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Barriers against the Transfer of Knowledge between Universities and the Industry in Newly-industrialised Countries – an Analysis of the Regional Innovation System of Bangkok

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Abstract: This paper presents empirical evidence on university-industry relations (UIR) and knowledge transfer in the regional innovation system of Bangkok and broaches the issue of adapting well-established concepts for the analysis of innovation processes in newly industrialising countries. The potential for UIR is restricted due to 1) a weak and fragmented innovation system, 2) low technological and absorptive capacities in the industrial sector, and 3) slowly improving research capabilities in the scientific sector. Hence the level of UIR in the regional innovation system of Bangkok is mainly limited to occasional and personal modes. It is suggested to strengthen the knowledge transfer capabilities within both actors and to establish effective mechanisms for bridging institutional barriers between academia and industry.

Keywords: knowledge transfer, university-industry relations, innovation system, newly industrialised countries, Southeast Asia, Thailand.

Introduction and Statement of Purpose

Like many of the other so-called tiger states of Southeast Asia, Thailand succeeded in keeping its gross domestic product growing at a rate of 6 to 10 percent over several decades, thus rising to the status of a newly-industrialised country. Even after the Asian crisis, the economy swiftly returned to the path of growth. The reasons for the success of this process of economic recovery and industrialisation included, among others, the existence of a stable, liberal macro-economic framework and the exploitation of comparative advantages, particularly the relatively low cost of the factor of labour (Kraas, 1996; Schätzl 2000, 234f). Confronted by rising wages and increasingly stiff competition for foreign direct investment after the liberalisation of China, Thailand so far did not succeed to an adequate extent in advancing structural reforms aiming at more sophisticated knowledge-based technologies and enhancing the country's endogenous innovation potential. In technological terms, therefore, its growth remained a superficial phenomenon (Arnold et al., 2000).

In the future, acquiring or imitating foreign technologies alone will not be enough to enable enterprises to build up their own technological capabilities and produce innovations, so that they may hold their own in competition with enterprises from other, more advanced emerging countries. In the long run, success can only be assured by manufacturing companies, company-oriented service providers, and scientific as well as governmental institutions forming an efficient innovation system based on suitable institutional arrangements that permit joint interactive learning.

Within such an innovation system, research institutions and, more importantly, state universities represent essential sources of knowledge. By tradition, they produce qualified human capital as well as scientific knowledge. Moreover, the academic services they offer on the market either by themselves or in cooperation with business enterprises enable them to interact directly with other players within the innovation system, thus ensuring the transfer of knowledge between universities and enterprises.

Against this background, this article investigates the barriers that impede the transfer of knowledge between universities and enterprises in newly-industrialised countries, using the regional innovation system of Bangkok as an example. The following hypotheses will be discussed theoretically and analysed empirically:

- Unlike the fully-formed innovation systems of the industrialised countries, fragmented innovation systems in emerging countries impede the transfer of knowledge between universities and enterprises.
- Although the industrial sector in Thailand is growing dynamically in quantitative terms, no corresponding improvement in technological capability has resulted so far.
- Structural changes in the scientific sector failed to keep pace with the dynamism of the economy; university research as a whole is too remote from technology.
- Because of the different specialties of the two sectors, the potential for cooperative relations between universities and enterprises is low at the moment.
- Cooperative relations between universities and enterprises are weak even within the regional innovation system of Bangkok.

Transfer of Knowledge between Universities and Enterprises in Newly-industrialised Countries

Today, regional-innovation researchers largely agree that new products, production processes, and forms of organisation are launched on the market as the result of an interactive process (Kline/Rosenberg, 1986). A process of innovation implies a close mutual exchange between different departments within an enterprise (R&D, production, marketing, etc.), other enterprises (suppliers, customers, competitors), company-oriented service providers, public research institutions, and universities (Nelson, 1993; Lundvall/Johnson, 1994). Interactions between these players are guided by both formal and informal rules within a so-called innovation system (Edquist, 1997; Freeman, 2001). Because of the different geographical and sectoral reach of institutional framework conditions and innovation fabrics, innovation systems tend to interpenetrate at various levels – global, national, regional, local, and sectoral (Bunnell/Coe, 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. 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). For this purpose, universities had to abandon the linear innovation model they mostly pursued in the past and turn to more interactive action. Knowledge is no longer transferred by a one-way road leading from public research institutions to business enterprises but through a mutual exchange which also operates in the other direction (Cabo, 1999).

At the same time, enterprises find that the importance of university knowledge is growing because their parent economy is 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 cooperations. Universities and other public institutions may potentially act as partners in this respect.

New Forms of Knowledge Production

In recent years, new forms of knowledge production evolved that are designated as Mode 2 by Gibbons et al. (1994). Mode 2 is characterised by growing diversity in the localisation of research activities and the enhanced importance of interdisciplinary research. The interplay between universities, enterprises, and the state, all playing different roles in each innovation strategy, is called a 'triple helix' by Etzkowitz, a structure within which different spheres overlap and 'hybrid' organisations form increasingly (Etzkowitz et al., 2005). Examples include the establishment of technology-transfer departments at universities, the creation of incubators for technology-based enterprises, and the establishment of science parks or venture-capital enterprises. As the universities expand their entrepreneurial activities, their capability to transfer technology to enterprises increases as well, which leads to partial superposition of the functions of universities and enterprises in a process of innovation.

Innovation Systems in Developing and Newly-industrialised Countries

Innovation systems in countries like Thailand, where industrialisation was delayed, and in western industrialised nations differ in their R&D regime. The impact of these differences on the manner in which technology is transferred is significant. While R&D is now a crucial

competitive factor in the industrialised nations, the proportion of enterprises operating their own R&D activities is markedly lower in the developing countries. To operate their own R&D, enterprises in Thailand must enhance their own technological capabilities, for which they need well-trained human capital and a functional innovation system.

Absorption Capacities and Technological Capabilities in Enterprises

Much of the technological knowledge needed in developing countries is available in industrialised states. This is why innovation systems in developing countries crucially depend on obtaining access to transnationally available knowledge and capital. At the same time, enterprises and research institutions in these countries need to improve their absorption capacities to utilise fresh technological knowledge (Asheim/Vang, 2004; Cohen/Levinthal, 1990). Such absorption capacities enable enterprises to identify relevant university knowledge and translate it into company-specific competitive advantages (Rothaermel/Thursby, 2005).

In the past, many countries pursued the strategy of acquiring fresh technological knowledge through the import of capital goods, reverse engineering, or licensing agreements. Together with other states in Southeast Asia, Thailand pursued the strategy of attracting foreign direct investment by granting taxation privileges. In Thailand, however, the key objective was to create jobs rather than to improve the technological capabilities of local enterprises, as it was in Singapore and elsewhere (Wong, 1999). Yet technological capability-building is the key to product and process improvement. Building such capabilities often proves a difficult undertaking, and many companies failed in an attempt to catch up with technologically advanced competitors (Hobday, 1995; Bell/Pavitt, 1995).

University-industry Cooperation

There are many forms of university-industry cooperation, from ad-hoc consultation to the formation of research consortiums. 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 cooperation. Because of this, most of the relations entered into are informal and based on mutual trust (Knack/Keefer, 1997).

Nevertheless, even the importance of such isolated informal interactions should not be underestimated because 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 cooperation 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 have demonstrated that corporate technological endeavours may be supported but not substituted by governmental and academic activities (Nelson/Rosenberg, 1993).

Whether or not an enterprise is inclined to conduct R&D jointly with a university depends on certain specific characteristics, including the knowledge base of the enterprise in question, the technology intensity of its parent industry, and the corporate culture of innovation (Faulkner/Senker, 1995). Successful R&D cooperation calls for a balance of interests between individuals and organisations, each with its own specific capabilities, and each guided by different motivations (Johnson/Johnston, 2004).

Cooperation among players may take place at various levels – between individuals, groups, or institutions – and may differ in its geographical reach – local, regional, national, or international (Inzelt, 2004). Cooperative relationships may be effected through different transfer channels (consultation, licensing, contract research, joint research, spin-offs). The nature and intensity of cooperative relationships within a system of innovation crucially influences the processes that govern the generation, distribution, and application of knowledge (ibid.).

Project Background and Methodology

The Thai innovation system was first examined by German economic geographers in 2000 and 2002 within the framework of the Thailand R&D/Innovation Survey (TIS). Conducted in cooperation with local partners, this innovation survey followed the methodology used in similar projects implemented in eleven European regions within the framework of the DFG (German Research Foundation) programme 'Technological Change and Regional Development in Europe' (Schätzl/Revilla Diez, 2000) as well as in another DFG project

addressing regional innovation potential and innovative networks in Singapore and Penang, Malaysia (Kiese, 2004; Stracke, 2003). One of the essential conclusions of the TIS was that both in Thailand as a whole as well as in the metropolitan region of Bangkok, the level of corporate R&D activity is not only much lower than in the European regions investigated but also falls short of that prevailing in the reference regions of Southeast Asia (Kiese, 2003; Schiller, 2003). In Thailand, even multinational enterprises contribute much less towards the national innovation potential than in other regions of Southeast Asia (Berger, 2005).

Lastly, the DFG project 'Public Research Institutions in Thailand' investigated the extent to which Thailand's universities might contribute towards strengthening the country's innovation potential by cooperating with business enterprises. In the period from July to October 2004, the authors interviewed 72 department-level institutions at five Thai universities as well as 34 enterprises from the manufacturing sector, using partially standardised questionnaires. All enterprises and three of the universities interviewed were located in the region of Bangkok, while the remaining two universities were located in the north and the northeast of the country.

As much of the manufacturing industry of Thailand is located in the extended region of Bangkok, an analysis of the regional innovation system of Bangkok reflects the situation prevailing in Thailand as a whole in many respects. In this context, the boundaries of the extended Bangkok region (EBR+) follow the demarcation suggested by Schiller (2003) that was adopted by Kiese (2003). The EBR+ comprises Bangkok itself, the five provinces surrounding the Bangkok metropolitan region, the three provinces of the eastern seaboard region, and the neighbouring province of Ayutthaya towards the north. In 2003, 75% of the added value created by the manufacturing industry was generated in this region (NESDB, 2004). Moreover, all major political control centres as well as a large proportion of the country's training and research institutions are located in the region as well.

The Compatibility of Thailand's Economic and Scientific System

Economic Development

Before the Asian crisis, Thailand's economy expanded from 1990 to 1996, with the GDP growing at annual rates ranging between 5.9 and 11.2% (NSO, 2003). Having declined

swiftly immediately after the Asian crisis in 1997, Thailand's economy returned to the path of growth in 1999, expanding again at rates ranging from 1.8 to 6.1% (World Bank, 2005). This economic catching-up process went hand in hand with a profound structural change. Between 1981 and 2001, the share of agriculture in the GDP was halved, dropping from 21.4 to 10.2%. Conversely, the industry's share increased from 30.1 to 40.0% during the same period. This increase in the importance of the industrial sector is based on the consistently swift expansion of the manufacturing industry, which grew at an average rate of 5.8% from 1991 to 2001. Even within the manufacturing industry, structural changes are evident. Between 1975 and 1998, the share of the food, wood, paper, and other resource-based industries fell from 50% to 25%. During the same period, knowledge-based sectors such as medicine, computers, and computer accessories quadrupled their share from 3 to 13% (UNIDO, 2002).

Foreign direct investments (FDI) provided a major impetus for Thailand's economic development, growing markedly from the mid-eighties onwards. Next to domestic technological activities, FDI play an important role in promoting the spread of technological capabilities, given adequate absorption capacities among local enterprises (Dhanani/Scholtès, 2002; Wu, 2004). In the beginning, foreign capital was mostly invested in the primary, steel, and petrochemical industries as well as in infrastructural projects (Brooker Group, 2002). In the nineties, investments began to focus on more knowledge-based sectors such as hard-disc production. Even now, however, these industries largely depend on imports of purchased materials and services. Thailand's specialty is assembling rather than manufacturing these products.

R&D in the Economy

The development of technological capabilities failed to keep pace with the swiftness of industrial development and structural change. Throughout the nineties, the share of R&D expenditures in the GDP stagnated at 0.10 to 0.15%. An increase to 0.26% was logged only very recently (2002) (NRCT, 2004; IMD, 2004). Western industrialised nations as well as emerging countries in Asia, such as Korea, Taiwan, and Singapore, spend as much as 3% of their GDP on R&D. Although the share of privately-financed R&D grew from 11% in 1997 to around 40% in 2002, more than half of Thailand's R&D expenditures are still financed by public funds (ibid.).

Previous studies showed that corporate technological capabilities in Thailand are low compared to those of other Asian countries (Hennemann/Liefner, 2006; Kiese, 2003). The innovation activities of Thai enterprises focus on the acquisition of machines and equipment, on design, licence purchases, and training rather than formal R&D activities. Similarly, the output of patents and innovations in Thailand is considerably lower than in other countries of Southeast Asia. One important reason for the low level of corporate R&D activity is a prevailing lack of scientifically and technically qualified human capital (World Bank, 2005).

Research and Development in the Science System

Thailand's science system is comprised by 24 state universities conducting graduate as well as postgraduate research and teaching (MUA, 2002). Next to these, there are 54 private universities as well as a multitude of universities of applied sciences, most of which specialise in Bachelor studies (Krongkaew, 2004, 2). Extramural governmental research is concentrated in four research institutes belonging to the National Science and Technology Development Agency (NSTDA). In addition, some ministerial departments operate their own minor research facilities.

As in many other developing and emerging countries, a major proportion of the R&D work conducted by state institutions and universities is in applied research (NRCT, 2000, 2004). More recently, universities have been expanding their R&D activities, particularly in the field of basic research. The recent increase in corporate R&D expenditures is mainly due to enhanced experimental development activities. The marked application orientation of research in the public sector and the growing development activities in the corporate sector might increase the knowledge transfer potential. However, as R&D volumes in Thailand remain low in absolute figures, any funds available need to be focussed on and employed in no more than a few areas.

(insert Table 1 about here)

A breakdown of R&D expenditures by scientific fields shows that the state, the universities, and business enterprises specialise in noticeably different fields (cf. Table 1). While universities traditionally cover a wide range of research, government R&D focuses on agricultural sciences. The increase in engineering R&D on the part of the enterprises is

duplicated to some extent in the public research sector. University R&D, on the other hand, shows a markedly slower structural change towards more application-oriented disciplines. Universities only spend somewhat more than one fifth of their R&D budget, usually low in the first place, on engineering sciences. In terms of human resources, public R&D presents a similar picture, the consequence being that, considering the input in the public research sector, technology-related fields of science that might be of interest to business enterprises are underrepresented (NRCT, 2004).

The output of the science system is commonly analysed on the basis of bibliometric data. In this case, the analysis was performed using the multi-disciplinary database Science Citation Index (SCI) (for methodological constraints applying to SCI use, see, *inter alia*, Legler et al., 2000, 48f). For the period from 2002 to 2004, publications in Thailand were subdivided into five scientific fields.

In the last few years, Thailand's publication activity as registered in the SCI increased markedly. Between 1977 and 1990, the number of publications per year doubled for the first time, increasing from about 250 to more than 500. In 1998, more than 1,000 articles involving Thai authors were published in SCI journals, and the number of articles published rose beyond the 2,000 mark for the first time in 2003. Even this powerful growth, however, falls short of the performance of other newly-industrialised countries in Southeast Asia (NIW et al., 2002). Today, most Thai publications by far deal with medical subjects. On the other hand, the rate of expansion is greatest in engineering and natural sciences, while agricultural sciences are stagnating.

Specialisation indexes enable researchers to classify individual fields of science by their cross-border relevance. To this end, the percentage of national publications within a given segment is related to the corresponding global percentage figure. Then, figures are transformed so that resultant values range between -100 and +100. Positive values indicate that the degree of specialisation is above average.

(insert Table 2 about here)

Like some other second-generation tiger states, Thailand's degree of specialisation is highest in the agricultural sciences. There is, however, no discernible focus on any of the industry-

related engineering sciences that might be compared to those of other emerging countries. Yet it is remarkable that Thailand alone among the Asian emerging countries specialises in medicine and life sciences more than the average (table 2).

However, publications alone provide no indication of the technological benefits of scientific insights. It is patents that indicate whether scientific knowledge is being successfully translated into technology-related applications (NIW et al., 2002, 28). For Thailand, patent indicators may be dispensed with as the number of international patent applications still is too low. This shows that the growing number of scientific publications did not result in new technologies and patents as much as it did in the first-generation tiger states and elsewhere. Whether and to what extent this scientific output nevertheless provided impulses for technological development will be investigated in the following.

University-industry Cooperation in Thailand

The impact of the imperfect compatibility of science and the economy within the regional innovation system of Bangkok will be examined in detail on the basis of a characterisation of the actual scope of cooperation between universities and enterprises.

Thailand's university landscape is undergoing a profound change at the moment. Because of its elitist roots and the predominance of teaching, the university system was embedded in the innovation system only through its training function right up to the nineties. Academic services were mainly provided free of charge for governmental authorities. In recent years, government subsidies stagnated or declined, while universities had to meet more stringent requirements owing to increasing enrolment figures and other factors. There are long-term plans to convert all universities into autonomous institutions. This is why options of commercialising and opening up the transfer of knowledge through organisational innovations are being debated at many universities. At the same time, many professors were induced in the past to carry out informal projects of their own to enhance their personal income, as the wages paid within the university system are low (Kirtikara, 2001, 2004). Furthermore, the acceptance of change is affected by cultural factors. Thus, university teachers enjoy social privileges as public education is rooted in the Buddhist monastery system, and all university graduates are honoured by the King in person.

Characteristics of Cooperating Enterprises

In the corporate sector, a rethinking process began after the Asian crisis of 1997. It is true that most companies still procure technologies (e.g. machines and software) as well as production licenses from providers abroad. On the other hand, relatively small local enterprises in particular are now unable to pay foreign consultancy firms because of the massive devaluation of the Thai currency, the Baht. Their interest in utilising new services offered by the universities has grown correspondingly.

As discussed in the theoretical literature, not all enterprises are equally receptive towards cooperating with universities and research institutions (Bell/Pavitt, 1995). As Fig. 1 shows, these differences are distinguishable in Thailand as well. Most of the universities' cooperation partners come from the manufacturing industry. Within this heterogeneous sector, it is mainly the companies that manufacture food and kindred products that cooperate with universities. Cooperation with enterprises from the textile and primary industries is very limited, despite the great importance of these sectors in Thailand. However, many of these companies lack the requisite capacity to absorb external knowledge. The chemical industry as well as the mechanical and electrical engineering sectors are dominated by relatively large enterprises whose inclination to cooperate is generally low. However, the first and last-named industries are dominated by local enterprises and foreign companies, respectively, which explains why the proportion of cooperating enterprises is different in each. Enterprises in which foreign owners hold majority shares tend to use sources of knowledge in their respective home countries. Small and medium-sized enterprises (SMEs) cooperate considerably more frequently with research institutions than bigger companies.

(insert Fig. 1 about here)

Corporate Requirements Regarding University Cooperation

The requirements applied by companies to cooperations with universities are often the same they would habitually apply to cooperations with other enterprises. They include, for instance, compliance with project completion deadlines and exclusive rights to utilise the results of cooperation. This calls for fostering a relationship of mutual trust between the partners. In addition, differences between various enterprise types can be distinguished. Multinational

enterprises frequently use cooperation to gain access to university graduates and influence the content of their training. SMEs, on the other hand, frequently expect cooperative projects to support them in the development of products and processes.

Forms of Cooperation

The theoretical debate emphasises that, while there is a multitude of ways in which universities and enterprises may interact, only a few cases go beyond mere individual contacts and involve genuine research work (Inzelt, 2004). Most cooperation projects in Thailand merely involve informal and personal contacts as well as services that do not include detailed research. There are some cases in which turnkey research results were either sold outright or licensed to business enterprises. Cooperations resulting from teaching play a certain role. Contract or joint research is confined to a few projects. Table 3 depicts the differences that exist between several fields of science.

(insert Table 3 about here)

A comparison of the forms of interaction prevailing in the different target sectors of cooperation shows that more recent industries, such as mechanical and electrical engineering as well as the chemical and pharmaceutical industry, tend to prefer research-oriented forms of cooperation, whereas traditional branches, such as the food, textile, and primary industries, predominantly use consultation services that relate to human resources. The mechanical and electrical engineering industries are the only ones in which 30% of all projects involve joint and/or contract research. One tenth of these projects result in joint patents, and researchers are beginning to plan the establishment of spin-offs. In the chemical and pharmaceutical industries, straight licenses on university research form the most important pathway of knowledge transfer, being used in more than two thirds of all projects. Moreover, these are the only industries in which long-term transfers of personnel between enterprises and universities are of any significance, being implemented in more than one fifth of all projects. Enterprises that do not belong to the manufacturing sector predominantly use consultation and further education services offered by universities. The high proportion of linear transfers (mainly through licensing) suggests that scientific capabilities in the health science sector are not reflected in the corporate sector. Obviously, the absorption capacity required for interactive cooperation is lacking.

(insert Fig. 2 about here)

The Regional Reach of Cooperation

One point of particular geographical importance is the integration of cooperations within the regional innovation system of Bangkok. Cooperation patterns differ markedly, depending on the location of the university in question (cf. Fig. 2). In regional terms, the cooperations of all Bangkok universities are concentrated in the EBR+. This trend is less marked in the light industry as well as in sectors outside the manufacturing industry. Likewise, universities located away from Bangkok find most of their partners in the extended Bangkok region, particularly in the mechanical and electrical engineering sectors. As regional partners are especially hard to find in the chemical and pharmaceutical industry, they tend to look for cooperation partners abroad. In part, this is due to the predominant influence of health sciences at Thai universities.

Typical Cooperation Obstacles

Interviews with players about the cooperation obstacles perceived by them led to relatively profound conclusions about cooperation barriers. It is obvious that most of the obstacles named at universities relate to the corporate side (cf. Fig. 3). In interviews with enterprises, most of the defects addressed were on the university side. This game of claim and blame shows clearly that in many cases, cooperation partners do not understand each other's specifics.

(insert Fig. 3 about here)

Professors blame enterprises for not being prepared to cooperate because they distrust the universities and are unwilling to pay in advance for uncertain research results. Moreover, there are many areas in which suitable partners are hard to find because many Thai enterprises still have no R&D activities of their own. The survey of the corporate sector showed that enterprises with advanced technological capabilities find it similarly hard to identify suitable partners at Thai universities because of the prevailing lack of material and human resources. This confirms that the two sectors specialise in different things. On the one hand, there are

many enterprises whose ability to absorb the results of university research is insufficient, while on the other, the universities are not yet equipped to offer adequately qualified results to large or multinational enterprises.

Within the universities themselves, professors as well as entrepreneurs would like to see bureaucratic processes simplified and rules for cooperation projects formulated clearly. This might help to resolve time- and interest-related conflicts between the academic core competences of research and teaching on the one hand and the provision of external services on the other. At the moment, these fundamental problems relating to the support of cooperations are more significant at the universities than the creation of specific incentive systems.

Summary

Within the regional innovation system, the scope of R&D and innovation activities by all players is markedly smaller than in the advanced emerging countries of Asia. This fragmentation reduces the potential for interaction among innovative players. More recently, however, R&D expenditures have been increasing, especially in the corporate sector. On the other hand, less than one fifth of the technologically-advanced, innovative enterprises describe themselves as cooperating intensely with universities. Corporate cooperation potentials are distributed differently among different industries and depend on corporate characteristics. Companies located in Bangkok are most receptive towards cooperating with universities, whose importance in the corporate process of innovation begins to decline in the neighbouring provinces.

Thai research institutions mainly specialise in applied research. The more technology-related engineering sciences, being underrepresented in comparison with other emerging countries in Asia, 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 facilities at universities and research institutions will reach a level of research high enough to render them interesting to large or foreign enterprises. Cooperation with SMEs, which is less research-intensive, is hampered mainly by defective absorption capabilities and financial capacities. As research expands in the sector of science, the potential supply of scientific

services is improving slowly. New incentive systems have induced some universities to begin trying harder to commercialise their research. Further investigation will be required to identify the impact of these changes on the universities' commercialisation strategies as well as on the transfer of knowledge within the innovation system.

At the moment, most cooperations between science and the economy that are to be found within the regional innovation system of Bangkok are based on personal contacts and operate without an elaborate institutional framework. Genuine research cooperations are lacking. The differences that exist in the cooperation potential of individual industries and fields of science are reflected in the intensity and quality of cooperation. There is a lack of confidence-building communication among players. For a final evaluation of the cooperation scene, the data now available will have to be analysed further.

All in all, the cooperative relations maintained by universities are strongly embedded in the region. This equally applies to all industries within the regional innovation system of Bangkok. Universities located at the periphery mainly seek to cooperate with local SMEs. As far as the more modern sectors of the economy are concerned, however, the lack of regional partners forces them to look for suitable enterprises either in Bangkok or, given adequate excellence, among companies abroad. Within Thailand as a whole, the regional innovation system of Bangkok offers the best opportunities for cooperation between universities and enterprises.

Action Recommendations

Enterprises in Thailand should step up their endeavours to build their own technological capabilities so as to achieve the competence to cooperate. At the same time, the content of university teaching and research should be harmonised with corporate requirements more than hitherto. At the moment, absorption-capability building is greatly hampered by a lack of adequately qualified university graduates.

To facilitate the establishment of cooperative 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, for instance, the success of their cooperative relationships.

Cooperation is greatly impeded by a lack of mutual trust among the players. Termed exchanges of employees between enterprises and public research institutions might be a way of building mutual trust and learning more about the others' research needs.

Enterprises located at the periphery find it even more difficult to build up cooperative relationships because the innovation system concentrates on Bangkok. To enhance Thailand's competitiveness as a whole, steps to improve cooperative relationships should not be confined to Bangkok alone.

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Tab. 1: R&D expenditures by scientific fields (1997)

Scientific fields	Total		Staat		Universities		Enterprises	
(Total in Mio. Baht)	11.065	(4.811)	5.020	(2.667)	1.950	(1.897)	4.095	(247)
Natural sciences	6,8%	(19,2%)	7,4%	(24,1%)	13,2%	(13,4%)	3,1%	(11,8%)
IC-technologies	3,7%	(2,3%)	5,3%	(1,3%)	3,6%	(3,5%)	1,7%	(2,9%)
Engineering sciences	41,9%	(12,7%)	16,8%	(6,9%)	21,0%	(18,6%)	82,6%	(28,8%)
Health sciences	7,9%	(15,3%)	10,5%	(19,1%)	14,1%	(11,4%)	1,8%	(3,5%)
Agricultural sciences	28,8%	(30,3%)	50,4%	(42,3%)	19,9%	(14,9%)	6,7%	(19,5%)
Social sciences	9,4%	(18,8%)	8,8%	(5,7%)	22,9%	(35,7%)	3,7%	(30,4%)
Human sciennces	1,5%	(1,4%)	0,9%	(0,6%)	5,4%	(2,4%)	0,4%	(3,1%)

Source: NRCT 2000; 2004

Tab. 2: Specialisation of newly-industrialised country in Asia by scientific fields¹

	agricultural sciences	medicine	engineering sciences	life sciences	natural sciences
Thailand	+47	+22	+11	+26	-51
1st Generation NICs²	-38	-34	+71	-26	+41
2nd Generation NICs³	+81	-36	-14	-37	- 2
China	-64	-88	+47	-72	+71
Indien	+45	-80	+ 8	-63	+40

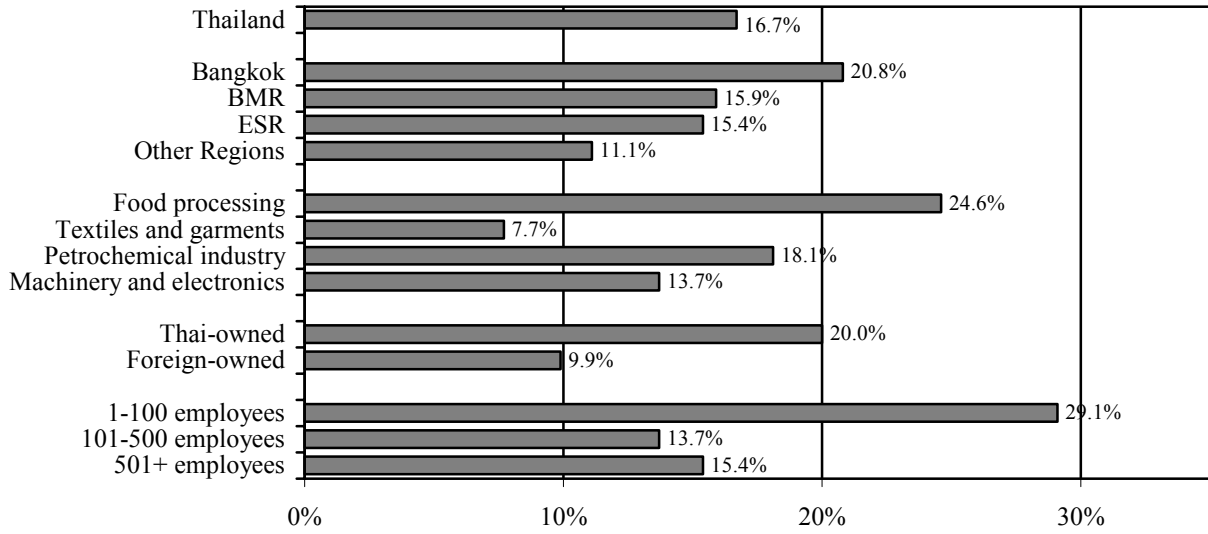
¹ Data for Thailand: 2002-04; other countries 1996-2000; ² Korea, Taiwan, Singapur, Hong Kong; ³ Malaysia, Philippinen
Source: own calculation folowing SCI EXPANDED; NIW et al. 2002

Tab. 3: UIL modes by fields of science (above 5 % response)

Form of interaction	Total	enginee- ring sciences	natural sciences	agri- cultural sciences	health sciences	other
Advisory services	49.3%	52.2%	34.5%	64.3%	35.3%	56.3%
Technical services	34.6%	45.7%	20.7%	50.0%	23.5%	12.5%
Informal meetings and conversations	19.9%	13.0%	24.1%	21.4%	23.5%	25.0%
Issue of licences	16.9%	6.5%	10.3%	14.3%	64.7%	12.5%
Industrial contract research	15.4%	23.9%	24.1%	3.6%	5.9%	6.3%
Selling of products	8.1%	2.2%	13.8%	10.7%	17.6%	-
Joint conferences	8.1%	6.5%	3.4%	14.3%	-	18.8%
Further training programs	8.1%	6.5%	3.4%	10.7%	5.9%	18.8%
internship	7.4%	15.2%	3.4%	7.1%	-	-
Joint research	6.6%	13.0%	6.9%	-	5.9%	-

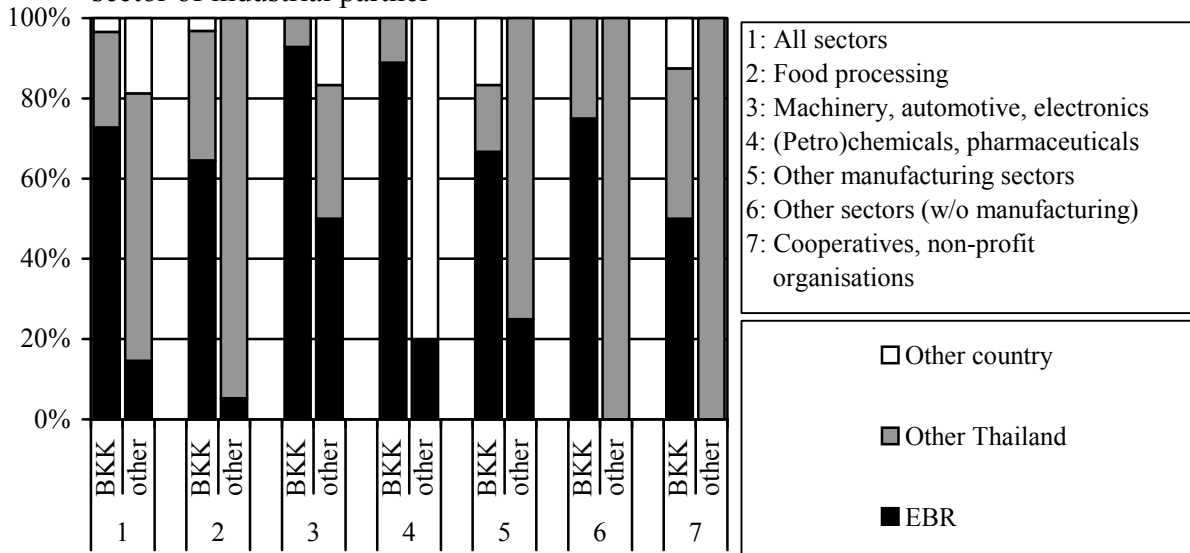
Source: own calculation, multiple answers possible

Fig. 1: Share of innovating companies with intensive linkages to public research organisations in Thailand, Singapore und Penang/Malaysia



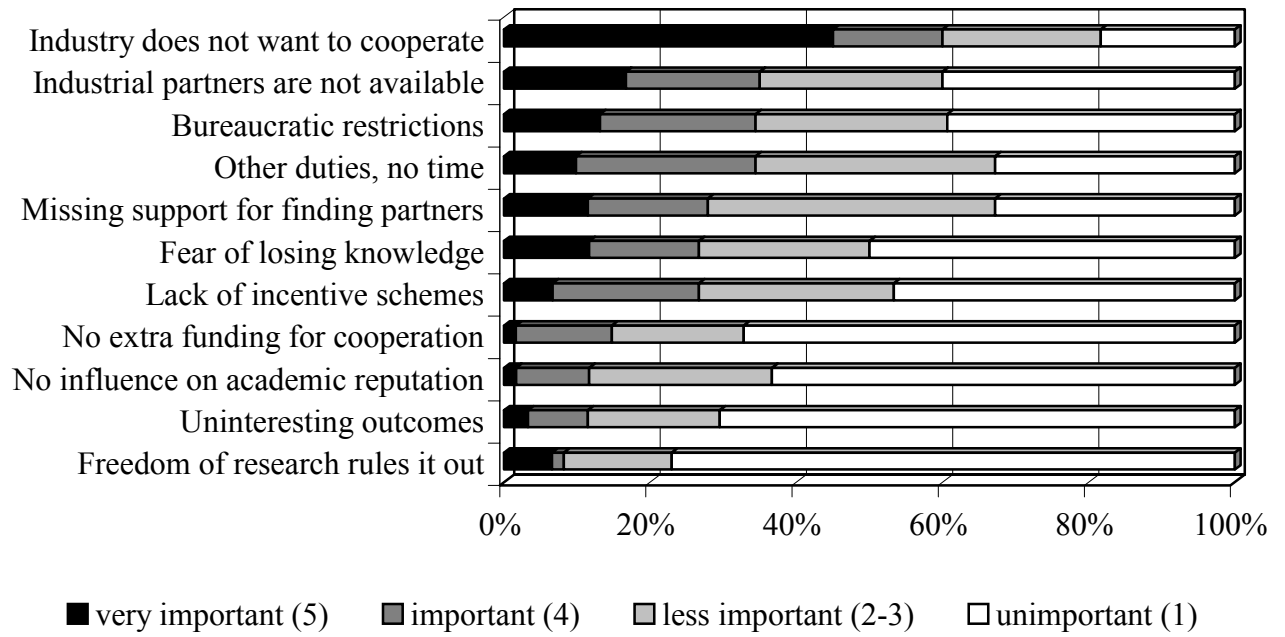
Source: Thailand R&D/Innovation Survey 2002; Singapore und Penang State Innovation Survey 2000

Fig. 2: Regional distribution of university-industry linkages by location of university and sector of industrial partner



Source: based on own survey

Fig. 3: Limitations for university-industry linkages at Thai university departments



Source: based on own survey