Capacity Building for University–Industry Linkages in Developing Countries: The Case of the Thai Higher Education Development Project[1]

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The aim of this article is to analyse the impact of academic capacity building on university–industry–linkages (*UILs*) *and to identify a set of critical success factors to guide improvements of university–industry knowledge transfers in developing countries. Extensive empirical evidence from a unique case of academic institution building and efforts to improve UILs in the context of a developing country—the Thai Higher Education Development Project* (*HEDP*)*—is used. Since the Thai HEDP combines the enhancement of both core academic missions and UIL activities within newly founded centres, it provides an interesting case study to support the cross-fertilization of ideas and academic entrepreneurship.*

The article is organised as follows: (*i*) *A generic overview of UILs in Thailand is presented to place the establishment and evolution of the centres into perspective;* (*ii*) *The quantitative relevance of UILs at the centres is measured and considered by looking at their sources of income generation;* (*iii*) *Approaches and best practices of the centres towards UILs are discussed with the help of qualitative analysis;* (*iv*) *The empirical results are used to identify critical success factors for UILs, and their potential for cross-fertilisation of academic tasks in developing countries.*

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Introduction

University–industry linkages (UILs) can play a crucial role in technological catch-up for developing countries. On the one hand, manufacturing and service companies can gain access to appropriate and cheaper technologies and become more competitive in the world marketplace. On the other hand, universities can improve their financial position and gain first-hand technological experience. Through these linkages, successful universities can become more entrepreneurial and play an active role in the economic development process.

However, several barriers have to be overcome before successful UILs can evolve in many developing countries. Industry often lacks the absorptive capacities and financial resources to invest in technological upgrading. Besides that, technology licensing from foreign partners or investors accounts for the majority of knowledge transfers during the first stages of the catch-up process. Universities continue to concentrate on teaching; academic capabilities in research and applied technological knowledge must be upgraded to complement the technological capabilities in the private sector (Liefner and Schiller 2008). In addition, institutional barriers are also hindering cooperation between private and public actors. Traditional higher education systems are closely bound to the government bureaucracy; university autonomy and comprehensive regulations governing cooperation with external partners are not yet in place.

The aim of this article is to analyse the impact of academic capacity building on UIL activities and to identify a set of critical success factors that can guide improvements in university–industry knowledge transfers in developing countries. In addition to a comprehensive survey of the relevant literature on UILs in Thailand and the region, extensive empirical evidence from a unique case of academic institution building and efforts to improve UILs in a developing country context—the Thai Higher Education Development Project (HEDP)—has been used. The HEDP has been jointly funded by a loan from the Asian Development Bank (ADB) and the budgetary resources of the Royal Thai Government (RTG). The funds have been allocated to seven centres in various fields of study, with each centre involving a number of departments and faculties at different Thai public universities. The goals of these centres are achieving excellence in (*i*) education of post-graduate students; (*ii*) carrying out international level research and (*iii*) implementing outreach activities in order to transfer

knowledge into the society and build long-term financial self-sustainability. Since the Thai HEDP combines the enhancement of both core academic missions and UIL activities within newly founded centres, it provides an interesting case study to support the cross-fertilisation of ideas and academic entrepreneurship.

The article is organised as follows: (*i*) A generic overview of UILs in Thailand is presented to place the establishment and evolution of the seven centres into perspective; (*ii*) The quantitative relevance of UILs at the seven centres is measured and considered by looking at their sources of income generation; (*iii*) Approaches and best practices of the seven centres towards UILs are discussed with the help of a qualitative analysis and (*iv*) The empirical results are used to identify critical success factors for UILs and the potential for cross-fertilisation of academic tasks in developing countries. In all sections, the roles of policies and government institutions are considered in detail.

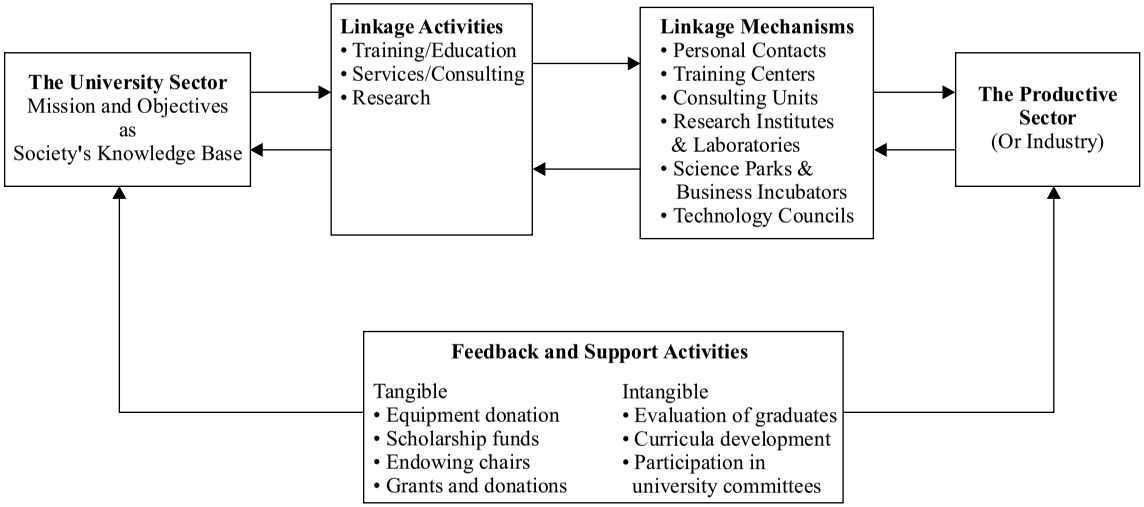
Conceptual Framework

In order to provide structure to the discussion of UILs, a conceptual framework has been developed and is shown in Figure 1. A distinction is made between the type of linkage activity being undertaken and the mechanism through which that UIL is implemented. This allows for a conceptual differentiation to be made between the types of linkage activities a university may decide to encourage or develop, and the mechanism(s) through which it actually delivers the various services to the productive sector.

Linkage Activities

University–industry linkage activities cover a broad and diverse range of modalities that are generally considered to constitute of non-traditional relationships between universities and the private sector, beyond the simple recruitment of university graduates. Three groups of such activities or modalities can be identified, corresponding to the three broad missions of the university sector referred to earlier: training and education-related activities; the provision of services and other consulting activities and research-related activities. In general, the evolution and development of UILs have increasingly focused strongly on the support of entrepreneurs. Such a trend is fully consistent with the needs of Thailand to strengthen

FIGURE 1
University–Industry Linkages: A Conceptual Framework



Source: Brooker Group (1995).

its entrepreneurial base in light of increasing competitiveness in global markets.

Linkage Mechanisms

Traditionally, the principal mechanism through which a transfer of university resources to the productive sector would take place was that of personal contacts. More formal mechanisms that have proliferated, primarily in the developed countries, can be broadly grouped as follows:

- training centres, such as entrepreneurship teaching facilities, cooperative education centres and small business training centres;
- consulting units, such as consulting practice plans, industry liaison offices and industrial outreach programmes;
- research laboratories/institutes, cooperative research centres and interdisciplinary research institutes;
- science parks and incubators, generally but not necessarily with greater physical space and additional facilities than the other mechanisms and
- technology councils, which carry out primarily policy and coordination functions between universities, the government, and the productive sector.

It should be emphasised that all of the above mechanisms, with the exception of personal contacts, can involve a range of levels of institutionalisation and physical needs. And, increasingly, they can all be developed to some extent as 'virtual' mechanisms, using existing resources in the case of teaching, or using new information technologies and telecommunication facilities to network the required resources together without the need for an actual physical base beyond a simple computer terminal. Indeed, advances in information technology are revolutionising the way in which we live. The impact of the Information Technology (IT) revolution on the nature, extent and potential of linkages involving the university sector in general and UILs in particular, are great.

The last group of cooperative measures identified in Figure 1 are not considered UILs as such, but tangible or intangible activities that strengthen the relationships between universities and the private sector. They generally involve a one-way flow of information or resources from the productive sector to the universities. These activities essentially constitute

either feedback, such as evaluations of graduates, development and improvement of curricula and participation in university committees, or support activities, such as donations, endowments, grants, and so on, which may or may not connect with linkage activities.

UILs and the Core Mission and Objectives of the University

A key question that has been raised in the literature concerns the extent to which UILs threaten the core mission and objectives of the university system—especially as they relate to basic research, knowledge creation and academic integrity. This concern is the basis for attempts to 'peripheralise' or 'institutionalise' the linkage mechanisms, and create a 'protective boundary' around the core functions.

There are valid elements to this argument. If universities are driven too much by demands of the market, imbalances or weaknesses may develop in the educational system and market failures may occur. This has been observed in many countries with regard to the allocation of resources to basic maths and science teaching, where lack of demand led to drastic reductions in supply, and severe weaknesses in the supply of such individuals to teach or carry out basic research. In the United Kingdom, for example, budget cuts and excessive pressure on academics and researchers to become self-sufficient and devote greater amounts of time to income-generating research has created serious problems with regard to the maintenance of one of the most comprehensive libraries of development studies in the world, the library of the Institute of Development Studies at Sussex University.

It has to be recognised that import elements of university's basic missions have to be publicly funded due to great externalities, long time horizons for decisions, and financial market weaknesses in the education area.

However, the need to allocate continued budgets and create mechanisms and structures for UILs that protect some elements of the core from the undue influence of private-sector goals and objectives should not simply be an excuse to insulate the core from outside influences; it can lead to the core disciplines stagnating in the face of rapidly changing global and national business and academic environments.

A balance must be struck that allows the university's core to retain its key characteristics and maintain its function as society's knowledge base, while at the same time permitting appropriate flexibility in the core

mission to respond in a dynamic manner to changing conditions. Carefully structured UIL mechanisms and procedures can greatly assist the university to reach this goal.

Generic Overview of UILs in Thailand

The aim of this article is to analyse a special case of capacity building for university–industry linkages. However, these results have to been seen against the backdrop of the unique situation of UILs in the Thai innovation system. In this section, we will give a brief generic overview of this situation with regard to the capability and credibility gaps and the role of government policy. Apart from that, the authors' more comprehensive record on the topic should be consulted for the broader view on UILs in Thailand (Brimble and Doner 2007; Brooker Group 1995; Liefner and Schiller 2008; Schiller 2006a, 2006b, 2006c; Schiller and Liefner 2007).

UIL activities in Thailand clearly differ from the experiences in Europe and North America. Major obstacles from the demand (industry) and supply side (university) have to be addressed with regard to the capability and credibility gaps between potential partners. Differences with the developed countries have to be taken into account for the development of efficient measures for UILs in Thailand.

Capability Gap

The major limitations facing industrial demands for UILs are the weak technological and absorptive capacities of the Thai industry. In the past, companies in Thailand had either been acquiring production technology from abroad, or were concentrated on trade rather than production. However, many interviewees noticed that recently, some big Thai companies (for example, Siam Cement Group, Petroleum Authority, Charoen Pokphand) are setting up Research and Development (R&D) departments to develop their own technologies. This development seems to have been driven by competitive forces since the Asian crisis in 1997 and by the expiration of technology licensing agreements with foreign partners (for example, in the petrochemical industry). Nevertheless, capabilities for UILs differ widely among industries and firms. The number of foreign companies to have contacted universities is still comparatively small (Berger and Revilla Diez 2006). Since these companies possess sufficient capacities and funding

resources, big Thai companies tend to develop in-house R&D capacities without contacting universities for critical activities. Small and medium-sized companies (SMEs) have a greater need for technology transfer from universities. However, they lack basic absorptive capacities and do not have sufficient funding resources for consulting projects. The same holds true for farmer cooperatives with close linkages to the agricultural and post-harvest sub-projects under the HEDP.

From the university perspective, capabilities to supply UILs can be limited because of insufficient equipment, funding, experience, or manpower. All centres expressed their satisfaction with improved lab equipment that allows them to serve industrial needs. However, it has to be noticed that it is very difficult for the centres to find experienced staff capable of working in UIL projects, since university regulations in general do not allow them to employ full-time staff that works solely in these projects without fulfilling teaching and research obligations.

Credibility Gap

Inflexible recruitment procedures and the autonomy of individual researchers is resulting in a credibility gap on the university side. On the one hand, lecturers are apprehensive of being unable to meet demanding project deadlines due to bureaucratic regulations. On the other hand, individual researchers cannot be forced to join industrial projects. Hence, it still depends on the definition of their peer groups, that is, international excellence versus. needs of Thai companies, which decides whether they will work in UIL projects voluntarily or not.

Both the institutional separation of universities and industry and the bad experiences in the past are main reasons for the lack of credibility between potential partners. The interviewees feel that private companies do not know what kind of services universities can offer them. Due to the unease in Thai culture in addressing problems frankly, it is more difficult to build mutual trust. The high prestige of Thai university teachers makes direct interaction even more difficult.

Lack of Consistent Policies for UILs

The general perception of policies on different levels (government, higher education system and university) is that while enhancing industrial

competitiveness and higher education performance by UILs is addressed by several initiatives, it lacks sufficient implementation and funding.

Universities have set up several UIL offices and policies to establish research excellence. However, interviewees agree that these initiatives either lack funding or experience to fulfil their task. Intellectual property regulations are seen as an additional obstacle to interaction between partners. There are no incentives to working with private companies besides additional earnings, since these projects are not recognised for personal promotion. Hence, especially for young researchers at the beginning of their careers, it is more important to concentrate on publications from research projects. Similarly, matching funds without the possibility of earning a personal honorarium are no incentives for UILs, since projects from research agencies incorporate this option. The general problem of formalised approaches to UILs, for example through technology transfer and licensing offices, will be addressed below.

Within the higher education system, universities are still suffering from the former interdiction to work with partners outside the state bureaucracy. There have been too few communication channels that have been opened. Even though regulations have been loosened to make it possible for all universities to work with private companies, clear procedures for industrial projects are mostly non-existent. From the experience of the interviewees, it is still much easier to link with industry at autonomous universities or research institutes. Government expenditures for capacity building in higher education are considered too low, apart from the specific situation at ADB-funded centres and a few strong departments at big universities.

The interviewees' perception of Thai government policies is that while there is a lot of talk about technology transfer and competitiveness, the resulting policies are weakly implemented or delegated to special agencies, for example, National Science and Technology Development Agency (NSTDA). Hence, the topic is not placed high enough on the economic development agenda of core ministries and agencies, for example the Ministry of Industry, Board of Investment. Centres working on environmental issues suffer from weak regulations for environmental protection, limiting the attention private companies pay to this matter. The pros and cons of third party projects with government or university involvement will be discussed below in detail.

Empirical Evidence of UILs at the Seven Centres

Data and Methods

Original data and information for this article was acquired through interviews with the directors and other staff at the seven centres in mid-2006. Secondary data from the seven centres was also compiled, as well as other information on UIL cases in Thailand. In addition, apparently meaningful UIL projects of the seven centres have been analysed, using information from in-depth interviews with cooperation partners from the business sector.

All interviewees placed emphasis on the variety of the seven centres. They expressed their discomfort with generalised comparisons of their UIL activities. Differences stem from the specialisation of the centres in their respective fields of science and their research foci, that is, on applied or basic research. Hence, it should be taken into account that industrial stakeholders and commercialisation potentials vary among the centres. From the centre perspective, UILs span both private companies in different sectors of the economy with distinct characteristics, for example, Thai versus foreign-owned, big versus small and stakeholders outside the industrial core, that is, government agencies, business association, co-operatives and farmer groups.

The following sections are divided into a quantitative analysis of the income sources of the seven centres and a qualitative analysis of a more complex set of UIL issues. The first part will provide data on the relevance of outreach activities in terms of money. However, qualitative aspects of UILs and in-kind contributions are expected to prevail in developing countries like Thailand and during the start-up period of the seven centres. The qualitative part is structured as follows:

- Facilitation of UILs at the seven centres
- Approaches to close capability and credibility gaps
- Cases of best practice at the seven centres
- Cross-fertilisation of other academic tasks by UIL

The Seven Centres within the Thai University System

The Thai university system has been expanded during the last decades. On the one hand the demand for university places has risen with the expansion

of upper secondary education, and on the other, the growing economy was demanding more highly qualified graduates and research results that are potentially meaningful for technological upgrading and innovation. However, the expansion has been driven by open and private universities which have a higher student-teacher ratio and concentrate on humanities and social sciences. Most of them are not performing research activities to a significant degree. Due to a lack of public investments in high-quality teaching at public limited admission universities, the country now lacks graduates in science and technology subjects, and the growth of its research capabilities is slow when compared with other newly-industrialising countries in the region (Liefner and Schiller 2008; Schiller 2006a).

Several studies on the Thai innovation system have identified the weak science and technology base in research and teaching at Thai universities as a major bottleneck in the country's long-term economic and technological development (c.f. Altenburg et al. 2004; Arnold et al. 2000; Berger and Revilla Diez 2006; Intarakumnerd et al. 2002). A recent study by Liefner and Schiller (2008) has conceptualised the role of higher education and economic development by looking at academic capabilities, that is, the set of functional skills and organisational ability possessed by a country's higher education institutions to carry out their extended role in the process of technological upgrading and learning. Their study identified several weaknesses in terms of academic capabilities in Thailand, but identified the HEDP and its seven centres as a promising approach towards capability building.

It has been the explicit aim of the ADB-funded HEDP to tackle weaknesses in R&D investment and human resources in Science and Technology (S&T). When the project was envisaged during the mid-1990s, it was in line with the Eighth National Economic and Social Development Plan (1997–2001) and the Long-Term Plan for Higher Education (1990–2004) and its aims regarding technological and academic upgrading (ADB 2006; Brooker Group 1995).

Seven centres or sub-projects were selected from several proposals, and were to become centres of excellence in their respective S&T fields. The HEDP has been funded by an ADB loan from 1999 to 2006. Additional financial sources have been procured by the Royal Thai Government and respective university sources. The total amount of the ADB loan has originally been set at USD 59.3 million. The major aims of the HEDP

are to achieve excellence in (*i*) post-graduate education and training; (*ii*) research; (*iii*) outreach activities and technology transfer and (*iv*) synergetic collaboration among all parts. The original breakdown of the loan to several activities has been as follows:

- Equipment (41 per cent)
- Staff Development (overseas training 23 per cent and scholarships 1 per cent)
- Consulting Services (visiting Academics and experts 12 per cent)
- Materials and Supplies (12 per cent)
- Unallocated (11 per cent)

The seven centres that have received funding are spanning faculties and departments at two to five Thai public or autonomous universities and research institutes. The list below introduces the names, acronyms and participating institutes. The first institute is leading the sub-project.

- Center for *Agricultural Biotechnology* (CAB): Kasetsart U., Chiang Mai U., Khon Kaen U., King Mongkut's Institute of Technology Ladkrabang, Mahidol U.
- *Environmental Hazardous Waste Management* (EHWM): Chulalongkorn U., Khon Kaen U., King Mongkut U. of Technology Thonburi, Chiang Mai U., Prince of Songkhla U.
- *Environmental Science, Technology, and Management* (ESTM): Mahidol U., Burapha U., Chulabhorn Research Institute, Asian Institute of Technology.
- *Joint Graduate School of Energy and Environment* (JGSEE): King Mongkut U. of Technology Thonburi, Chiang Mai U., King Mongkut's Institute of Technology North Bangkok, Prince of Songkhla U., Sirindhorn International Institute of Technology.
- *Chemistry* (PERCH): Mahidol U., Khon Kaen U., Prince of Songkhla U., Chiang Mai U., Kasetsart U.
- *Post-Harvest Technology* (PHT): Chiang Mai U., Kasetsart U., Khon Kaen U., King Mongkut U. of Technology Thonburi.
- *Petroleum and Petrochemical Technology* (PPT): Chulalongkorn U., Kasetsart U.

The centres were established in the fourth quarter of 1999; thus teaching and research activities commenced in 2000 with the exception of JGSEE, which started with its own funds in 1998. The official closing date of the first phase of funding was 2006. After the termination of the ADB loan, the seven centres received further funding from the Royal Thai Government, the Science and Technology Postgraduate Education and Research Development Office (PERDO) for a second period from 2006 to 2009. They have been formally renamed the National Centres of Excellence and additional partners from other universities have joined them; for example, in the case of PERCH there are thirteen member universities in the second phase as compared to five in the first phase.

Table 1 summarises some basic data on the seven centres regarding enrolment, graduates, publications and patents. However, since it is not the aim of this article to evaluate the overall performance of the seven centres, this information is meant to provide an overview of some structural differences that might be reflected in the centres' UIL activities.

Table 1
Selected Performance Indicators for the Seven Sub-Projects

	Enrolment		*Graduates*		*Publications*		
Centre	*M.Sc.*	*Ph.D.*	*M.Sc.*	*Ph.D.*	*National*	*International*	*Patents*
CAB	400	102	183	9	153	316	6
EHWM	143	88	86	13	33	81	0
ESTM	439	120	210	22	107	130	0
JGSEE	127	124	54	22	31	121	0
PERCH	515	137	282	47	34	295	4
PHT	418	85	195	5	129	47	0
PPT	870	193	676	56	157	354	3
Total	**2,912**	**849**	**1,686**	**174**	**944**	**1,344**	**13**
Target	*2,842*	*556*	–	–	*1,004*	*773*	–

Source: ADB 2006.

Data on the staff attached to the centres is not available in a comparative way. Most academic staff is employed by the respective department and joins the centre in its research and teaching programmes for a certain amount of time. Staff employed directly by the centres in most cases is administrative staff.

The total number of enrolled students and publications exceeds the targeted figures set by the ADB. The number of Ph.D. students enrolled in programmes of the centres is usually around 100, with a higher number in the PPT centre. The contribution of the centres to the M.Sc. target differs more significantly, with the highest number at PPT, four centres in the range of 400 to 500 and two centres with less than 200 enrolled M.Sc. students.

Research output differs clearly between the centres and is not only affected by the number of Ph.D. students, but also by different ratios of international publications per Ph.D. students. High ratios are reached at CAB with 3.1 international publications per Ph.D. student, and PERCH with 2.2. PPT has an intermediate ratio of 1.8, while all other centres are clearly below the average of 1.6 with ratios around 1.0.

Income Generation of the Seven Centres

In this section, we present data on the financial benefits of the seven centres from UILs and other income sources of their own. Data on their own income generation as a percentage of the total income of the seven centres is presented in Table 2. The relevance of their own income is analysed by a comparison between two time periods (1999 to 2002 and 2003 to 2006). The total income of the centres consists of the ADB loan, co-funding by the Royal Thai Government, additional funding by the respective universities, and own income generation, which has been obtained competitively. Own income is split up between research grants from Thai funding agencies and income from various types of outreach activities (industry, government and non-profit organisations).

A clearly positive result is that the share of own income has been growing in all centres except the ESTM, which in turn reached one of the highest own income ratios during the first period. This overall growth can be attributed to both income from research agencies and outreach activities. In absolute figures, the seven centres earned 1,260 million Baht of their own income from 1999 to 2006. Thereof, 803 million Baht are from research agencies and 457 million Baht from outreach activities. However, income from industry, that is, UILs in a strict sense, accounts for eighty-nine million Baht only. Hence, this income source is still much less profit-yielding than outreach activities in cooperation with government agencies.

Table 2
Own Income Generation by the Seven Centres, 1999–2006

			Own income in % of total income					
					Outreach			
Center	*Time period*	*Total income in million Baht*	*Total*	*Research funding agencies*	*Total*	*Industry*	*Government*	*On-profit organisations*
CAB	99–02	411.529	11.3%	8.1%	3.2%	0.4%	1.9%	0.9%
CAB	03–06	212.448	29.1%	19.8%	9.3%	2.9%	4.3%	2.1%
CAB	*99–06*	*623.977*	*17.3%*	*12.1%*	*5.3%*	*1.2%*	*2.7%*	*1.3%*
EHWM	99–02	190.608	7.5%	5.5%	2.0%	0.2%	1.7%	0.2%
EHWM	03–06	570.671	18.0%	5.3%	12.7%	1.8%	10.0%	0.9%
EHWM	*99–06*	*761.280*	*15.4%*	*5.4%*	*10.0%*	*1.4%*	*7.9%*	*0.7%*
ESTM	99–02	229.382	19.1%	8.6%	10.5%	9.6%	0.9%	0.0%
ESTM	03–06	425.543	11.5%	4.6%	6.9%	4.9%	2.0%	0.0%
ESTM	*99–06*	*654.925*	*14.1%*	*6.0%*	*8.1%*	*6.6%*	*1.6%*	*0.0%*
JGSEE	99–02	194.431	16.5%	4.8%	11.7%	0.0%	11.7%	0.0%
JGSEE	03–06	407.164	40.2%	13.9%	26.3%	0.7%	24.5%	1.1%
JGSEE	*99–06*	*601.594*	*32.6%*	*11.0%*	*21.6%*	*0.5%*	*20.4%*	*0.7%*
PERCH	99–02	196.844	na	na	na	na	na	na
PERCH	03–06	385.245	na	na	na	na	na	na
PERCH	*99–06*	*1,214.489*	*34.7%*	*28.8%*	*5.9%*	*0.5%*	*3.7%*	1.6%
PHT	99–02	146.192	5.4%	3.2%	2.2%	0.1%	2.1%	0.0%
PHT	03–06	339.146	12.2%	7.0%	5.2%	0.2%	4.8%	0.2%
PHT	*99–06*	*485.338*	*10.2%*	*5.9%*	*4.3%*	*0.2%*	*4.0%*	*0.1%*
PPT	99–02	349.114	21.0%	16.1%	4.9%	1.2%	2.0%	1.8%
PPT	03–06	634.227	32.0%	23.4%	8.6%	2.1%	5.8%	0.6%
PPT	*99–06*	*983.341*	*28.1%*	*20.8%*	*7.3%*	*1.8%*	*4.5%*	*1.0%*

Source: www.oanda.com, as accessed on 30 November, 2008.
Note: Average exchange rate in 2006: 37.99 Thai Baht per US Dollar.

A closer look at individual centres reveals that four centres (CAB, JGSEE, PERCH, PPT) have been extraordinarily successful in receiving competitive research grants. The share of research grants has more than doubled at PHT over time, but on a much lower level. This share is stagnant on a low level at the two remaining centres (EHWM, ESTM). With regard to income from outreach activities, JGSEE is the most successful. However, its good performance is mainly the result of linkages with government agencies. EHWM has also been successful in obtaining substantial funding from government agencies. The share of outreach activities at the other five centres is below 10 per cent.

Income from industrial projects is still rare at all centres. Only ESTM seems to be an exception. Industrial income reached 1 per cent or even less of the total income at the other centres during the first period (1999–2002). However, a few centres realised a quite significant growth in this field during the second period (CAB, EHWM, PPT) by elevating the share of private-sector income to about 2 per cent.

In conclusion, a trend towards increased financial self-sufficiency can be observed at the seven centres. Four centres (CAB, JGSEE, PERCH, PPT) have been able to obtain more than one quarter of their total income from competitive own income sources. However, this is still insufficient to provide for the required financial sustainability of the centres without public base funding. Income generation from private-sector sources is still unsatisfactory. Missing or inefficient strategic approaches towards UILs result in a weak profitability of this potentially promising source.

Facilitation of UILs at the Seven Centres

This section addresses several topics dealing with how the seven centres try to facilitate UIL. The self-conception of the centres, their linking strategies and related topics of support to individual researchers, quality assurance of UILs and ways to close capability and credibility gaps will be discussed.

Self-Conceptions of the Centres

Through an analysis of the self-conception of the seven centres, we are trying to assess their readiness and willingness to establish close links between academic activities and the needs of external stakeholders. When asked about the importance of UILs, the answers of the interviewees

showed quite different self-conceptions. In general, they all rated the importance of UILs for the future of the centre as high, very high, or critical, since it is an important means to receive additional funding. In detail, the self-conceptions can be summarised as follows:

1. CAB: Strategic alliances with external partners are the unique selling point of the centre, but UILs should not be overstressed as an end in itself at the cost of academic core activities.
2. ESTM: It is too early to think about UILs yet. Excellence in research has to be established before commercialisation can be attempted. Financial contributions from industry will not be sufficient for the centre's sustainability.
3. EHWM: The main tasks are two full-time activities (research and teaching), but engineering and science can only survive with industry funding since government expenditure on higher education is insufficient.
4. PERCH: We are the only basic science consortium, but at least 10 per cent of the projects should be directly useful for industry. UILs will be much more important in the second phase.
5. JGSEE: UILs are a soft target of the centre besides academic excellence, but relevant research questions cannot be addressed without feedbacks from industry. UILs are important, even though they are not providing substantial financial returns yet.
6. PPT: At the end of the project, the centre has to be self-sustainable. Its goal to earn one-third of its financial resources from UILs will be reached.
7. PHT: UILs can contribute to the objective of the centre to establish academic excellence. Therefore, technology transfer and services are ranked equally with the academic core activities of research and teaching.

[**Source:** Authors' interviews at the seven centres.]

Linking Strategy

By looking at the linking strategy of the seven centres, we expect to get an idea about the existence of a conscious, suitable strategy aimed at

UILs with realistic targets within the Thai context. As mentioned in the preliminary note, UILs differ among fields of science. Hence, it is neither efficient nor is it expected that they will follow similar linking strategies. We will therefore provide an overview of the strategies, as described by the interviewees.

1. CAB: The centre tries to respond to the needs of Thai agriculture by producing benefits for the people, not for rich companies. Applied research projects are encouraged as long as they fulfil academic standards. A deepening of existing personal contacts is a central part of the linking strategy. Target industries are seed producers, agro-industry, ministry of agriculture and farmer cooperatives.
2. ESTM: UIL projects have to fit within the centre's aim of academic excellence. The centre's strength is the technical perspective of biological waste water treatment. Target sectors are petrochemical and fabric dyeing industries. In general, the Thai industry is not yet interested in research outcomes from toxicology.
3. EHWM: An emphasis is placed on the technical and social perspective of environmental sustainability assessments. Intermediaries are used to get in touch with companies on a personal level (for example, Greening Industry Network).
4. PERCH: Besides its basic research in chemistry, the centre focuses on natural products and food safety as promoted by the government. Four distinct strategies are followed: (*i*) industry meetings, (*ii*) industry briefings, (*iii*) training and analytical services and (*iv*) collaborative research. Intermediaries are used to get in touch with companies (for example, National Innovation Agency, Clean Technology Project).
5. JGSEE: A semi-formalised industrial outreach programme (IOP) has been recently developed. It comprises: (*i*) talks and seminars, (*ii*) identification potential customers for each group of the consortium, (*iii*) analytical services, (*iv*) training programmes and public lectures and (*v*) industrial internships. The centre establishes a new focus on policy research and tries to contact industry via former students and visiting professors from abroad.

6. PPT: The focus industries of the centre are petroleum, petrochemical, polymer, and polyethylene companies. The linking strategy is based on personal contacts via alumni and visiting professors from abroad at the PPC. Short courses are offered to develop linkages. Analytical services are offered at the central lab on a regular basis.
7. PHT: The linking strategy is based on the personal contacts of senior staff members. In future, the centre will try to gain a reputation in the field of post-harvest technology to establish institutionalised linkages. Target industries are food processing companies (for example, rice and longan producers), orchards and the ministry of agriculture.

[**Source:** Authors' interviews at the seven centres.]

Support for UILs within the Centre

The internal support extended to UIL activities by the centre management is critical in the communication of the linking strategy and its implementation across the centre. The seven centres offer various kinds of support to UILs within the centre, ranging from financial and administrative support to coaching junior staff members to develop contacts with industry. The following activities are in place at the seven centres.

1. CAB: Senior staff advises about the difficulties of working with industry. The centre helps to manage and administer industrial projects. The centre director meets regularly with all lab directors to discuss UIL topics.
2. ESTM: The industrial outreach coordinator tries to introduce researchers to private companies. No further incentives have been offered yet, but they plan to introduce matching funds in the second phase.
3. EHWM: The centre offers matching funds for industrial projects. Junior staff is joining in talks and meetings with industry.
4. PERCH: The centre offers matching funds of the same amount for industrial projects and pays for expenses to file patents.
5. JGSEE: A recently developed outreach programme will help to identify potential customers for all activities of the

centre. It is planned to introduce matching funds in the second phase.

6. PPT: Visiting professors help to gain access to the executive levels of big Thai companies. The annual report is sent to about 100 private companies. This has increased awareness and the centre has been contacted by several companies.
7. PHT: Personal contacts of senior staff in companies and government agencies are used to establish UILs on behalf of the centre.

[**Source:** Authors' interviews at the seven centres.]

Industry Advisory Boards and Industrial Outreach Coordinators

Industry Advisory Boards (IAB) and outreach coordinators (IOC) are not useful as measures by themselves. However, the necessity of IAB and IOC should be monitored with regard to its additional value within the respective linking strategies of the centres. These two strategies are one way to support the development of systematic approaches towards UILs and to detach them from a purely personal basis. They have to be integrated within the overall linking strategy. However, its usefulness has been called into question by most of the interviewees, since any kind of formalisation of UILs is perceived as being inappropriate in the Thai context.

Recently, two centres have appointed an IAB (EHWM and PPT), and two centres employ an IOC (ESTM, JGSEE). The IOC of PERCH has been left to a private company, the PHT has been unable to find a suitable person willing to work in Chiang Mai, and three centres made a conscious decision against an IOC (CAB, EHWM, PPT).

1. CAB: The centre made a conscious decision against IOC and IAB. An IOC has not been employed because outsiders do not have information about the services the centre can offer. Every researcher in the centre is responsible for UILs.
2. ESTM: The centre employs an IOC from the private sector. He coordinates the activities of the centre members, but does not directly interact with each lab. He tried to contact companies proactively and introduce them to researchers from the centres. However, the researchers have been quite

reluctant to work in these projects and the strategy has not proven a success. An IAB has not yet been appointed since the centre does not have a clearly defined focus industry. Environmental consulting companies who know the market quite well are seen as competitors.

3. EHWM: CEOs from industry have been appointed to the general advisory board of the centre. The IAB comprises of working-level staff that gives advice and formulates industry needs. The centre made a conscious decision against an IOC. Since UILs in Thailand are mainly based on personal contacts, the centre sees no value in this kind of formalisation.
4. PERCH: The centre employed one junior staff as an assistant for industrial linkages, who has been supervised by the deputy director. She has been responsible for facilitating meetings and following up contacts, but had to rely on the commitment of the individual researchers. She was hired by a private company. The centre did not find an experienced senior researcher as IOC.
5. JGSEE: A senior academic member who had been employed as IOC quit. Now an academic member from abroad is responsible for setting up a new outreach programme.
6. PPT: The centre appointed twenty-five members to the IAB at the beginning of the first phase. There are no board meetings since the members have no need for debates, and are either competitors or the nature of their businesses is too different. The members of the IAB are contacted for individual consultation on industrial projects. The centre made a conscious decision against an IOC. The person would have to understand university and industry, but his work would be constrained by too many limitations. He cannot bring in projects and force academics to join them, because it is not possible to employ full-time staff for UILs. It is also impossible to identify potential companies for researchers on their request.
7. PHT: The centre tried to find an IOC twice, but could not find suitable staff. They were either too young, or did not have business experience, or were not interested to move to

Chiang Mai for work. Now senior staff members of the four groups of the consortium are responsible for UILs. Advice on industrial projects are received on an individual basis from the personal contacts of senior staff.

[**Source:** Authors' interviews at the seven centres.]

Approaches to Close Capability and Credibility Gaps

As outlined in the generic view of UILs in Thailand, capabilities for UILs and credibility between university, industry and government partners are an important limitation facing more sophisticated and intense linkages. These two gaps have to be narrowed before UILs can succeed. Recently, partners have been seen to possess different capabilities (for example, problem-solving capacities, use of up-to-date knowledge and technologies, and so forth). This gap can be closed by the joint definition of research questions that have mutual benefits and that can be handled by both partners. Public investments are needed for initial investments in research equipment and staff development to enhance the capabilities of public universities.

However, closing the capability gap is only the precondition for UILs. To turn these capabilities to account, a credibility gap has to be closed. This gap results from institutional borders between private business and public research. In general, personal contacts are the most efficient way to facilitate UILs. Ongoing communication can help to establish mutual trust, and develop existing personal contacts into comprehensive UILs. Multiple interfaces for industrial contacts increases the probability of establishing new contacts systematically. Since several attempts related to capability and credibility building for UILs have been discussed in the sections above, this part concentrates on the remaining topics.

Additional Capabilities for UILs from the HEDP

The seven centres received substantial funding from the ADB and the Royal Thai Government. Therefore, the centres have been asked whether the funding has been sufficient to acquire up-to-date equipment that fulfils the needs of external partners from the industry and government. It is also important to know the extent to which the centres are using this equipment for their UIL activities.

All interviewees agreed that the HEDP support significantly improved their capabilities in terms of equipment and staff development. The larger

number of graduate and post-graduate students broadens the human resource pool for research assistants in industrial projects, since it is not possible to employ full-time staff for UILs under most university regulations. The equipment is now perceived as being sufficient for UILs, and most centres are offering regular analytical services for private companies. The instrumentation is more exact, and some centres are aiming at ISO certifications for their analytical services. Some centres use their labs to convince private companies of their ability. The equipment can be further improved through the joint collaboration of labs with private companies, as shown by the CAB. Other centres have similar plans, but have not realised them yet. Nevertheless, some interviewees pointed to the importance of capable people, besides the availability of good equipment. It has been mentioned that it is still too soon to assess the overall impact of the HEDP since some labs are not operating at full scale and several staff members are still abroad, finishing their Ph.D. studies.

Compared with other departments that are not part of the centre, most interviewees see a clear difference in terms of the quality of equipment and flexibility of regulations. In a few cases, companies compared the services of different universities and decided to work with one of the centres because of its equipment, or openness towards cooperation. A company that contacted the Thailand Science Park before working with the CAB reported that the approach of the science park is too inflexible and lacks multidisciplinary experience.

In general, universities with an agricultural background (for example the Kasetsart, Khon Kaen University) can contact private companies more easily. Universities with a focus on basic sciences (for example Mahidol, Chulalongkorn University) will find it more difficult to offer down-to-earth services to meet the needs of the Thai industry. Also, in some cases it has been reported that strong departments or faculties within the centres are less open to joint activities, since they are able to move forward without the HEDP. Less reputed groups and universities are showing stronger commitment and support, for instance through matching funds from the university budget.

University–Industry–Government Projects

Support from third parties (government offices, research agencies, business associations) is one strategy used as a substitute for insufficient individual capabilities for UILs in Thailand. Co-financing from government is also

useful in narrowing credibility gaps. Government and research agencies or industrial associations have the potential to define suitable projects, provide the necessary funds and support project management. Even though these projects are often limited to small consulting projects, they offer an opportunity to establish new contacts.

Such projects at the seven centres are facilitated by the Thailand Research Fund, National Innovation Agency, research institutes of the NSTDA, Federation of Thai Industries and National Food Institute, or the Greening Industry Network.

Four centres are using this mechanism to get in touch with private companies as part of their linking strategy. The other three centres believe that this strategy is not beneficial for their UIL activities since these projects are too inflexible. These centres also mentioned that industry is even more reluctant to contact government agencies.

Cases of Best Practice Towards UILs at the Seven Centres

In this section, we will briefly outline projects that the centres have identified as best practice approaches to UILs. Through this, the variety and creativity of the UILs of the seven centres are illustrated. These examples should be used by the centres to promote the benefits of UILs among all parts of the consortium. Cases of best practices towards UILs could be used to promote successful linking mechanisms within the centres and the respective universities.

CAB has established a long-term relationship with a company that buys wood chips from farmers and exports them. The relationship started from a personal contact with a field manager. The company site is located close to Kasetsart's Kamphaeng Saen campus. Beginning with several informal talks, the project has now evolved in three years from consulting and contract research to a joint lab. It is multidisciplinary and spans several groups of the centre (not only genetics), which has been an advantage compared with the Thailand Science Park. The funding from this project is now sufficient to run one lab for one year.

ESTM has undertaken several projects in cooperation with a petroleum company on workers' exposure to toxic substances. This is the only company to have allowed the university to carry out research on this sensible topic. The project began with informal talks with the managing director of the company. Finally, three projects have been proposed:

(*i*) the first project in Thailand on occupational health and benzene exposure based on the research interest of the centre and conducted by full-time staff; (*ii*) project on mercury in the air based on a mutual interest conducted by graduate students; (*iii*) project on mercury in the soil based on industry interest with support from graduate students. The company donated money to the university and the centre received matching research funds from Mahidol University.

EHWM has established links to a pulp and paper company from a personal contact with the managing director via another joint working group. The contact has been evolving over several years. A first project for pulp and paper companies in Thailand has been co-financed by the Thailand Research Fund. After that, the centre prepared the first sustainability report in Thailand. Now the centre is working in a collaborative research project with a Ph.D. student and another project is being conducted by the Khon Kaen branch of the company with the respective university (networking within the centre). This well-institutionalised link represents two important strategies of the centre: long-term evolution of UILs and the use of third parties to facilitate UILs (Pulp and Paper Association and the Thailand Research Fund).

The director of PERCH did research on a plant called 'Plai' (*zingiber cassumunar*) for more than twenty years without an interest of application. His research has been picked up by the National Innovation Agency for commercialisation. Recently, fifteen to twenty companies have been producing Plai products (for example, Plaitanoids by Kovic Kate). The basic knowledge about Plai is public property, and the university cannot benefit financially from it. However, the centre is using its unique knowledge of it to offer services to the companies (for example, on more efficient extraction processes).

JGSEE established a close link with the energy business group of a big Thai conglomerate. The contact stems from a former Ph.D. student of the centre director, who has been hired by the engineering department of the company. Mutual interest has been identified through informal talks and a project on biomass gasification has been proposed. Even without a formal contract, the company sent samples to the university and a lab scale pilot application has been developed. The presence of the former Ph.D. student helped to find a common way in which to address the topic. In the future, it has been planned to extend this contact to an institutionalised link between the company and the centre.

PPT has a successful link to a major Thai petrochemical company that conducts research and development very actively and has several linkages with Thai universities. The centre contacted the company via a personal contact with a former student. A meeting of company engineers and researchers has been organised to discuss ways to upgrade a high value-added product. After mutual interest has been defined at the working level, the centre has been introduced to the executive level, and presented with a proposal for the joint project supported by a visiting professor from abroad. It took only three months from the first meeting to the signing of the contract. The main outcomes are reports and theses and the university offered a follow-up study after the first twelve months, which has been approved by the company.

PHT provided detailed information on several UILs with public organisations, industrial associations and private companies. Quite a close link has been established with the Department of Agriculture (DOA), based on a personal contact with the director general. The joint activities span research projects on economically interesting crops (for example longan), DOA staff as co-advisors for research projects and theses, analytical services, a joint online database for pre-harvest (DOA) and post-harvest technologies (PHT), a quota for staff from DOA and other public organisations in research-based study programmes, short course training on food safety and ISO certifications. The centre also developed linkages with rice and longan exporters through seminars with industry associations on specific topics (for example, packaging technology). At these meetings, the companies were reluctant to discuss problems with their competitors, but after these contacts have been followed up, they discovered common interests and the companies provided small research budgets or donated money for new equipment.

Cross-Fertilisation of Other Academic Tasks by UILs

In this section, experiences of the seven centres in stimulating their core academic missions through UILs are discussed. This topic is of critical importance since UILs are not only ends in themselves, but also a means to spill over into research, post-graduate education, networking within the consortium, and other university goals.

Spill-Over to Research and Post-Graduate Education

It has been asked whether the centres used UIL projects to strategically enhance their academic core capabilities in research and post-graduate education. Most centres have been unaware of the possibilities that UILs have to stimulate their academic core. Rather, they perceived them as the final step in the research cycle. By contrast, we propose an interactive approach to research and teaching with feedbacks from industry at all stages (for example, alignment of research projects with industrial needs, training of staff and students in an industrial environment). Hence, there are at least as many intangible benefits from UILs as tangible ones. The following list contains examples of interactions that are—mostly unconsciously—in place at the seven centres.

1. CAB: Research-based UIL projects are linked with Masters and Ph.D. projects, but even in consulting projects research assistants are exposed to applied problems and samples can be used for teaching.
2. ESTM: The centre did not consider that UILs could contribute to the overall goal of research excellence. However, Masters students are trained in an industrial environment and two graduates who worked in an industrial project have been hired by this company after their graduation.
3. EHWM: Students who have worked in industrial projects as research assistants have been hired by these companies in two or three cases. Company employees applied for Masters programmes in the centre.
4. PERCH: As the research focus of centre is basic science, it is more difficult to link its academic activities with UILs; for example, internships are not required. However, it has been possible to place a few graduates at a petrochemical company to establish an analytical lab. Consulting projects are strategically used to get inputs for new research topics.
5. JGSEE: Research assistants are involved in most UIL projects, which helps them gain experience. It is too early to evaluate

the job opportunities of these graduates, since the number is as yet too small. The centre has recently started a new Masters programme on technology and management with a compulsory term in industry.

6. PPT: Faculty and students gain experience from solving industrial problems. However, in most projects it is difficult to use the results for publications.
7. PHT: Industrial linkages are strategically used in curriculum development and selection of research topics. Students become more experienced through solving real-world problems and working with advanced equipment. Quotas are reserved for company staff to study in research-based Masters and Ph.D. programmes without course work. The centre does not offer internships, but a two-week study trip to visit companies and other organisations from the post-harvest value chain.

[**Source:** Authors' interviews at the seven centres.]

In general, spillovers from UILs are limited by confidential agreements and most results cannot be published. However, this depends on the bargaining carried out before agreeing on the terms of reference. Another important limitation is that most UIL projects are not at the research frontier, but are limited to minor adaptations of existing technologies.

Networking within the Consortium

The centres often consist of departments with distinct individual specialisations. Hence, networking between all parts of the centre is expected to add value to its linkage capabilities. It is an important to note whether outreach activities of individual members of the centre are performed under the name of the centre or not. If it is, then the interdisciplinary capacities of centre members can be used to further improve its outreach capabilities. This strategy has been incorporated by different centres quite differently.

1. CAB: Pooling interdisciplinary expertise by networking is a unique selling point of the centre. Some companies have recently begun using different labs. One company decided

to work with CAB instead of Thailand Science Park or another faculty at Kasetsart University because of this asset.

2. ESTM: The consortium offers the possibility of pooling resources for research and teaching, but there is no networking in UIL projects. Only those UILs that are directly linked to the operations of ESTM are undertaken on behalf of the centre, but most UILs are individual projects in respective departments.

3. EHWM: There is one successful project that was initiated by one group and is now being continued by another. In general, the centre only coordinates the activities of the departments. There are no means by which to force members to conduct UILs under the name of the centre. More and less active members can be clearly distinguished. Conflicts are more likely if the projects are subject to the regulations of different universities. Within each university, the centre can help to facilitate additional funding and equipment. Personnel and equipment of the centre are shared within the university for a small overhead. UIL projects that belong to the centre are also open to partners from outside the consortium, depending on their expertise.

4. PERCH: The centre is only a label for existing departments. However, industrial seminars and briefings are attended by all members and thereby offer a critical mass of relevant research for industry.

5. JGSEE: The centre operates under an autonomous structure separated from the university. The lab at KMUTT is the focal point within the centre. However, the equipment is shared for research and teaching and industrial projects are mostly performed by the departments individually. Former contacts are not brought into JGSEE and new projects are only taken up under the name of the centre on a voluntary basis.

6. PPT: Chulalongkorn and Kasetsart University have distinct policies towards UILs, which inhibits efficient networking. The focus industries of partners differ widely and are not suitable for strong networking for UILs.

7. PHT: Networking is quite efficient since each member has a clearly defined thrust area to avoid competition. There are meetings among the four groups on UILs. Joint projects are set up depending on the required expertise (for example agricultural machinery, physiology). The centre also discussed networking with other consortia (CAB and PERCH).

[**Source:** Authors' interviews at the seven centres.]

A main feature of knowledge transfer between universities and industry is its interactive nature. Like in a game in which the ball is passed on amongst the players continuously, UILs are based on reciprocity and evolution. To a large extent direct personal contacts are necessary for that. However, to improve reliability, personal contacts should be complemented by more formalised modes of UILs, based on institutions rather than persons. Through this, long-term linkages and commitments of companies can be created; and legal security, contract enforcement, and credibility can be improved.

Discussion: Critical Success Factors for UILs in Developing Countries

Identification of Critical Success Factors

The empirical results on the seven centres under the Thai Higher Education Project have shown several innovative and inspiring approaches to link with industry. It is not possible to suggest a single best practice for all centres. Most approaches cannot be generalised, since they depend on path-dependent specialisations and research outputs with different commercial values. However, a common set of critical success factors have been identified during this project.

The following factors might be considered in further studies:

- Provision of multiple interfaces for interactive communication
- Definition of target industries/potential demand
- Evolutionary approaches to UILs/UILs as a continuous process
- Commitment of all key players that facilitate UILs
- Support to individual researchers
- Responsiveness to industry needs

- Spillover to research and teaching/cross-fertilisation
- Institutionalisation of UIL projects instead of scattered personal contacts

Can Successful UIL Strategies from Other Countries be Implemented at Thai Universities?

As the results have shown, the level of interaction and tangible contributions are still at a nascent stage. The main reasons for that, besides the relatively low age of the centres, are related to basic prerequisites for UILs, for example conscious strategies and commitments towards UILs, and reliable structures to carry out joint projects with external partners.

In general, comparable centres in industrialised countries are much better equipped with tangible (for example research equipment, qualified lecturers) and intangible assets (for example world-class research results, institutional capacities) to reach out to private-sector partners. Therefore, it is a common strategy in developing countries to turn to policy concepts that have proven successful in other countries. The centres have been asked to what degree their linking strategy has incorporated experiences from other countries and the degree to which it has been adapted to the situation in Thailand. Most interviewees mentioned the inconvenience they faced in attempting to copy UIL strategies from developed countries and different cultural backgrounds (mainly the US or Europe). They would prefer to develop a unique approach to UILs in the Thai context.

The most common arguments against formal structures for UILs brought up by the interviewees are:

- UILs in Thailand are solely based on deep trust-based personal relationships.
- Formal structures are perceived as a barrier to cooperation, not as an incentive (for example, strict intellectual property regulations before a project has been started).
- UILs should be formalised after trust has been built from working together on an informal basis.
- There is no tradition of donating money to universities or endowing seed money for joint research centres.
- UILs in Thailand should aim at the development of appropriate technologies for the Thai economy: it is as yet difficult to link them with excellence in research.

However, experiences with success stories and failures to facilitate UILs from other countries should be taken into account. It would be beneficial to narrow the credibility gaps between universities and the public sector, which would happen if the legal structures and procedures of the seven centres and of Thai universities in general were adapted to industry needs, that is, clear regulations on responsibilities, sharing of costs, and so forth.

Overview of Measures to Monitor UILs from Different Perspectives

Based on the examples of the seven centres and their efforts to build up additional capacities for UILs, a set of measures has been developed to evaluate their progress. These measures are expected to be suitable for similar centres or university departments in other higher education systems as well. The measures go far beyond traditional quantitative indicators (number of projects, amount of funding from industry), which might especially fall short when it comes to reflecting UIL performance in developing countries properly. Intangible measures seem to be more efficient in capturing the variety of UIL activities in different fields of science and with different kinds of stakeholders. Monitoring efforts should be based on surveys with the respective research units and their major stakeholders. The results should be discussed among all members of the unit and integrated within its overall development agenda.

Based on our survey, six distinct perspectives on UILs have been identified:

- *Testimonies from people who benefit from the outcomes*: Satisfaction of industry partners, duration of partnerships, follow-up projects as an objective measure of satisfaction.
- *Outcome perspective*: What kind of output did the industrial partner receive? In what ways have the outcomes been implemented or applied? What impact did the research have on the company in terms of its earnings, product development, efficiency and productivity?
- *Evolutionary perspective*: How is industrial funding developing on a year-by-year basis in each single centre? A cross-sectional analysis among the centres for a single year might be insufficient because of inherent differences in UILs among scientific disciplines and industrial sectors.

- *Normative perspective*: Who benefits from UILs (big companies or the people)? How many companies/farmers are using the results?
- *Macroeconomic perspective*: What percentage of the production is affected?
- *Market perspective*: How big is the market potential of the results?

Conclusion

The results of this article indicate that UILs in Thailand are still weak and fragmented. The HEDP has without doubt helped to upgrade the academic capabilities of the seven centres in post-graduate education and research. However, the implementation of UILs in the seven centres remain limited to a few cases of best practice. This is also true when it comes to income generation by UILs, and a shift towards academic entrepreneurship. Nevertheless, by studying the rich and unique experience of the HEDP, a set of critical success factors has been identified, which is potentially useful for the Thai higher education system as a whole and other developing countries at a similar stage of technological and economic development.

Institutionalisation of UIL

Fostering the institutionalisation of UIL projects and tackling related legal issues is a major policy advice arising from this project. Institutionalisation of UIL projects is critical to improving trust and credibility among the partners. In contrast, the interviewees unanimously emphasised that formalised approaches towards UILs are not suitable for the Thai context. This statement is expected to hold true in other developing countries as well. However, this appraisal should not be confused with the need to run industrial projects with proper project management after contacts have been established on a personal basis—which is indeed the most efficient way to start UILs, even in Western countries. Systematic structures offer legal security for partners and can be seen as a clear incentive for private companies to commit more financial resources to UIL projects. Important topics that have to be covered are:

- objective, target and scope of the project;
- responsible contractual partners and staff;

- terms of payment;
- duration of the project;
- ownership of intellectual property rights;
- confidentiality agreement;
- legal remedies.

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