	8%	1%	61%	48%	15%	28%	44%	84%

Source: own calculations based on NRCT 2000, 2004; MOSTE 1999

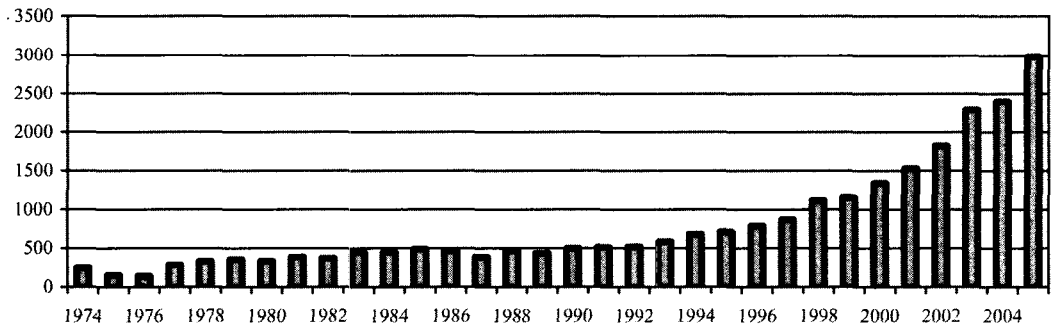
5.2 Research Performance of the Thai Higher Education System

We are using publications listed in the Science Citation Index (SCI) as an indicator for research activities in science & technology. These fields are expected to have the highest potential to establish linkages with private companies. Since the SCI only covers the most renowned and cited journals, having an SCI publication is already a quality measure. However, most journals

in the SCI are still American ones which distorts the results for other regions in the world. Therefore, Thailand will be compared with other Asian countries which are expected to have the same starting position. By comparing the impact factors of the journals in which Thai scholars have published with the world average impact factor of a publication in a certain scientific field we introduce another measure of the quality of Thai publications.

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. 2000:119, Intarakumnerd et al. 2002:1451, Brooker Group 1999, Altenburg et al. 2003).

The total number of Thai publications grew significantly during the last 10 years (fig. 1). The output has been about 500 publications per year until the mid-1990s. 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. Before that, Thai universities solely concentrated on teaching.



Source: own calculations based on SCI EXPANDED

Figure 1: Number of Thai Publications in the Science Citation Index (SCI) 1974-2005

To a large part, the growth is a result of the introduction of new journals into the SCI, especially by the intake of non-American journals. Actually, all Asian countries have reached high growth rates. Table 3 shows that 1st generation newly industrialised countries (NICs, i.e. Korea, Taiwan, Singapore) have realised a first expansion of their scientific activity 20 years before Thailand. Thailand is similar to Malaysia, another 2nd generation NIC, but still much better off than the Philippines or Indonesia.

Table 3: SCI Publications of Asian Countries, Yearly Average (and Index 1980-84 = 100)

	1980-84	1985-89	1990-94	1995-99	2000-05
Thailand	394 (100)	446 (113)	557 (141)	926 (235)	2,059 (523)
Korea	341 (100)	1,043 (306)	2,756 (809)	9,813 (2,879)	21,471 (6300)
Taiwan	642 (100)	1,644 (256)	4,326 (673)	8,608 (1,340)	13,307 (2071)
Singapore	253 (100)	597 (236)	1,142 (451)	2,501 (988)	5,177 (2,045)
Malaysia	259 (100)	298 (115)	421 (163)	745 (288)	1,221 (471)
Philippines	237 (100)	207 (87)	246 (104)	329 (138)	474 (200)
Indonesia	104 (100)	141 (135)	198 (189)	366 (351)	524 (502)
China (incl. Hong Kong)	2,694 (100)	6,244 (232)	1,0365 (385)	21,205 (787)	48,552 (1,802)

Source: own calcultions based on SCI EXPANDED.

By splitting up the publication output by scientific fields, we receive more detailed results for the linkage potential. Today, most Thai publications are from medical sciences. During the last years, engineering and natural sciences have significantly increased their position while agricultural and life sciences are stagnant (tab. 4). The share of Thai publications in the world is still highest in agricultural sciences. The weakness in natural sciences points to low levels of basic research which is more important in this field than e.g. in engineering.

An index of specialisation allows us to compare the relevance of these scientific fields in Thailand with other countries in the region. The index expresses the share of a scientific field in one country in relation to the share of this field in the world. The transformed values range from -100 to +100. Positive values indicate a specialisation above the world average.

Table 4: Thai SCI Publications by Scientific Fields (1995-2004)

Scientific field	Share of total			No. 2002-2004	Growth 2002-2004	Thailand's World Share 2003	Average impact factor	
	1995-1997	1998-2001	2002-2004				World 2003	Thailand 2002-04
Total				2,120	+28.7%	0.30%	2.373	2.101
Agricultural sciences	9.6%	8.5%	10.0%	213	+6.9%	0.50%	1.380	1.060
Medical sciences	54.9%	49.8%	43.0%	912	+29.7%	0.37%	2.894	2.793
Engineering sciences	18.1%	21.0%	26.3%	558	+40.2%	0.33%	1.153	0.977
Life sciences	27.2%	28.7%	28.4%	602	+27.5%	0.39%	2.995	2.190
Natural sciences	13.0%	13.8%	18.8%	399	+43.9%	0.17%	2.154	1.812

Source: own calculations based on SCI EXPANDED.

The general trend of the Thai research output in table 5 is comparable to that of other 2nd generation NICs with agricultural science reaching the highest specialisation index. Thai universities have established faculties for agro-industry who perform research at the interface between agriculture and post-harvest processing. They are obvious partners for a whole set of traditional food manufacturing companies. However, a special focus on engineering - as in 1st generation NICs or China - has not been established. Due to its strength in medicine and life sciences, Thailand differs from other Asian countries.

As expected, the impact factors of journals in which Thai scholars are publishing are lower than the world-average. Interestingly, the gap is smallest in medicine and engineering and biggest in life sciences (tab. 4). Hence, unique linkage potentials might exist in applied medical sciences (e.g. pharmaceuticals).

Table 5: Index of Specialization for SCI Publications of Asian Countries

	Agricultural sciences	Medical sciences	Engineering sciences	Life sciences	Natural sciences
Thailand	47	22	11	26	-51
1st Generation NICs[2]	-38	-34	71	-26	41
2st Generation NICs[3]	81	-36	-14	-37	-2
China	-64	-88	47	-72	71
India	45	-80	8	-63	40

[1] Thailand: 2002-04; other 1996-2000; [2] Korea, Taiwan, Singapore, Hong Kong; [3] Malaysia, Philippines
Source: own calculations based on SCI EXPANDED, NIW et al. 2002

5.3 Technological Capacity in the Manufacturing Sector

Private companies show a weak performance for all R&D indicators if compared with other regions in Asia and Europe (Berger 2005). A more detailed picture can be drawn if the results are split up for different industries within the Thai manufacturing sector. The traditional food processing industry reaches the highest innovation and R&D performance, followed by petrochemicals. In the automotive industry and electronics, local companies show a better performance than foreign affiliates. In the textiles and garment industry R&D or innovation activities are nearly inexistent.

The overall picture of technological capacities in the Thai manufacturing sector is as follows: A few capable foreign affiliates and some Thai-owned companies (mainly bigger ones) have acquired intermediate technological capabilities in product design or process improvements. Most

local small and medium-sized enterprises (SMEs) have only adaptive capabilities (Arnold et al. 2000:78). Affiliates of multinational companies in Thailand are mainly manufacturing arms that have not tied intensive linkages with the local economy. New technologies are imported from abroad and used without a transfer of competences for minor changes or - in some cases - for maintenance (Dietz 2001:4).

The following more detailed factors affect private sector's demand for academic services.

- *Embeddedness of foreign-owned affiliates within the Thai innovation system*: Technologically more advanced foreign companies from industrialised countries have the potential to foster technological upgrading of the host economy. Nevertheless, in Thailand their technological capabilities are not generally higher than those of local companies. However, they introduce advanced equipment and competition into the Thai market and possess higher absorptive capacities (Berger 2005). In general, they are not interested in co-operation with local research institutes and universities, but a few of them have a strategy to upgrade higher education in Thailand (see below). In those cases, the knowledge flows from industry to university.
- *Linkage potentials outside the manufacturing sector*: The traditional focus of research on UIL in industrialised countries is on the co-operation between science & technology departments and manufacturing industries. Universities in developing countries contribute to economic development by adopting state-of-the-art research for appropriate applications and local needs. Target groups for those projects are communities or local cooperatives in rural areas. Above that, economic and social science departments have the potential to link with the service sector, e.g. IT companies, environmental protection. Besides linkages with the private sector, Thai universities are traditionally a knowledge provider for other government agencies.
- *Linkage potential in the SME sector*: 94% of all Thai companies are SMEs by the official definition of having less than 200 employees or less than 200 million Baht sales (Alpha Research 2003:161). 39% even have less than 20 employees (NSO 2001:18). In general, SMEs might have higher needs for externally acquired services due to limited in-house resource. However, many of these micro-enterprises are lacking basic absorptive capacities and financial resources. If they cooperate with universities, the scientific level is expected to be low and fees are often subsidised by government programs.
- *Peculiarities of Thai business culture*: As in many other Asian countries, Thailand does not have an endogenous class of entrepreneurs. All big companies and many SMEs are owned by families with cultural roots in China. In that respect, Thai entrepreneurialism is similar to Taiwan (EAU 1995). UIL are affected because networks of these companies mostly comprise family members. Besides that, ethnic Chinese are especially risk avers

and operate in the trade sector more often than investing in long-term R&D (Intarakumnerd et al. 2003:44). Recently, the picture is changing since the younger generation graduated from Thai universities. They are more open towards co-operation with universities.

5.4 Matching the Linkage Potentials in Science and Industry

The survey of R&D capacities in science and industry points to a weak performance and a wide gap between the sectors that limits the potential for linkages between them. Only those few departments at Thai universities that perform state-of-the-art research are able to supply relevant services to those companies being engaged in R&D activities. Outstanding departments (e.g. in pharmaceutical sciences, chemical engineering) can benefit from lower costs of doing research in developing countries by the offshoring of R&D activities. Since technological capabilities of foreign-owned companies are low, we expect few demands for academic services. Most foreign companies acquire knowledge from their home bases. However, most companies in Thailand are SMEs whose needs for academic services differ markedly from that of bigger companies. They are more likely to use basic consulting and technical services without sophisticated research.

The distribution of R&D and innovation activities amongst industrial sectors shows that potentials for UIL are highest in the food processing industry, followed by the chemical industry. The share of local companies is also especially high in those two sectors (Bank of Thailand 2004, cited by Berger 2005). In contrast, we do not expect linkage potentials within the textile industry since its innovative performance is the lowest of all sectors.

The Thai higher education system is not well-developed in terms of its research output. Financial resources are not focussed on a few promising technological fields that have the highest potential to contribute to the technological catching-up as it is done in other NICs or in China. Above that, a large portion of the limited funds for higher education is spent in humanities and social sciences which leads to a serious lack of S&T graduates (Chalamwong and Pomlakthong 2004).

Compared with other developing countries, potentials in certain parts of medical and life science are a peculiarity of the Thai research system. Excellent departments in these fields can offer relevant results for the private sector. But pharmaceutical companies in Thailand still lack necessary capacities which is another hint for a missing co-evolution of science and industry during the past decades in Thailand.

Hence, the potential for UIL is shaped by the following factors:

- Technological and absorptive capacities of most Thai companies are too low to generate a significant demand for sophisticated academic services.

- Foreign-owned companies in Thailand receive their technological and knowledge inputs from R&D departments of their parent companies abroad.
- A critical mass of excellent research outputs from Thai universities is only achieved in very few fields and is not yet attractive for technologically advanced companies.
- Thai universities have the potential to support SMEs to build up technological capabilities. These projects are most likely to succeed if they are subsidised by public funds.
- R&D activities in science and industry are located in different technological fields which further deteriorates the critical mass for linkages between both sectors. This argument is in support of the fragmented nature of the Thai IS.
- The general quality of Thai universities differs markedly. Only a few public universities have taken steps to transform themselves into research universities. Private or open universities mainly focus on undergraduate teaching. Therefore, only some departments have the potential to engage in research-based UIL.
- Unlike other NICs in Asia, Thailand does not have an integrated approach towards its S&T policies and investments (Arnold et al. 2000, Turpin et al. 2002, Bell 2003).

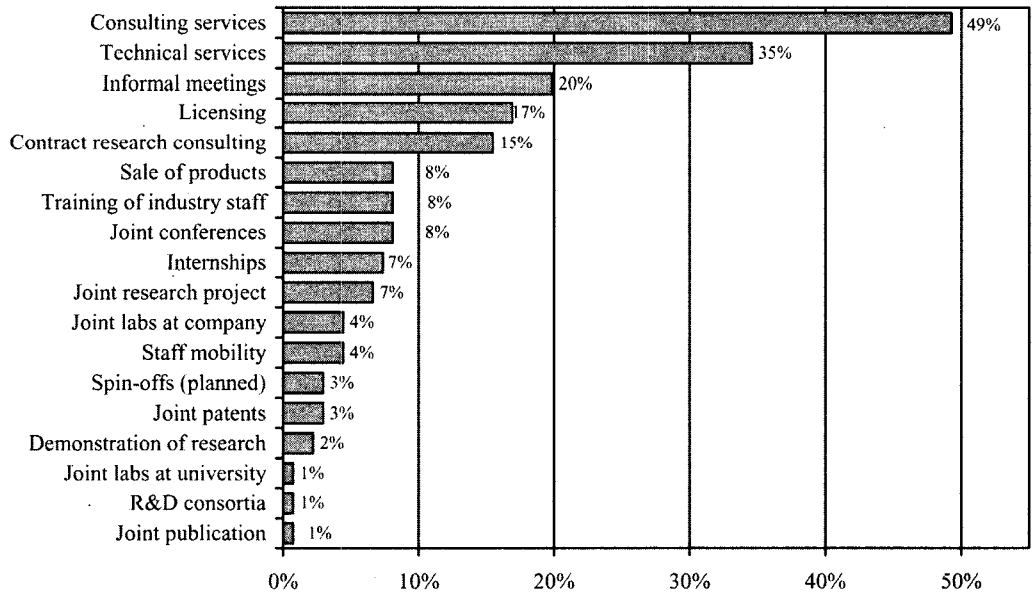
The linkage potential is also shaped by the spatial distribution of science and industry within Thailand, since spatial proximity of actors in the IS has proven to be beneficial for UIL. While most industries are located around Bangkok (BMR) and the Eastern Seaboard Region (ESR), the spatial distribution of the higher education system is more balanced. Most of the leading universities are located in the BMR, but there are no universities in the ESR. The public regional universities in the North (Chiang Mai), North East (Khon Kaen) and South (Songkhla) - which are among the best in Thailand - will have difficulties to find adequate business partners within their regional innovation systems.

6. University-industry Linkage Performance of Thai Universities

Modes of co-operation between universities and industry are giving a first overview of the UIL performance within the Thai innovation system. Linkages that comprise research are regarded to be more sophisticated than those limited to consulting or technical services (Inzelt 2004). Market-coordinated linkages like licensing and sales of products or research results are based on a linear model of innovation; institutionally embedded, interactive modes are most challenging. Universities benefit more than their industrial partners from teaching linkages (e.g. internships) or the use of company labs.

Since our sample only comprises departments with industrial linkages, it is not possible to measure the share of departments which have such linkages. Withayagiat (1993:41) and Temsiripoj (2003:201) estimate by random sampling that about 25% of all Thai professors are involved in outreach activities with the private sector, but most of them on an informal, personal base.

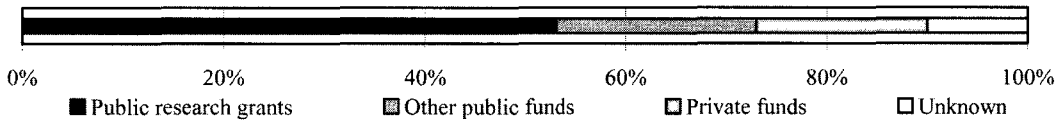
Modes of UIL in Thailand are mainly limited to services without deeper research involvement and to linear modes of knowledge transfer (fig. 2). Half of the UIL projects in Thailand comprise consulting services. Technical services (e.g. testing of samples) and informal contacts are the second most important modes of co-operation. Service-oriented UIL are followed by linear modes (licensing, sales, and contract research). The third most important group of linkages is based on teaching (internship, training). Linkage modes that are both research-based and interactive have been included in less than 10% of the projects (e.g. joint research etc.). The results are in line with similar but less extensive study by Brooker Group (1995a:46). In her survey of UIL in IT and biotechnology in Thailand, Temsiripoj (2003:226) concludes that interactive modes are less common than interactive ones.



Source: based on own survey

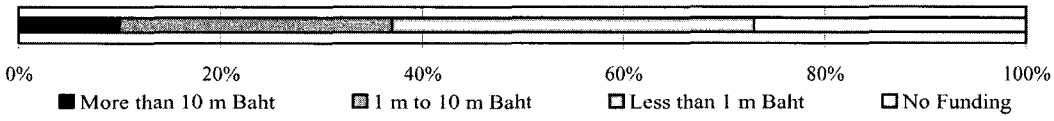
Figure 2: Modes of University-industry Linkages in Thailand (Multiple Answers Possible)

Despite expectations of many professors and university administrators to obtain large incomes from commercialisation, most industrial projects are still quite small in terms of money and contribute to funding to a limited degree (fig. 3a, b). Nevertheless, Thai scholars already spent more time for projects outside the university than allowed by government regulations (one day per week) at the expense of their time committed to research (Sharma et al. 2004).



Source: own investigation

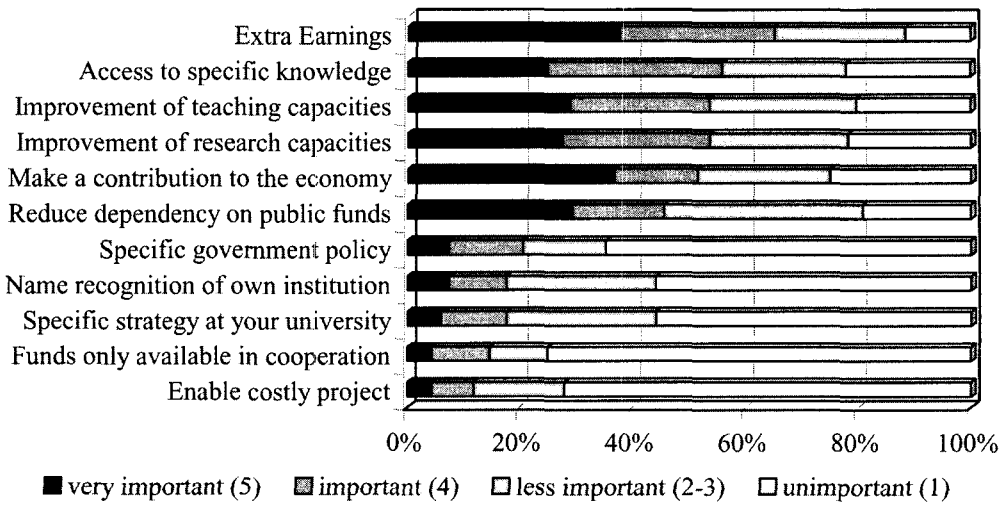
Figure 3a: Sources of External Funding for Research at Thai Universities (n=68)



Source: own investigation, 1 US$=41.60 Baht (2003 average)

Figure 3b: Financial Size of Industrial Projects at Thai Universities (n=120)

The analysis of *reasons for UIL* distinguishes between academic and monetary reasons. The most common reason is the generation of an additional personal income. Other economic reasons (e.g. independence from public funding, implementation of costly projects) are less important (fig. 4). Consulting projects as sideline jobs to supplement low incomes in the public sector are a common feature of higher education systems in developing countries (World Bank 2000). Salaries in the public sector have remained low while private sector income has been growing continuously. The wage premium for engineers in the private sector is estimated at about 500% of the corresponding salary in the public sector.

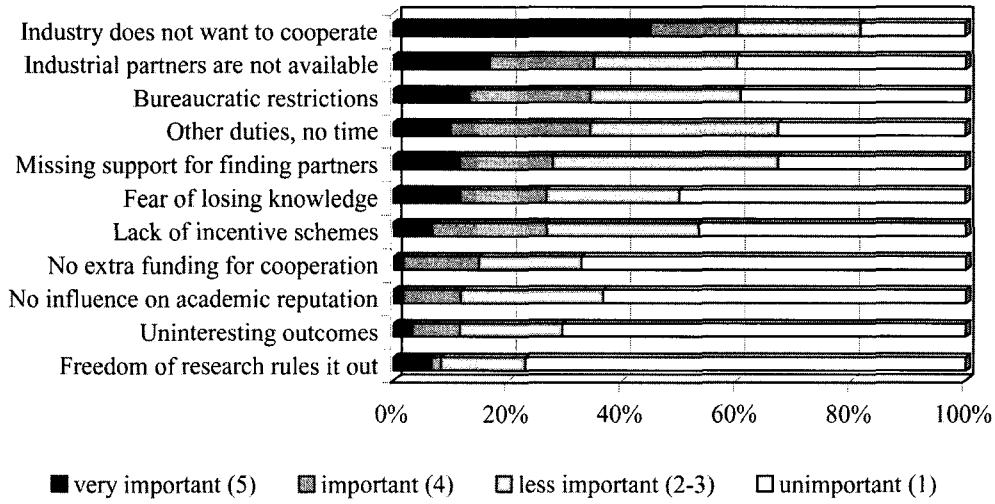


Source: based on own survey

Figure 4: Reasons for University-industry Linkages at Thai University Departments

The second most important set of reasons for UIL is to gather applied knowledge and to improve research and teaching. Many professors argue that it is their duty as a civil servant to provide academic services to foster the economic development of their country or region. Albeit, industrial relations are insufficient to raise the reputation or to promote academic careers since performance is measured by teaching and publications.

Limitations for UIL can be divided between industry- and university-related limitations and personal factors. Figure 5 indicates that professors most often mentioned limitations on the industry side. A survey amongst private companies brought up the opposite picture. Since both sides are playing the same blame game, limited knowledge about potential partners and a lack of trust and communication seem to be important underlying barriers to co-operation. Academics think that companies do not want to cooperate at all because they do not trust their industrial partners or do not receive money before they have finished a project successfully. Others blame a lack of adequate local industrial partners in their field of research or foreign-owned companies that are not interested in working with Thai universities. Private companies' perception of Thai universities is that they lack applicable results and advanced equipment. Above that, academics tend to make too ambitious promises about possible outcomes.



Source: based on own survey

Figure 5: Limitations for University-industry Linkages at Thai University Departments

If we look further down the list there are some quite important limitations within the university itself. Bureaucratic restrictions and other duties (e.g. heavy teaching loads, hiring freeze after the Asian crisis), a lack of incentives, and the omission of UIL in academic performance monitoring are the most severe internal barriers. Hence, in most cases it is not only more profitable but also easier to sidestep bureaucratic red tapes by informal twilight projects. Most universities do not support their staff for accounting, protection of intellectual property rights or project management. Therefore especially young academics fear to make mistakes or to lose knowledge and money.

Limitations that have not been quantified, but mentioned in several interviews are:

University-related factors:

- Institutional differences and division of both sectors in the past,
- lack of communication and channels for interaction,
- missing PR and marketing strategy of universities,
- short-time employment of research assistants in industrial projects who do not commit themselves to the project since they are only interested in the academic title,
- difficulties to arrange interdisciplinary teams even within a university or faculty,
- lack of equipment for state-of-the-art research and development of prototypes or pilot plants (especially in projects with more advanced companies).

Personal factors:

- Fear of conflicts of interest and to become dependent on private firms,
- losing face by making mistakes,
- resistance to adjust fields of research with private sector's demand and lack of experience to conduct applied research,
- self-conception as teachers (ajarn) by royal appointment instead of an endogenous interest in research.

Industry-related factors:

- Short-term profit orientation on the expense of long-term capability building,
- poor capability to define problems and to absorb scientific results,
- reluctance to invest into R&D at universities that are financed by taxpayers' money before a useful result or product has been received,
- trust in persons, but not in the university as an organisation,
- embeddedness of ethnic Chinese businesses into family networks

Smaller surveys conducted by Temsiripoj (2003:227-230) and Brooker Group (1995b:Annex 4.3) have revealed similar limiting factors.

7. Characteristics of Industrial Linkages at Thai Universities

In this section we go into the details of four characteristic linkage mechanisms to open up the discussion about potential paths to upgrade the Thai IS by UIL. First, we analyse linkages with big Thai companies based on training graduate students. Second, a unique linkage with a multinational company is surveyed. Third, limitations to projects based on a linear model of innovation (e.g. licensing, sale of technology) are elaborated. Fourth, the most common UIL mechanism in Thailand - consulting and technical services for SMEs - is illustrated.

7.1 Joint Graduate Program with the Petrochemical Industry

The Chemical Engineering Practice School (ChePS) is an autonomous graduate program at the Department of Chemical Engineering at KMUTT. The department lends the teaching staff. The program has been started in 1996 in co-operation with the M.I.T. that runs a similar program. Each year 20 students are enrolled in the two-year international master program. It is a unique program because all students spend one term of their second year in one of the three participating Thai-owned petroleum processing or petrochemical companies (Thai Oil, Siam Cement, Bangkok

Synthetics). The students conduct a small applied research project at the practice site. The university nominates a lecturer as site director for each company who is responsible for coordinating and selecting the projects. Finally, the project results are presented at a workshop at the company. Since there is a close contact between the company and the site director, other joint projects evolve from time to time. The students are generally offered a job by the practice site later, but many decide to join another company because of higher salaries.

The program is negotiated between KMUTT and the respective companies. Companies pay for the current costs of the projects and for allowance. The ChePS program is financed without government or university money. Thereby it is different from similar smaller programs for 'cooperative learning' funded by the Thai government.

The funding structure is as follows: students contribute 10% by tuition fees, the three companies joining the project pay for another 10%. The main portion is provided by donations. Partners have been the foundation of Thai M.I.T. alumnae (Suksapattana), the National Science and Technology Development Agency (NSTDA) and, up to now, the National Energy Policy Office (NEPO) and other petrochemical companies that are interested in graduates, but do not want to join as a practice site (e.g. ESSO Thailand).

7.2 Upgrading of Thai Universities by a Multinational Hard-disk Drive Company

In the theoretical discussion, innovation systems in developing countries have been described as learning systems (Viotti 2002). The same applies for universities that have to establish a critical mass of academic excellence before they can tap into UIL with advanced companies. In general, the operations of multinational companies in Thailand are technologically more advanced than local university research. Hence, in those UIL projects more new knowledge flows from the industry to the university.

The most advanced project of this kind is the support offered by Seagate to the Department of Electrical Engineering at KKU. The Thai head office and the biggest production facility (30% of Seagate's total output) are located in the Northeastern province of Nakhon Ratchasima half-way from Bangkok to Khon Kaen. The company is the main private employee in Thailand and is most actively supporting local capacity building amongst all multinationals in Thailand (Berger 2005). The company also sponsors teaching at other universities on a smaller scale.

In Thailand, Seagate is producing sophisticated read-write heads. Based on a long-term personal contact between a leading engineer at the company and the head of department of KKU's electrical engineering, the joint lab has been appointed to improve these parts in 2003. The multi-million

Baht lab has been donated by the company and the equipment and clean room technology has been build in accordance with the original assembly line. The lab employs 5 master and 2 Ph.D. students who conduct research in co-operation with Seagate's engineers. These projects receive additional funding from the company.

The main benefit of this project is academically. Besides training of young scientists with state-of-the-art equipment, the department has been able to published selected project results in international journals. Seagate's main benefits are the customised skills of graduates from the lab, who can start to work at Seagate's R&D department right away.

Besides this lighthouse project, there are some other UIL projects in which Thai universities join hands with foreign companies, e.g. pharmaceutical sciences and medical technology at CMU and chemical engineering at CU. In some projects foreign companies aim at exploiting cheap R&D capacities at Thai universities. Compared with India or China, this kind of R&D outsourcing to developing countries is still at a very initial stage with only a few outstanding departments that are able to succeed.

7.3 Linear Model of Innovation: Selling and Licensing of Technologies by Universities

Budget cuts have forced Thai universities to tap into new sources of income. At the same time, interactive research with private companies is limited due to different capabilities of the actors. Hence, many Thai universities are producing and selling ready-made technologies or products to companies. However, licensing of existing research results often fails because of technological incompatibility or because private companies are not willing to pay for technologies. The linear production of technologies for private companies holds the risk to miss their real needs. Thus, there are only few successful licensing projects in which the technology has been implemented by the company and royalties are paid to the university.

One example for a failed licensing project that turned into the selling of a product by a university is from the veterinary science department at CU. A research project to develop test kits for the analysis of antibiotic residues in slaughtered meat had been financed by the Thailand Research Fund (TRF) at this department for three years. The tool has proven to be remarkably cheaper than the imported technology. A private company bought the license and tried to produce the technology by themselves, but failed and returned the license to the university. Now 10,000 test kits are produced in the university lab per year and the researchers spend most of their time for it. The principal researcher considers to set up a spin-off company unless they find a capable private partner.

The only successfully completed licensing project in our sample is from the applied medicine department at KKU. This department developed a test kit for thalassemia ? a common hereditary blood disease in northeast Thailand. Right now a Thai-owned company in Bangkok is producing the test kit under a licensing agreement and pays 4% of its sales to the university.

However, most projects did not get over the phase of negotiations. At CMU's pharmaceutical department several research units are trying to license their products to companies from Sweden, Switzerland, Lithuania, Germany and Japan. Oftentimes, Thai researchers have been proactively looking for partners abroad since they could not find capable Thai pharmaceutical companies. Recently, a UK-based company contacted the university on one of the few inventions from universities that has been granted an international patent.

Thai researchers worry about making mistakes in such licensing agreements since legal or administrative support is not offered by the university ? the Intellectual Property Institute at CU (CU-IPI) is the most advanced unit in this respect. Therefore, it is impossible to enforce royalty payments in many license agreements. The respective companies claim that the technology does not work even though the product has been introduced into the market. Similar problems occurred in several projects indicating the general weakness of intellectual property protection in Thailand (Ryan and Garduño 2004).

7.4 Subsidized Consulting Services for Thai SMEs

Almost all Thai universities participate in one of the several publicly funded programs for technological consulting of SMEs. Common examples are the "One Tambon, One Product" program (OTOP) and the "Invigorating Thai Business" scheme (ITB). Both aim at the upgrading of technological capabilities in traditional sectors (e.g. food processing, textiles, handicraft, herbal products). Universities receive several million Thai Baht and have to provide cost-free consultancy either to SMEs in specific provinces or in specific sectors that have been selected by government. Most universities or engineering faculties have set up specialised consulting units that match budgets and resources at the university. In general, this constellation of partners seems to be most promising to resolve the lack of financial resources and absorptive capacities of SMEs.

However, the efficiency of these projects has been called into question (Altenburg and Stamm 2004). University staff only spends a few weeks with one project or company in the OTOP program. Hence, the results are not customised and cannot be adopted by SMEs that lack almost any technological capabilities. The ITB scheme is slightly better in this respect, since it starts with an ex-ante analysis as the basis for a detailed proposal for a six month consulting project.

The commitment of private partners is higher because the government agency only pays 80% of the total costs. Nevertheless, critics state that these projects are crowding private business services out of the market. Only public universities are entitled to apply for projects in these heavily subsidised programs. The main benefit is supposed to be an extra income for the researchers who work in these projects. Nevertheless, long-term benefits are mutual learning and trust-building between private and academic partners that might result in other projects that are completely financed by the private sector in future.

8. Conclusion: Upgrading the Thai Innovation System by UIL

The identification of potentials for UIL within the Thai IS has shown that there is a wide gap between absorptive capacities of private companies and knowledge production of universities. The scope of R&D and innovation activities by all players is markedly smaller than in the advanced Asian NICs. Recently, Thai universities put a stronger emphasis on applied research, but were unable to keep pace with the growth of modern industries. Because of their traditional orientation towards teaching, R&D at universities is growing more slowly overall than the commitment of the private economy in this field. Very likely, only a few top-flight units at universities will reach a level of research high enough to qualify for UIL with more advanced or even foreign enterprises. Co-operation with SMEs, which is less research-intensive, is hampered mainly by low absorptive and financial capacities. As research expands in the university system, the potential supply of scientific services is improving slowly.

We have presented survey results for individual departments at Thai universities showing that UIL are mostly limited to consulting and technical services, hampered by mutual distrust, and maintained to receive an extra personal income. At the moment, most UIL are based on personal contacts and operate without an elaborate institutional framework. Genuine research linkages are lacking. The differences that exist in linkage potentials of individual industries and fields of science are reflected in the intensity and quality of UIL. There is a lack of confidence-building communication among players.

Case studies on four typical modes of UIL allow us to discuss various ways to upgrade the Thai IS by UIL in future. SMEs in Thailand should step up their endeavours to build own technological capabilities - with assistance from government programs - so as to achieve the competence to co-operate with universities. At the same time, the content of university teaching and research should be harmonised with corporate requirements more than hitherto. Nevertheless,

the enhancement of Thai universities is only possible in the long run and will require consistent substantial investments in scientific equipment and staff development.

To facilitate the establishment of co-operative relationships, bureaucratic obstacles should be gradually abolished and incentive structures built up at the universities. The evaluation of professors should no longer be based exclusively on their academic excellence but also on other indicators such as the success of their co-operative relationships. UIL are greatly impeded by a lack of mutual trust among the players. Termed exchanges of employees between enterprises and universities might be a way of building trust and learning more about the others' research and technological needs. Future research on the role of UIL in the Thai innovation system should concentrate more in-depth on specific sectoral innovation systems to identify unique core competencies where university knowledge production and needs of multinational and local firms could fertilise each other mutually.

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