Towards a Knowledge Economy in Thailand

Office of the National Economic
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(Thailand)

The World Bank

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Executive Summary

Sustaining strong economic performance by enhancing productivity through innovation, buttressed by higher rates of private investment, is an objective for the Thai economy and is reflected in the country's Tenth Economic and Social Development Plan. This objective needs to be made central and urgent if Thailand is to join the ranks of the high income countries within the next two decades. A handful of economies in East Asia, including the Republic of Korea, Taiwan (China) and Singapore, have already made the transition to high levels of per capita income. For Thailand to emulate some of the more successful economies in the region, it must embrace the challenge of achieving rapid growth led by gains in productivity. The measures proposed in this report and the further analytic work which it highlights should help Thailand reach this objective in an increasingly competitive global environment.

Increasing Productivity

Between 1977 and 2004, the increase in total factor productivity (TFP) contributed about one percentage point to Thailand's aggregate growth. The source of much of this was and remains the transfer of workers from low productive jobs in rural areas to more productive urban employment mainly in the manufacturing sector. However, total factor productivity growth within the manufacturing sector has been limited. As 42 percent of Thailand's labor force is currently employed in the primary sector, the transfer of workers from rural areas to more productive jobs will continue for some time. So long as higher value added jobs continue multiplying this productivity bonus will persist. But the trend growth from this source is heading downward. There is potential for raising the skill-level of workers, but further progress will depend upon improvements in the quality of primary and secondary education in rural areas (World Bank 2006) and in tertiary education in urban areas. Higher levels of investment will help, but not as much as in the past when capital-to-labor ratios were lower. Thailand has joined the ranks of middle-income countries and most of the gains in productivity will have to come increasingly from innovation and efficiency improvements within the manufacturing and services sectors. Such innovations can take many forms. While process and product innovation tend to attract the most attention, organizational innovation and innovative institutions will also play significant roles. Efficiency gains will accrue mainly from intrasectoral reallocation of resources and the redistribution of resources between urban industry and urban services.

Comparative experience from East Asia would suggest that innovation and advances in efficiency could contribute one percentage point or more in terms of additional TFP to the increase in GDP. For example, Korea experienced average TFP gains of 1.1 percent per annum during 1975-2000 (see Table 1) even though the country is past the stage when the migration of labor to the urban sector served to enhance productivity. TFP growth in Taiwan (China) during the same period was even greater at 2.4 percent, while Singapore's TFP rose by 1.8 percent. Meanwhile, China achieved TFP growth rates of 3.9 percent per annum during 1975-2000 as during this period it still benefited substantially from the migration of labor out of agriculture into the manufacturing sector.

Table 1: Sources of Growth in East Asian Economies, 1975-2000

(Average annual percentage change)

Region/ period	Output	Output per worker	Physical capital	Education	Factor productivity
China	8.8	6.9	2.5	0.4	3.9
Indonesia	5.8	3	2.4	0.5	0
Korea	7.3	4.8	3	0.7	1.1
Malaysia	6.9	3.7	2.2	0.6	0.9
Philippines	3	0.2	0.8	0.4	-0.9
Singapore	7.7	4.4	2.1	0.5	1.8
Thailand	6.5	4.1	2.1	0.5	1.4
Taiwan (China)	7.8	5.5	2.6	0.4	2.4

Source: Bosworth and Collins (2003a). Updated estimates for China as well as for India can be found in Bosworth and Collins (2007b)

In other words, at Thailand's current stage of per capita income and industrialization, it is realistic to assume that a third of the growth in GDP could come from advances in innovation across a wide spectrum of activities. In Thailand's case it is also realistic to assume that industry, which accounts for 44 percent of GDP, is likely to be the principal source of gains in productivity growth in the next five to ten years. Although the Government's recent adoption of the Productivity Master Plan has appropriately raised the profile of this issue, if progress is to be achieved then further immediate action will be needed in several areas. For example, business services could become an increasingly important source of innovation as their share of GDP and employment progressively expands. This is because business services are able to fully harness the potential of IT and related services in order to become more closely integrated into the global trading system. But that will require a greater openness to international services when compared with what exists at present.

Moreover, because the private sector is the dominant force in both manufacturing and business services, it must inevitably take the lead in promoting innovation. In an open and competitive environment firms have every incentive to raise their productivity by absorbing and developing new technologies and pursuing opportunities for innovation, especially in the face of rising competition. Nevertheless, the government's contribution to innovation by private firms and to productivity growth will remain substantial through policies, institutions and investment in human capital and R&D. The government needs to work together with the private sector to maximize the economy's potential for innovation. It is through such cooperative efforts that a highly efficient and productive national innovation system can be forged in order to effectively support the actions of producers in the private sector.

Indicators of Competitiveness

According to a number of international business indicators, Thailand still lags well behind Singapore, Malaysia, Taiwan (China) and Korea. For example, in the World Economic Forum's Competitiveness Index for 2006 Thailand was ranked in 35th place, Korea and Malaysia whereas were in 24th and 25th place, respectively. Meanwhile, IMD's global competitiveness ranking put Thailand in 32nd place in 2006, down slightly from 30th place 2003, while the World Bank's "Doing Business Survey for 2007" ranked Thailand in 18th place based on the ease of doing business among 175 economies worldwide. Another source, AT Kearney's Global Services Location Index for 2005, ranked Thailand in sixth place amongst 40 countries. Finally, the World Bank's Knowledge Economy Index gave Thailand a rating of 4.88 in 2006 as against 8.12 for Taiwan (China) and 8.20 for Singapore. This mixed picture reflects in part Thailand's weaknesses in the areas of technology development and innovation. The four main factors that are responsible for this situation are discussed below.

Constraints on Technology Development

Firstly, businesses are insufficiently motivated, unwilling or unable to invest substantially in R&D, whether in-house or through outsourcing, in order to improve/diversify their products or introduce process innovations on a routine basis. This is particularly true in the case of medium and large-sized firms that are responsible for most technology development in Thailand. This might be a function of Thailand's level of development, the ease of access to codified technology and to technology embodied in equipment. It might be the result of flaws in corporate strategies arising from shortsightedness, the ownership structure or firms' managerial deficiencies. It might also be a logical response to a relatively sheltered domestic environment which blunts competitive pressures (Ariyapruchya, O-lanthanasate, and Karnchanasai 2006). Whatever the reasons, Thai firms do not yet see innovativeness as critical to their competitiveness and profitability. Thailand's policy framework – openness to competition in goods and services, financial sector openness and labor market flexibility – must all be adequately supportive of firms that pursue innovation. While macro stability and the openness of markets for goods have been favorable, there is still a lot that could be done in the areas mentioned above (World Bank 2006c, 2006d) to improve Thailand's policy framework. Secondly, numerous government programs to encourage R&D, technology absorption and technology development have so far failed to produce the desired effect. Thai spending on R&D hovers around 0.26 percent of GDP, but the share of R&D spending by private firms is small. In addition, the number of personnel engaged in R&D is low and few Thai companies file for patents. There is also little evidence of movement up the value chain by Thai companies in the key manufacturing sectors of the economy. This might be related to the forcefulness and consistency of government initiatives, the strength of the incentives offered, as well as the direct budgetary allocations for research and how effectively they are distributed across a few targeted programs. It might also be the case that these programs lack a sufficiently supportive overall policy framework, as noted above. To overcome these factors it is important to synchronize both government investment programs and policies.

Thirdly, the supply of Science and Technology (S&T) workers as a percent of total university graduates is below that of Thailand's principal competitors, i.e. economies at comparable levels of income as well as some lower income competitors. But perhaps more serious, are the deficiencies in the training of these workers, which reflects the quality of Thailand's secondary education (World Bank 2005b) and its universities, even the leading ones. None of Thailand's tertiary institutions are ranked among the leading universities of East Asia. Universities engage in little research and none have adopted a proactive entrepreneurial approach in exploiting their research findings or in engaging with the business community. Thus, linkages between universities and industry remain limited and the tertiary education system is contributing less than it could towards the strengthening of the innovation system. Thailand also lacks the benefits of having world-class research institutes which could serve as conduits for technology from abroad, as well as the means of developing technology indigenously in specific areas that would help create local industrial clusters.

Lastly, while technology development in Thailand has benefited from globalization, this mainly comes in the form of imported technology embodied in equipment. Foreign direct investment (FDI) by multinational corporations (MNCs) has transferred amazingly little tacit knowledge and technology through vertical or horizontal spillovers. Only a handful of companies have set up research establishments in Thailand and the scope of the research being done in Thailand is limited. Thailand has a substantial diaspora of S&T workers in the U.S., in Taiwan (China), Singapore and Malaysia. However, this diaspora has not been a source of local entrepreneurship, venture capital, angel investors or a vehicle for the technological leadership unlike their Chinese and Indian counterparts. Moreover, Thai companies are not making use of the globalization of research to exploit their capacity for technology development worldwide through outsourcing. Likewise, Thai firms have yet to take the lead in forming local consortia or joint ventures with foreign firms to pool their research assets for the purposes of joint research. Nor for that matter are Thai researchers actively collaborating with academics worldwide and with researchers in foreign corporations to produce co-authored papers or research reports.

Strengthening the Knowledge Economy

In the light of the initiatives taken and the experience gained over the past 15 years, the medium-term need is for a focused strategy backed by strong leadership from both the government, as well as from the business sector. Joint and coordinated efforts are needed to embed technological change into the urban industrial economy and "routinize" the process of innovation. A sustained and consistent emphasis on technology by the government backed by effective leadership and policies, can appropriately drive home the importance of technological dynamism for Thailand's economic future. The effectiveness of such efforts can be seen from Korea and Taiwan (China) where an unwavering commitment to developing a knowledge-based economy contributed to both countries' technological ascent from a modest initial base of natural resources and human capital.

Volume and Quality of Education

The poor quality of education and the shortages of industrial skills are problems which Thailand cannot avoid tackling forcefully if the intention is to evolve into a knowledge economy on par with other leading East Asian economies. Our focus in this report is on tertiary level institutions, but it must be remembered that the acquisition of S&T skills rests on the foundations laid by primary and secondary education. If these are weak, then it requires more resources and effort at the tertiary level to remedy earlier deficiencies, as well as a greater emphasis on and investment by employers to bring workers up to the desired standards of technical proficiency. The most common complaint of Thai employers are that skilled workers are in short supply, that workers are insufficiently computer and IT literate, and that few have a working knowledge of English (World Bank 2006e). The high wage premium offered for such skills does point to shortages—those with college degrees command starting salaries much higher than secondary school graduates.

Skills Development

The tight labor market for skilled workers is not a new development. Employers complained of such shortages even as Thailand shifted from the production and export of resource-based low-tech products to the assembly and manufacture of many medium and higher tech items. Similar problems have been encountered by producers in Korea and Taiwan (China). Increasingly, these same problems are being encountered by firms those countries that are Thailand's main competitors, namely China, Malaysia and Vietnam. Where firms are determined to compete they increase their in-house spending on training, more fully utilize the training facilities and subsidies offered by the both government and by private sector providers and to pursue personnel management policies to retain their skilled workers. Similarly, through political channels business lobbies attempt to push measures to raise the outlay on education, as well as to improve its quality. Many countries find that such problems do not go away, even in the US where employers in a number of industries complain of the shortages of skilled workers. But firms learn to cope and to seek improvements. It is the use of 'voice' and initiatives by firms individually and collectively that leads to change.

Initiatives by the business sector in Thailand, including in the form of increased spending on training, greater utilization of public training facilities, as well as effective pressure through political channels to raise public spending on education (especially for S&T), are not commensurate with the perceived extent of the shortages. This was reflected in the 2004-05 NESDB-FTPI survey of 1,300 firms (World Bank 2006e). If Thai businesses are losing their competitive edge due in part to a shortage of skilled labor, then it must be asked why they are doing so little to remedy this. In other words, why have market forces failed to solve this problem? Although public action might be a partial answer this needs to be preceded by a deeper analysis of the shortage, its persistence and the manpower strategies of firms. To what extent are skills critical to their long-term competitiveness? If having a skilled labor force is important then what are private sector firms doing independently, through business associations, as well as through their lobbying of government agencies to alleviate the shortage of skilled labor? To what extent are individuals responding to market signals that communicate the demand for particular skills? These questions need to be studied further. Based on the conclusions that are reached, action can to be taken to correct the failure of the market to deal with these problems, as well as to improve the quality of the education services provided by the public sector.

Raising Spending on R&D

Leading Thai firms, which depend on exports for a significant share of their revenues, must recognize the business case for investment in R&D for the purpose of "embedding" technology development into their operations and basing their competitiveness more on innovation. Moreover, they must be convinced that the returns from R&D can be highly attractive and essential for future growth. In the absence of a clear perception of such a business case, the demand for R&D will simply not materialize and government investment and incentives will exert limited leverage.

In most cases the incentive to innovate is derived from competitive pressures. Firms tend to be knowledgeable about and keep close tabs on the activities of their competitors so as not to be late in introducing products based on new technology. This is clearly evident amongst Korean firms that identify competitors as the second most significant source of information. Innovation is also being rapidly integrated into the strategies of the leading Chinese and Taiwanese firms. Thai firms seem not to pay as much attention to their competitors' moves as yet, while domestic investors appear more concerned about external market competition and uncertainty.

Although Thailand's aggregate spending on R&D as a percentage of GDP is rising gradually from a low base, it is still the case that spending on R&D by the private sector remains modest. It has been repeatedly observed that Thai firms in the automotive, jewelry, food processing and electronics industries focus on labor intensive and lower technology areas (Kohpaiboon 2006Yusuf and Nabeshima 2006b) and thus rely more on labor cost advantages and lower overheads to compete. Few firms are attempting to move up the value chain by investing in R&D to stimulate innovation and enhance their technological capability. This will become increasingly important, especially as Thailand's labor cost advantage is likely to be eroded further by the continued appreciation of the Baht against leading foreign currencies towards the exchange rate levels seen before the economic crisis. One good reason for Thailand's relatively slow transition up the value-chain may be because Thai firms are able to compete and achieve their desired returns on sales without having to conduct research. In some cases, the technology they require is embodied in the equipment they purchase, supplemented by the support they receive from suppliers and buyers. But given the composition of Thailand's industrial base and its exports the volume and mix of research and its distribution among relevant entities is inadequate. Between 1990 and 2005, a combination of FDI and domestic entrepreneurship shifted the structure of Thailand's exports away from natural resource based products towards exports of electronic products, components, auto parts and engineered products. Such a structural evolution is desirable and should continue.

The widespread perception among government agencies and external observers is that Thailand is already or may soon find itself at risk of losing ground in key export subsectors because of insufficient technological capability. And for this same reason Thai firms might not be able to continue to diversify into new product areas.

Until recently it may not have been necessary for Thailand to invest much in R&D because the existing mechanisms for technology transfer were enough to achieve the required level of technological capability and growth. In fact, under these circumstances (i.e. with easy access to codified industrial technology and the considerable distance from the technology frontier) it could be argued that investing more in R&D might well have been wasteful in the past. However, for Thailand to remain a player in the industries where it is currently a leader and to offer a more sophisticated range of products and services in the future, the country will need to raise its technological capability to a higher threshold. Moreover, it may be necessary for Thailand to do so in the span of 5-7 years as its competitors in Asia and other parts of the world are clearly accelerating their own efforts to become more innovative. But just how fast Thailand can achieve this depends on how quickly it can raise it capacity to absorb a higher level of spending on R&D. There are significant first-mover advantages for technological leadership in many sub-sectors and market niches, especially for middle-income countries like Thailand (World Bank 2007). The stakes have thus been raised. For Thailand to remain an East Asian 'tiger' economy and to ensure that its people benefit from the global economy, it has to climb the ladder of technological capability relatively quickly.

Increased spending on R&D is a necessary step towards achieving such goals, and international experience indicates that on average both the social and private sector returns on such investment are high. However, spending on R&D needs to be coordinated with parallel efforts to augment a country's capacity to efficiently utilize the additional resources. To this end, both public and private entities need to institute and or improve their processes for planning and programming well-targeted research activities, as well as for evaluating R&D activities on a regular basis. For example, when research is of an exploratory nature and the likely outcome is highly uncertain then it would be better to proceed with small, pilot R&D projects. Successful ventures could be scaled up, others discontinued, thereby minimizing the waste of scarce research talent.

Links with Universities and Intermediaries

As countries master codified technologies in an effort to catch up, technological capability is becoming more dependent upon basic science and upstream, applied research. These are areas in which universities and dedicated research institutes have a comparative advantage and can add value to corporate research. But much depends on the quality and scale of these institutions, as well as the mix of incentives that influence collaborative research.

While it would seem desirable for the leading universities in Thailand to engage in research, it is an open question as to whether they should be actively induced to cultivate linkages with business, do contract research and consulting, as well as to seek to spin-off firms. Depending on organizational factors, the incentives offered and philosophy that is adopted, such policies might be neither desirable nor workable. Instead, it would be better to pursue further five sets of policies that to varying degrees are already being implemented in Thailand.

Firstly, universities in general and the leading public universities in particular, should be given greater autonomy to: a) manage their hiring strategies and pay scales; b) to compete with each other for students and teaching staff; and c) experiment with new technologies for teaching that make use of different combinations of research and teaching. In a word, universities should have more flexibility and be disciplined by competition.

Secondly, the government should gradually step up the funding for research facilities and for basic research at universities. This could include block grants, grants for specific programs, as well as scholarships for science, math and engineering studies for both Thai and foreign students as is already being done in Singapore. It might be far better to focus such funding on the leading universities and merge some of the specialized research institutions with the universities in the pattern practiced by France. The reason for this is that universities have the interdisciplinary range and the continual access to new talent. Also, universities are more likely to explore new technologies relative to specialized institutes which have an uneven track record in the region. Rather than thinly distributing funds across many entities, a better strategy for Thailand might be to concentrate research funding in a few universities in order to build “critical mass” in the form of high quality interdisciplinary research where the pay off is high.

A third step is to create science parks and incubator facilities adjacent to the selected universities so as to maximize the likelihood of spillovers and start ups, as well as to support such measures with generous incentives.

A fourth step is to make university–industry linkages more attractive for universities and firms by offering some grants to universities conditional on the university pursuing collaborative ventures with the private sector. These could be reinforced by tying some government procurement contracts, such as for IT, software and computers, to the condition that firms also engage with university researchers.

The fifth and final approach, variants of which have already been adopted in the U.S., the U.K., Canada, Korea, Israel and other countries, is to fund programs which help finance post-doctoral internship positions in participating firms. These public-private programs ensure that there are immediate employment opportunities for graduates, which give them a foot in the door and lessen the risks of unemployment. More importantly, because many of these schemes are subsidized – or the post-doctorates are paid relatively low wages – firms are in a position to benefit from an infusion of fresh research talent from universities which can energize their own research activities. They can also evaluate individuals before making them an offer for the longer term. Such programs are most appealing to firms in the pharmaceutical and biotech fields, as well as to developers of software. They are more likely to spur research in smaller firms which generally do less research and have a weaker research orientation. By providing a channel linking universities and private sector firms, such programs provide a means for diffusing technical knowledge. Additionally, they can induce larger companies with ongoing research to diversify their activities. For students enrolling in doctoral courses in science and engineering, these programs also provide a form of employment insurance.

Many companies, especially small and medium-sized enterprises, lack information on potential partners. They simply do not know which universities (or faculties) are engaged in relevant research activities that may be of use to them. Similarly, university faculties often lack first-hand knowledge of the technical constraints faced by private sector firms. Intermediary organizations can help bridge such gaps to stimulate university–industry linkages.

Intermediaries such as the Knowledge Integration Community (KIC) by the Cambridge-MIT Institute (CMI) recognize the fact that knowledge transfer can be multidirectional. Each KIC consists of representatives from universities, the business community and government agencies. If such a diverse composition of participants were to be included in the governing boards of universities this would enhance communication among the three parties (as in Singapore) and make universities more responsive to the needs of the business community.

In addition to the multidimensional nature of knowledge transfer, effective intermediaries recognize that much new knowledge is often tacit knowledge embodied in people and the transfer of such knowledge is difficult without interaction between researchers and the potential recipients of the new technology. Moreover, the absorptive capacity of the recipient firms is often essential for the transfer of knowledge to be consummated. Here intermediaries can help to identify firms that are doing their own R&D and are also actively seeking specific kinds of technology. Hence, intermediaries often help provide channels for interaction between the developers and user of technology.

In many cases, intermediaries also generate their own revenue streams and can benefit from partial public funding. This ensures the long-term viability of such organizations while also giving them time to raise funds from other sources.

None of the above policy proposals can make much of a difference overnight. But at least they would prime the pump and show that the government is serious about making a credible commitment to building Thailand's technological capability. As we noted earlier, success will depend on the business sector's demand for this capability and its readiness to work hard to strengthen it.

The Urban Context of the Knowledge Economy

Virtually all of Thailand's future gains in productivity arising from increased efficiency and innovativeness will occur in urban areas. Much of the development of manufacturing and services will also be concentrated in urban areas. Most of the research will be conducted in urban centers in connection with activities with an urban focus, and the linkages between universities and businesses will be forged in cities. Moreover, the extent to which urban areas contribute to economic performance will vary depending upon the location of the cities in question, as well as their size and how they cultivate and extend their dynamic comparative advantages. A strategic location, scale and agglomeration economies contribute to productivity. The size of cities is also linked to the level of innovation (World Bank 2007; Yusuf 2007a; Yusuf and Nabeshima 2006b).

As Thailand's premier city, Bangkok has the size, industrial diversity, locational advantages, as well as the concentration of tertiary level institutions which could serve as the foundation of an innovation system. The metro region accounts for almost 45 percent of the country's GDP, suggesting that its economic footprint is likely to remain substantial into the indefinite future. Thus, the efficiency and innovativeness of Bangkok's economy and its ability to harness potential agglomeration economies will profoundly affect Thailand's innovation system, competitiveness and economic performance. In other words, the efforts to raise productivity, to promote technological development, to strengthen the quality of university education and research, as well as to maximize spillovers, will all need to be pursued in close coordination with policies and institutions oriented towards urban development, in particular the development of Bangkok as a technology intensive economy. At the same time, considerations of equity and internal integration will require investments in secondary cities away from Bangkok. The trade-offs will need to be examined further, and future policies and public investments will have to be designed based on the findings of such examinations.

Conclusion

Promoting innovation as a key source of future TFP growth is a high priority policy objective. Other middle-income countries are racing to establish niches where they acquire technological leadership and scale-economies to drive productivity growth, as well as raise incomes. Thailand cannot afford to fall behind in this race, especially if it wants to avoid the fate of many middle-income countries in Latin America and Middle-East that have already experienced economic stagnation. Therefore, implementing such an agenda, as well as the need to conduct further studies (i.e. on tertiary education, urban development, etc.) as mentioned above, with a view to devising targeted policies for promoting an innovation and knowledge-based economy is taking on greater urgency. This is particularly true given the urban focus of a knowledge-based economy. The competition facing Thailand today is intense and the time for action is now.

Summary of Recommendations

Objectives	Recommendation
Improving the policy framework—openness to competition in goods and services, openness in financial markets, efficient labor market—to create a more favorable environment for firms' innovation	▪ Continue openness in goods, increase openness in services (especially financial services) and enhance the efficiency of the labor market
Improving the quality of secondary and tertiary education and building research capabilities in key universities	▪ Improve the quality of teaching and emphasis on research at leading Thai universities. Give importance to focused efforts, quality of staff, incentives, lab facilities, and funding. Further work in these areas is needed in order to make specific recommendations.
Enhancing the supply of science and engineering skills in particular and other technical skills more broadly	▪ Skill shortage (S&E skills, language and communication skills, etc.) is cited as one of the constraints that Thai firms face. Before investing in more facilities, the government needs to determine why firms are not providing training (via in-house, outsourcing, recruiting from outside, etc.), and why the market signals are not aligning the demand and supply of skilled labor. Further work in this area is needed in order to make specific recommendations.
Increasing R&D spending by firms and raising its productivity, using pilot projects, assessing the impact and return on R&D	▪ Providing conditions more conducive to R&D by private firms and MNCs, including a more competitive environment, provision of fiscal incentives, encouragement for inter-firm

before scaling up	collaboration on research, strengthening of major public research institutes, as well as incentives for foreign researchers to visit and participate in research.
Stimulating linkages between the business sector and key universities so as to encourage knowledge generation, its transfer and its use for germinating commercially viable technologies (i.e. pilot impact evaluation and scaling up cycle)	▪ Providing greater autonomy to universities to give them greater flexibility in a more competitive environment ▪ Increasing funding for research facilities at universities ▪ Creation of science parks and incubator facilities adjacent to universities ▪ Providing grants to encourage universities and firms to collaborate with each other. ▪ Providing assistance to place post-graduate students in firms for a period of time ▪ Building intermediary organizations so as to improve the information flow between universities and firms (and government).
Development of Bangkok as the driver of a knowledge economy in Thailand	▪ Knowledge intensive activities are more likely to multiply in urban centers which provide agglomeration, urbanization, scale economies and a deep pool of diverse technical skills. Although size is one factor, the creation of a dynamic urban region is not only a matter of sheer size. Further work can identify the necessary ingredients and arrive at specific recommendations

Part 1

Strengthening the Knowledge Economy and Technological Capability in Thailand

I. Introduction

During the 9th National Plan (2002–2006), Thailand recovered from the economic crisis of 1997–98. This period witnessed a steady deepening of the manufacturing sector's technology intensity through the absorption of more sophisticated production methods from abroad. As Thailand implements its 10th National Plan (2006-2010), the need to develop the country's technological capability has taken on a greater significance. Although Thailand has maintained respectable growth rates over the past five years, the impetus derived from the "tradeable" sector has weakened as the country's traditional exports currently face increasingly tough competition from its neighbors, especially from China. "Commodification" of many traditional exports, as well as worldwide excess capacity in consumer electronic products, textiles, auto parts and other industries, has compounded the pressure on producers. Since 2005, the rising prices of energy and other raw materials are additional sources of worry for firms.

Throughout East Asia, firms are seeking ways of ameliorating this situation. Increasing production efficiency, upgrading the quality of products, moving up the value chain, diversifying into new products, bundling services with products, improving logistics, marketing and after-sales services are some of the options being adopted by manufacturers across the region. However, the leading firms are learning that their competitiveness hinges on innovation embracing products, design, production processes, and by broadening the gamut of services. Through such measures innovative firms will be able to expand their market share and enlarge their earnings.

For Thailand, the stakes are high and rising. There is no avoiding the "technological arms race." Should Thailand fall behind, growth is likely to suffer. And once Thai firms begin to fall behind there is the risk that the economy will become prey to a vicious spiral, including the exodus of the leading MNCs and talented workers (both foreign and local), along with a further slowdown in domestic investment that is already well below the pre-1997 level. There is also the risk of a further deterioration in productivity and competitiveness. Some warning signals are already in the air: flagging GDP growth relative to the first half of the 1990s,[1] stagnating TFP, low rates of R&D spending, as well as a dip in the country's international competitiveness rankings. The domestic value-added of Thailand's manufactured goods also remains modest.[2] These trends need to be reversed through determined policy actions and corporate initiatives during the 10th National Plan period. The most direct way of regaining competitiveness is by building the country's technological capability that contributes to gains in productivity, innovation and diversification.

Efforts to achieve these objectives have been ongoing for some time with numerous initiatives having been undertaken, organizations created and institutions legislated. A strategy for the 10th National Plan must accommodate and capitalize on these legacy factors.

To assemble the building blocks of a strategy to enhance Thailand's industrial competitiveness, this report starts with a brief diagnosis of the country's key weaknesses. Part 1 sketches the recent macroeconomic developments that underscore the warning signs which demand an early response. In Part 2, the report then draws upon international experience to indicate how technological capability has been created in other countries and juxtaposes it in Part 3 with developments in Thailand. Part 4 suggests how Thailand might modify and build on its ongoing policy initiatives so as to accelerate the deepening of the knowledge economy.

II. Recent Growth Performance

Thailand has long been considered as one of East Asia's most dynamic economies. Between 1960 and 2004, GDP expanded 15-fold, increasing in size from under $9 billion to over $150 billion in constant 2000 prices. Per capita GDP rose almost 7-fold, from $332 in 1960 to $2,356 in 2004.[3] Only six other economies have matched or exceeded Thailand's performance, and with the exception of Botswana, the five others are all in the East Asia region – these

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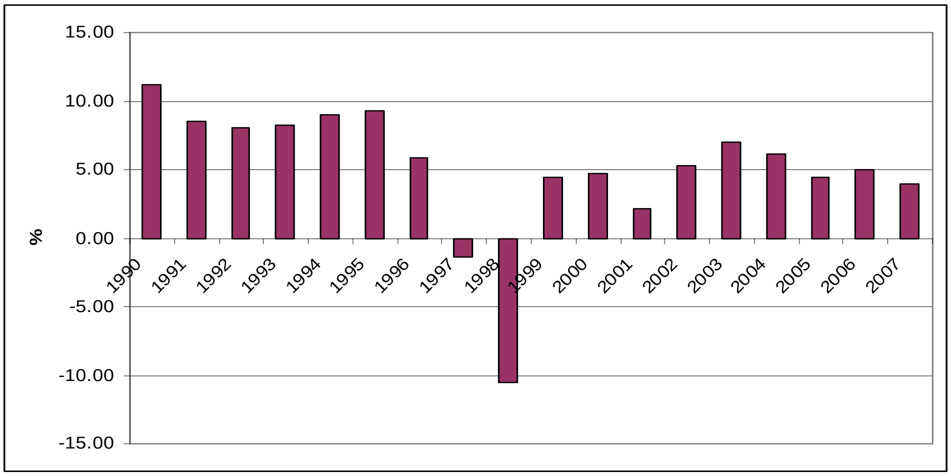
[1] Thailand's growth performance viewed in an East Asian context was a little below the average in 2006. At 4.3 percent it was lower than most of its neighbors and nearly two percentage points less than in 2005. Growth was close to five percent in 2007.

[2] Using export price index as a measure of quality of exports, the quality of exports from Thailand is low, especially for differentiated goods (Hallak 2006).

[3] World Bank World Development Indicators.

being Singapore, Hong Kong (China), the People's Republic of China, Taiwan (China), and the Republic of Korea (Richter 2006). Although the Asian economic crisis caused Thailand's GDP to contract by an average of six percent per annum during 1997 and 1998, the economy rebounded after 1999. However, growth has averaged 4.9 percent during 1999-2005 as against 8.6 percent p.a. between 1990 and 1996 (see Figure 1.1).

Figure 1.1: Thailand GDP Growth

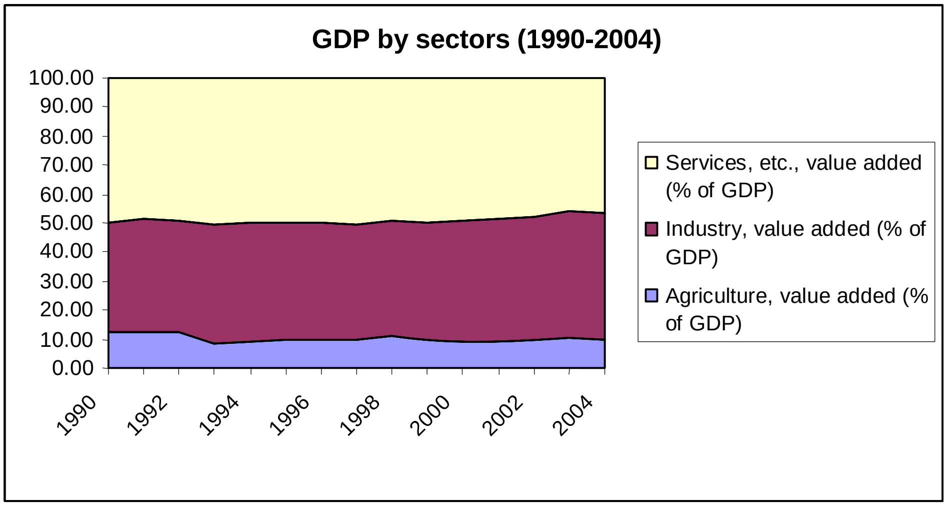


Note: data for 2006 and 2007 are projections.
Source: World Development Indicators; Bank of Thailand (http://www.bot.or.th/bothomepage/databank/EconData/EconFinance/index04e.htm)

From a sectoral perspective, growth over the past decade and a half can be traced mainly to the expansion of manufacturing. From 1990–2004, the manufacturing sector's share of GDP increased from 27.2 percent to 34.5 percent, while that of industry as a whole rose from 37.2 percent to 43.5 percent (see Figure 1.2). The manufacturing sector was hit hard by the 1997-98 economic crisis. Although it revived thereafter, growth has been lower than in the 1990s and parts of the manufacturing sector suffer from overcapacity, low technology and a dependence on imported components. Meanwhile, agriculture's contribution to GDP has declined, falling from 12.5 percent in 1990 to 10 percent in 2004. This is partly a manifestation of normal structural changes apparent throughout the region. In part it is also the result of falling commodity prices prior to 2002. The agricultural sector expanded by 6.8

percent in 2003, then experienced a year-on-year contraction of 4.4 percent in 2004, primary due to the devastating impact of that year's bird flu outbreak and drought. The contribution of services to GDP also dropped, from 50.3 percent in 1990 to 46.4 percent in 2004, mainly because of the weak performance of the financial sector that was badly hit by the crisis and its aftermath. The sector would have contracted further had it not been for the buoyancy of the tourism industry (Economist Intelligence Unit 2006).

Figure 1.2: GDP by Sectors



Source: World Bank.

Although Thailand's aggregate manufacturing output has grown more slowly in the past two years, the output of electronic products continues to surge ahead, increasing by nearly 40 percent in 2005 and by around 29 percent year-on-year in January 2006. The production of refrigerators, air-conditioners, construction materials and processed foods has also continued to expand strongly. All other sub-sectors have experienced a tapering off of their growth rates (see Table 1.1). In particular, textile and garment manufacturers continue to confront intense pressure from low-cost producers in the region, particularly China, India and Vietnam.

Sources of Growth: Factor inputs and TFP

Thailand's economic growth is derived mainly from investment in physical and human capital.[4] Capital accumulation was responsible for 4 percentage points and labor for 1.6 percentage points of real output growth. Only 1.6 percent of the country's real output growth of 7.7 percent from 1977 to 1996 can be traced to the increase in TFP (see Table 1.2).

Table 1.1: Manufacturing Production Index (% Change, year on year)

	2004	2005		2006		
			Q4	Q1	Q2	Q3 p
			(percent)			
Foods	-1.2	-0.3	0	5.1	9.2	10
Beverages	5.2	2.9	8.3	15.3	3.3	26.2
Tobacco	8.9	-5.1	-11.7	-30.8	-15.3	4.4
Textiles & Textile Products	6.6	2.2	2.4	7.4	5.2	0.1
Petroleum Products	8.4	-0.4	-9	3.5	0.9	0.3
Construction Materials	10.5	11.3	4.2	2.7	6.9	6.8
Iron & Steel Products	10.4	-3.6	-11.4	-12.1	4.8	0
Vehicles and Equipments	20.4	6.3	8.7	14.5	8.4	3.1
Electronic Products	31.4	39.7	33.3	24.7	19.7	23.3
Electrical Appliance	8.8	1.8	-0.2	1.2	-9.1	-12.8
Setting Jewelry	2.8	2.3	2.3	-0.2	1.9	-1.6
Others	-5.8	1.6	-0.3	2.9	6.1	21.8
Total Index	11.7	9.1	7.2	9.6	6.6	6.5

Note: Data for 2006 Q3 is projected.
Source: Bank of Thailand
(http://www.bot.or.th/bothomepage/databank/EconData/EconFinance/index04e.htm)

[4] In a review of growth accounting studies on Thailand, Bosworth argues that most discrepancies in the findings link back to two sources: how labor inputs are adjusted to account for rising education standards; and how income of the self-employed, roughly half of the Thai labor force, is attributed to labor and capital. As capital grows faster than labor, attributing self-employed income to capital lowers the TFP estimates (Bosworth 2005; Richter 2006).

To a large extent gains in TFP have come from a reallocation of factors from agriculture to industry and services, whereas within-sector contributions to TFP are low.[5] The average annual rate of increase in value-added-weighted TFP growth was only 0.5 percent for 1977–96 and zero for 1977–2004. The difference, 1.1 percent annually, is a measure of the gains from resource re-allocation (Bosworth 2005). Labor productivity is about 10 times higher in manufacturing and close to five times higher in services than in agriculture (see Figure 1.3). The improvement in TFP has been more substantial in the post-crisis years, i.e. a gain of 2.1 percentage points annually during 1999–2004. This is partly attributable to increases in capital utilization following the rebound from the crisis.

Table 1.2: Sources of Growth: Total Economy and Major Sectors, 1977–2004

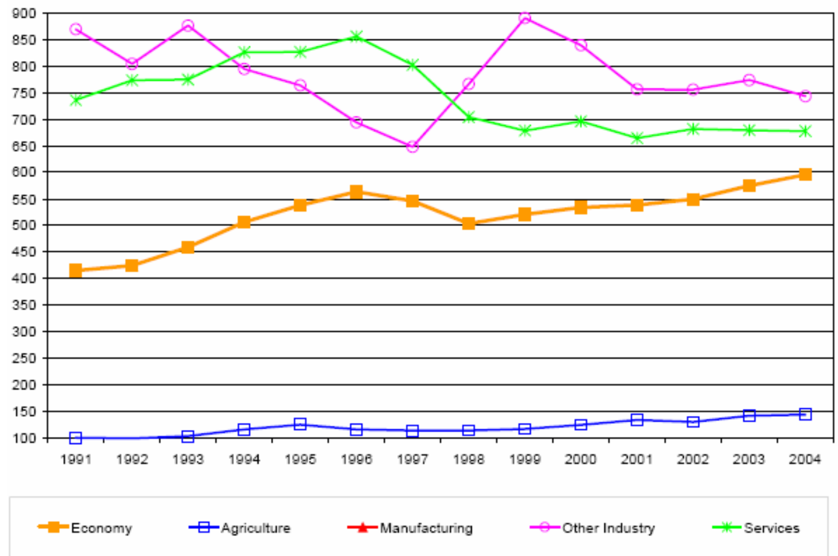
	Total Economy			Agriculture			Industry			Manufacturing			Services		
	1977–2004	1977–1996	1999–2004	1977–2004	1977–1996	1999–2004	1977–2004	1977–1996	1999–2004	1977–2004	1977–1996	1999–2004	1977–2004	1977–1996	1999–2004
GDP growth	6	7.7	5	2.9	3.3	3.2	8	10.2	6.3	8.4	10.2	6.6	5.4	7.3	4.2
Contribution of															
Labor	1.8	2	1.9	0.4	0.5	0.1	2.7	3.5	2.9	2.8	3.2	2.9	3.4	3.5	3.6
Capital	3.1	4	0.9	1.9	1.9	1.6	4.7	6.1	1.2	4.1	5.4	0.8	2.5	3.2	0.6
Land	0	0	0	0	0.1	0	na	na	na	na	na	na	na	na	na
TFP	1	1.6	2.11	0.5	0.7	1.4	0.4	0.4	2	1.2	1.3	2.7	-0.5	0.5	0

Source: Bosworth (2005)

[1] By comparison, contribution of TFP to growth in Malaysia during 2000-2005 was 2.7 percent per annum.

[5] Diao, Rattso, and Stokke (2005; 2006) find that sustained economic growth in Thailand came from the shift from agriculture production to export-oriented manufacturing industries, coupled with learning through exporting. Similarly, Rasiah (2003) finds a strong link between exporting and process technology improvements. The improvement in process technology in turn depends on the availability of human resources and R&D expenditures, even though such spending is relatively low.

Figure 1.3: Labor Productivity: Overall and by Sector, 1991-2004, Agriculture 1991=100



Source: Richter (2006)

A cross-sectoral comparison shows that typically the industrial (mostly manufacturing) sector has the highest TFP contribution. This is followed by agriculture and the services sector in which the TFP contribution has been almost zero. Output growth in the agricultural sector was largely attributable to increases in capital, particularly in the 1990s. TFP reached its peak in 1991. Agriculture appears to have been largely unaffected by the 1997-98 crisis. However, the estimates of factor shares and thus the relative importance of capital and labor for growth are highly uncertain, making it difficult to decompose the sources of growth for this sector.

The industrial sector is dominated by manufacturing, and growth has been the result of an increase in factor inputs. As with agriculture, the contribution of TFP peaked in the early 1990s, and except for the crisis years it has been constant since then. TFP in industry and the subgroup of manufacturing did not return to pre-crisis levels until 2004. A smaller contribution of TFP within total industry relative to manufacturing is consistent with the results from many countries that report constant or declining TFP in construction. Overall, a low TFP contribution occurs because of the relatively large weight assigned to capital. However, it is difficult to argue for a re-adjustment of the wage compensation data in the national accounts to offset this. At least within manufacturing, the various categories of self-employed workers are not that significant.

The service sector has grown more slowly than industry and its growth is dominated by increases in the input of labor. Capital accumulation did slow sharply after 1997, but because of the large decline in output the capital-output ratio has increased. As expected, the result has been a substantial fall in the return to on capital, as well as a shift of the factor weights toward labor i.e. from 60 percent in 1997 to 69 percent in 2003. Educational levels of the workforce in the service sector have also improved. The finance industry, a large component of the services sector, suffered the largest disruptions in the aftermath of the 1997-98 economic crisis. As a result of this multitude of factors, TFP growth in services turned highly negative after 1997. The longer-term trend, however, may be more accurately measured by the 1977-1996 pattern that showed a small positive growth rate of 0.5 percent per year (Bosworth 2005).

A regional comparison of Thailand with its competitors in East Asia places Thailand in the middle of this group with respect to growth in both labor productivity and TFP (see Table 1.3).[6] While the country's TFP contribution is higher than Malaysia, the Philippines, and Indonesia, it is lower than Singapore, Taiwan (China) and China.

Sources of Growth: Demand Related

A decomposition of the demand related sources of economic growth shows that since the mid-1980s, Thailand has become more dependent on trade and private investment. The pre-crisis boom was supported by both expanding exports and an increase in investment, while the post-crisis recovery relied initially on exports. But in the last few years the salience of domestic consumption also increased. In 2005, higher energy prices dampened private investment and consumption, and weaker world demand, drought and the effects of the 2004 tsunami constrained export growth to 15 percent. In 2006,

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[6] If we look at a different time period (1977-2004), the average TFP growth was only one percent.

Thailand's estimated GDP growth rate of 4.3 percent is derived mainly from net exports, whereas domestic demand has been affected by oil prices, rising real interest rates, depressed business confidence and political developments. Private investment growth slowed to 9.5 percent from 11 percent, while public investment slowed to 6.5 percent from 11.7 percent in 2005.

Table 1.3: Sources of Growth in East Asian Economies, 1975–2000

(Average annual percentage change)					
Region/period	Output	Output per worker	Physical capital	Education	Factor productivity
China	8.8	6.9	2.5	0.4	3.9
Indonesia	5.8	3	2.4	0.5	0
Korea	7.3	4.8	3	0.7	1.1
Malaysia	6.9	3.7	2.2	0.6	0.9
Philippines	3	0.2	0.8	0.4	−0.9
Singapore	7.7	4.4	2.1	0.5	1.8
Thailand	6.5	4.1	2.1	0.5	1.4
Taiwan (China)	7.8	5.5	2.6	0.4	2.4

Source: Bosworth and Collins (2003a). Updated estimates for China as well as for India can be found in Bosworth and Collins (2007b)

Trade and Competitiveness

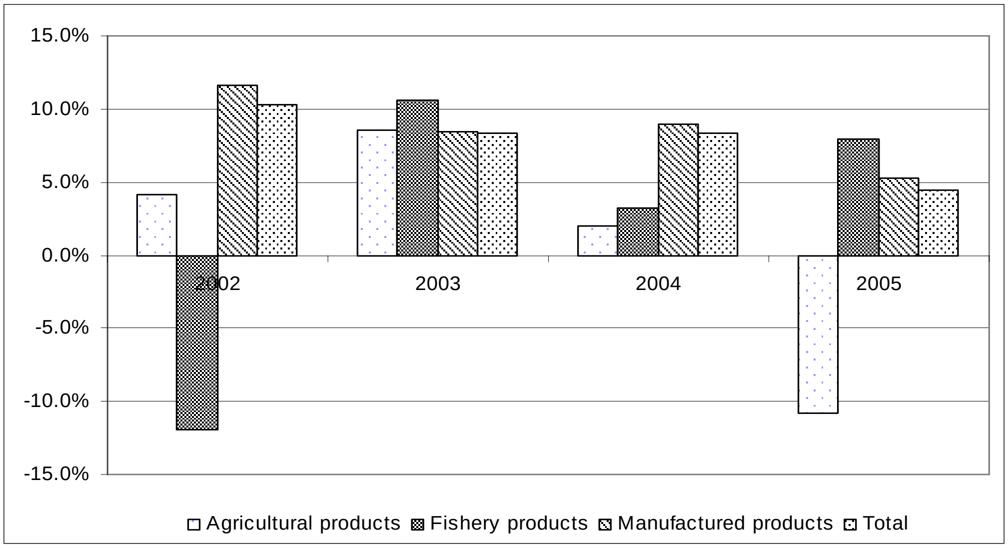
Exports are a key driver of the Thai economy. Exports accounted for 20 percent of GDP in 1980, followed by around 45 percent of GDP before the Asian economic crisis before reaching 65 percent of GDP in 2004. However, in 2005, Thailand's increase in export volume halved relative to the 2002–04 period. This was because of the large drop in the growth rate of manufactured exports (see Figure 1.4) especially of electronics; the volume of rice and rubber exports, accounting for a tenth of total exports, also contracted in 2005 because of drought. Hence, the growth of total export earnings was 15 percent (vs. 22 percent in 2004). This was much lower than the export growth rates achieved by India, Indonesia, China, the Philippines, etc., but higher than Singapore, Korea and Japan (see Figure 1.5). However, merchandise exports recovered in 2006 with a gain of 17 percent to $128 billion.

Table 1.4: Thailand GDP: Recent Performance (1988 prices)

	2003	2004	2005	2006p	2007p
Total Consumption	5.9	5.2	5.5	3.4	3.4
Private Consumption	6.5	6.2	4.3	3	3
Gov Consumption	2.5	5.6	13.7	5.3	6
Gross fixed capital formation	12.1	13.2	11.1	4	4.2
Private Investment	17.7	16.2	10.9	3.7	3.6
Public Investment	-0.6	5	11.3	4.7	6
Total Domestic Demand	7.8	7.9	7.3	0.7	4.1
Exports	7.1	9.6	4.3	9.4	6.1
Goods	9.5	8.4	4.3	9.6	6.3
Services	-2.7	15.3	4.3	8.6	5
Imports	8.4	13.4	9.3	2	6.7
Goods	10.6	12.2	8.8	-0.5	6.2
Services	-3	20.4	12.1	15.2	9
Net Foreign Demand	2.6	-3.8	-16.5	49.7	3.7
GDP	7.1	6.3	4.5	5	4

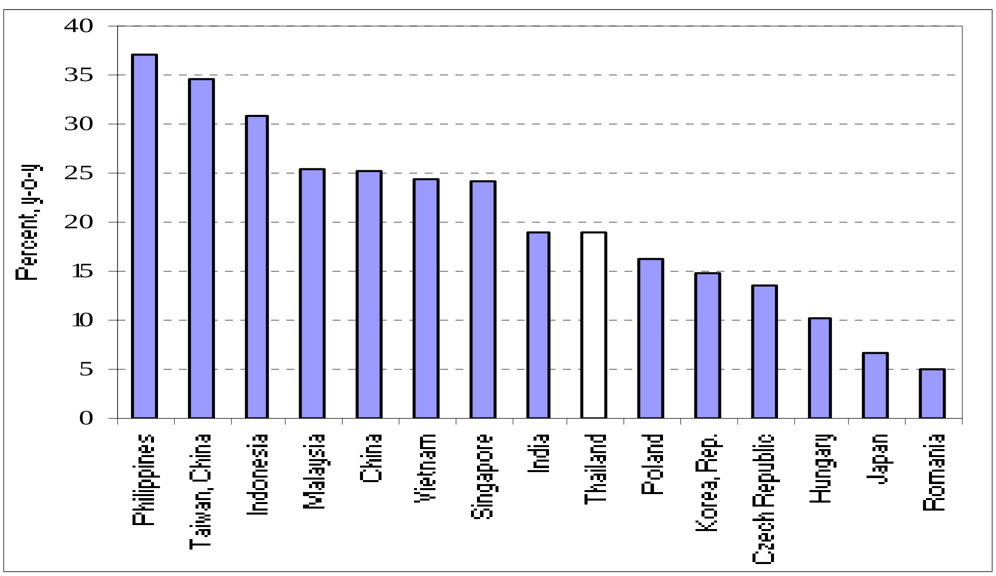
Note: data for 2006 and 2007 are projections.
Source: Bank of Thailand
(http://www.bot.or.th/bothomepage/databank/EconData/EconFinance/index04e.htm)

Figure 1.4: Export Volume Growth: 2002–05



Source: Bank of Thailand
(http://www.bot.or.th/bothomepage/databank/EconData/EconFinance/index04e.htm)

Figure 1.5: Growth Rates of Total Export Earnings
(January–October, 2005): Thailand v. Competitors



Source: World Bank (2006d)

Between 2000 and 2004, Thailand's share of total merchandise exports by ASEAN countries to Asia increased from 5.4 percent to 6.8 percent, but decreased from 7.5 percent to 7.1 percent as a percentage of ASEAN's exports to the rest of the world.[7]

In the last fifteen years, the composition of Thailand's exports has undergone rapid change (see Table 1.5). In 1990, the country's exports were comprised mainly of agricultural and light industrial products (11 out of the top 15 categories). By 2005, these were displaced by electronics, transportation equipment and electronic components. The importance of light industrial products such as garments and footwear, which were once among the top 15 export categories by value, diminished throughout the 1990s, as did that of agricultural products with the exception of a short-lived revival in the years around the Asian economic crisis. Currently, machinery and transportation equipment occupy the top 10 slots. Valves and transistors, as well as office machine, both maintained their rankings, whereas electronics and telecommunication products have seen their share increase.

The change in the composition of exports was paralleled by a substantial diversification of exports within individual categories. This is reflected in the Herfindahl indices presented in Table 1.6. According to these, Thailand's exports have diversified whereas Korea's and Malaysia's exports have become more specialized.[8]

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[7] WTO: International Trade Statistics, 2005.

[8] On balance, diversification is viewed as a positive development, assuming that it is into more sophisticated products with higher added value and better market prospects. This trend is not yet apparent in Thailand.

Table 1.5: Top 15 Commodities in Thailand's Export in 1990 and 2005

	1990	2005
1	Office equipment parts/accessories	Computer equipment
2	Rice	Valves/transistors/etc.
3	Crustaceans, mollusks etc	Natural rubber/latex/etc.
4	Fish/shellfish (prepared or preserved)	Office equipment parts/accessories
5	Natural rubber/latex/etc.	Goods/service vehicles
6	Valves/transistors/etc.	Telecoms equipment nes
7	Vegetables - fresh/chilled/frozen	Electric circuit equipment
8	Pearls/precious stones	Heavy petrol/bitum bituminous oils
9	Footwear	Fish/shellfish (prepared or preserved)
10	Men's/boy's wear, woven	Industrial heating/cooling equipment
11	Women's/girl's clothing woven	Rice
12	Sugar/molasses/honey	Electrical equipment nes
13	Articles of apparel nes	Passenger cars etc.
14	Jewelry	Motor vehicle parts/accessories
15	Telecoms equipment nes	Jewelry

Note: nes refers to "not elsewhere specified".

Source: UN Comtrade.

Table 1.6: Herfindahl Index of Exports, 1990-2005

	1990	1995	2000	2005
Korea	88.69	174.08	250.37	208.23
Malaysia	314.95	216.9	341.17	n.a.
Thailand	131.44	102.05	159.2	93.72

Source: UN Comtrade. Author's calculations.

Recent trade data shows that Thailand's competitiveness is eroding in some of the fastest growing export sectors. In 2005, electronics and electrical machinery, as well as rice, were no longer among the top ten fastest growing export categories when compared with the recent past. Between 2004 and 2005 exports of electrical machinery and equipment slowed from 18.3 percent to 2.3 percent, while their contribution to export growth dropped from 19.4 percent to 3.3 percent. A breakdown of electronics and machinery sector exports also shows that except for electronic integrated circuits, the share of other principal export products in this sector declined (see Table 1.7).

Table 1.7: Top Five Export Products under HS 85 in 2003 to the First Two Months of 2006

(Percent)

		2003		2004		2005		Jan-Feb 2005		Jan-Feb 2006	
		Growth	Share	Growth	Share	Growth	Share	Growth	Share	Growth	Share
HS 85	**Electrical machinery and equipment**	**15.5**	**100.0**	**18.3**	**100.0**	**2.3**	**100.0**	**-5.5**	**100.0**	**12.6**	**100.0**
8542	Electronic integrated circuits	39.8	27.0	5.8	24.1	12.7	26.6	-16.1	23.0	52.9	31.2
8528	Reception apparatus for television	1.0	6.6	44.9	8.1	1.0	8.0	37.3	8.7	-19.2	6.2
8534	Printed circuits	24.4	4.3	75.6	6.4	-3.0	6.1	60.1	8.1	-27.2	5.2
8541	Semiconductor devices	-6.1	7.9	-20.3	5.3	-24.4	4.0	-25.0	4.6	-2.4	4.0
8517	Electrical apparatus for telephone	24.1	6.3	-2.3	5.2	-1.8	5.0	-38.5	4.1	4.4	3.8

Source: World Bank (2006c).

The proportion of manufactured goods to total exports rose from 45 percent in 1986 to 87 percent in 2004. And while most of these goods are classified as high-tech products they still consist mainly of goods that are assembled in Thailand using imported components. Thailand's domestic value-added in exports remains limited with very little local innovation or contribution from local designs. Such exports may be profitable to produce, but so long as competitiveness rests mainly on low labor costs then Thailand will remain highly vulnerable to competition from other Asian countries. By most accounts, Thailand is mainly an "assembler" rather than a "designer" or an "innovator" (World Bank 2006e).

An analysis of Thailand's exports with reference to comparative advantage also conveys a mixed picture. Over half of the sub-sectors do not have or are actually losing their comparative advantage.

Currently, the strongest sub-sectors are motor vehicles, other electrical machinery and apparatus, and office machines. Overall, natural resource-based and labor intensive products, such as plastic materials, paper, fish, live animals, footwear, etc., are Thailand's most competitive exports in the global context (see Table 1.9), as was the case prior to the Asian economic crisis.

Table 1.8: Thailand's Revealed Comparative Advantage
(Electronics, Machinery and Vehicles) SITC revision 1 (Ranked by 2005)

Code	Product	1990	1995	2000	2005
714	Office machines	1.7	1.96	2.03	2.4
725	Domestic electrical equipment	1.81	1.61	2.11	2.37
729	Other electrical machinery and apparatus	1.2	1.07	1.36	1.43
722	Electric power machinery and switchgear	0.45	1.41	1.89	1.41
733	Road vehicles other than motor vehicles	0.56	1.21	1.11	1.39
723	Equipment for distributing electricity	1.9	1.53	1.06	1.11
724	Telecommunications apparatus	0.89	1.06	1.06	0.99
732	Road motor vehicles	0.04	0.08	0.37	0.68
719	Machinery and appliances-non electrical- parts	0.35	0.57	0.63	0.67
711	Power generating machinery, other than electric	0.05	0.1	0.24	0.5
734	Aircraft	0	0.67	0.05	0.43
735	Ships and boats	0.03	0.18	0.11	0.38
715	Metalworking machinery	0.14	0.26	0.34	0.34
717	Textile and leather machinery	0.06	0.13	0.2	0.31
718	Machines for special industries	0.03	0.09	0.19	0.19
712	Agricultural machinery and implements	0.04	0.03	0.1	0.07
726	Electronic apparatus for medical purposes, radiological apparatus	0.01	0.02	0.07	0.02
731	Railway vehicles	1.5	0.74	0.01	0.02

Source: Author's analysis based WITS database.

Table 1.9: Thailand's Top Ten Sectors with the Strongest Revealed Comparative Advantage SITC revision 1 (ranked based on 2005)

Code	Product	1990	1995	2000	2005
42	Rice	39.97	24.08	22.03	22.46
32	Fish, in airtight containers, nes & fish preptns.	24.11	15.42	19.35	18.21
231	Crude rubber-incl. synthetic & reclaimed-	14.73	16.06	13.57	12.5
275	Natural abrasives-incl. industrial diamonds-	1.19	0.38	14.97	7.1
13	Meat in airtight containers nes & meat preparations	0.27	1.95	5.47	6.16
687	Tin	6.82	0.89	3.49	5.84
47	Meal & flour of cereals, except wheat/meslin	16	9.14	9.49	5.58
61	Sugar and honey	10.78	7.45	5.9	5.44
53	Fruit, preserved and fruit preparations	6.35	3.92	3.57	4.71
31	Fish, fresh & simply preserved	6.49	6.46	4.95	4.36

Note: nes refers to "not elsewhere specified".
Source: Author's analysis based WITS database.

In line with the continuing emphasis on processing and assembly activities, Thailand's dependence on imports of intermediate and capital goods is on the rise. Merchandise imports were equivalent to around 58 percent of GDP in 2004. Capital goods imports expanded by 20 percent and accounted for around 43 percent of the total, and imports of intermediate products and raw materials jumped by 32.5 percent to $26.5 billion in 2004, partly because of the rising oil price beginning in 2004. The rapid expansion of the automotive industry has contributed to sharp growth in imports of vehicles and parts, which totaled $3.5 billion in 2004, compared with less than $2 billion in 2000 (Economist Intelligence Unit 2005).

Thailand's global export and import shares and growth rates in key sectors in the global market shed some more light on the competitiveness of these sectors.

Table 1.10: Thailand's Share in World Imports and Exports (1980–2004)

Sectors		Share in World Total				Average percentage change
		1980	1990	2000	2004	2000–04
Agricultural products	Exports	1.2	1.9	2.2	2.1	7
	Imports	0.3	0.7	0.8	0.8	10
Office & telecom equipment	Exports	0	1.2	1.9	1.9	8
	Imports	0.2	1.1	1.4	1.5	5
EDP & office equipment	Exports			2.4	2.2	4
	Imports			1	1.2	6
Telecom equipment	Exports			1.4	1.5	15
	Imports			0.6	0.8	11
Integrated circuits & electronic components	Exports			1.9	1.9	7
	Imports			2.7	2.8	3
Auto products	Exports	0	0	0.4	0.7	27
	Imports	..	0.8	0.4	0.4	19
Textiles	Exports	0.6	0.9	1.3	1.3	8
	Imports	0.3	0.8	1	0.9	3
Clothing	Exports	0.7	2.6	1.9	1.6	1
	Imports	..	..	..	..	..

Source: Compiled from data in WTO: International Trade Statistics, 2005.

Table 1.10 shows that except for auto parts and telecom equipment, Thailand's share of exports in all other product categories as a percentage of global exports was stagnant or slightly declined during 2000-04. Meanwhile, during this period the country's share of global imports was either stable or increasing due to rising import volumes of agricultural products, EDP (electronic data processing) & office equipment, office & telecom equipment and integrated circuits & electronic components. In agricultural products, the export volumes and shares fell, while import shares and volumes increased. Agricultural products and EDP & office equipment had the highest global shares among other Thai producers of export products. In textiles and clothing, Thailand's share of global exports was either stagnant or declined. This suggests that Thailand is losing its competitiveness in its traditional sectors, except in a few sub-sectors which are expanding rapidly. Moreover, sluggish exports by some technology-intensive sectors such as electronics and machineries, where Thailand had gained strength in recent years, also implies that Thailand is losing ground in the face of rising global competition.

There are three aspects of these developments which deserve to be noted because they have a bearing on technological capability. First, the export pattern that has emerged resembles that of Malaysia, the Philippines, and China, all of which are dependent upon exports of electronic products and office equipment. Second, the growth of production capacity for these products, and also in auto parts and certain types of machinery, has put downward pressure on the prices of products in international markets which strengthens the case for product diversification and for upgrading quality in order to widen profit margins (Schott 2006). Third, the export mix has been driven to a significant extent by FDI and by MNC-controlled supply chains, although FDI is transferring relatively little technology to Thai companies through vertical or horizontal spillovers. Few if any Thai companies have emerged as important and innovative producers of electronic components based on their own R&D and technological expertise. And similarly, Thai firms are not represented in the ranks of first-tier suppliers to multinational auto companies (Takayasu and Mori 2004), AAPICO being an exception. This is not dissimilar when compared with the experience of China, which relies on MNC's and joint ventures for 58 percent of its exports (Yusuf and Nabeshima 2006a).[9] China is also finding that technology transfer is related to local firms achieving absorptive capacity – or cognitive proximity – through their own R&D in order to benefit from spillovers (Boschma 2005; Guan and others 2006). The purchase of equipment, assembly operations, as well as a passive dependence on foreign blueprints/designs and production practices, is a recipe for declining competitiveness in the event that MNCs shift the location of their production activities to other countries.

Foreign Direct Investment

As economies have become more open, foreign direct investment (FDI) has emerged as a more important source of fixed investment and technology transfer. While FDI inflow continues at a steady pace, Thailand is facing competition from China, India and even Vietnam.[10]

Based on the A.T. Kearney FDI Confidence Index, Thailand ranked 20th among 68 countries in 2005.[11] By contrast, the two frontrunners were China and India, with Malaysia ranked 15th in 2004.

Table 1.11: Thailand's Confidence Rankings (2001–2005)

	2001	2002	2003	2004	2005
Thailand	14	20	16	20	20
China	2	1	1	1	1
India	7	15	6	3	2
Malaysia	22	..	23	15	..

Source: Global Business Policy Council 2005.

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[9] Sixty-two percent of all patents granted to Chinese assignees are to foreign companies or joint ventures registered in China.

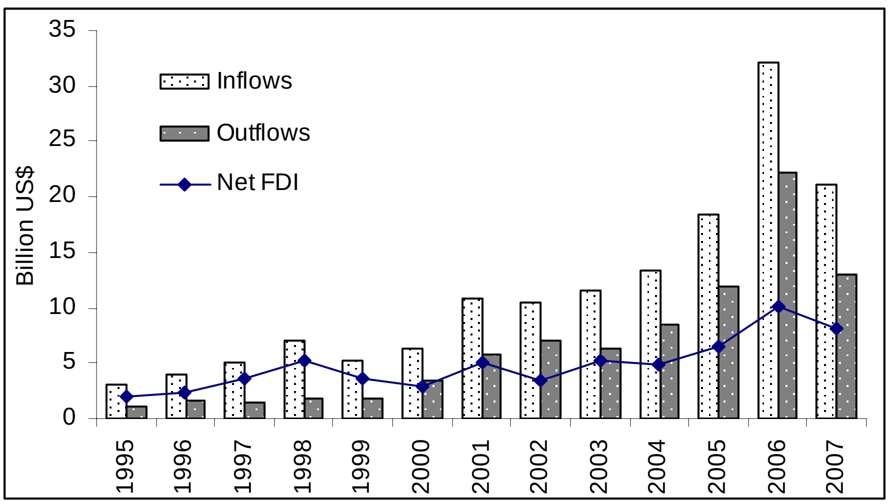
[10] So far, research on FDI does not suggest that FDI is being diverted from Southeast Asian countries to China or that China – given its GDP level – is absorbing a disproportionate amount of FDI.

[11] The *Foreign Direct Investment Confidence Index*, 2005 is based on an annual survey of executives from the world's largest companies conducted by A.T. Kearney.

From 1990 to 1996, gross FDI in Thailand hovered around a plateau of over $3.5 billion per year. Following the depreciation of the Baht in 1997, gross FDI inflows increased substantially during 1998-99. In 2001, the country's gross FDI inflow reached $10.8 billion (see Figure 1.6).[12] Thailand ranks as the third most preferred destination by Japanese MNCs after China and the U.S. (JETRO 2006). Net inflow of FDI from 2002 to 2006 averaged $6 billion, much higher than that of 1992–96 which averaged $1.8 billion, reflecting the surge in 2005 and 2006. Based on preliminary data for 2007, Thailand's net FDI inflow was significantly higher at $10.2 billion (see also Table 1.12).

In recent years, the automotive and electronics sub-sectors have attracted most of the FDI in Thailand, followed by metallic and non-metallic products. Auto and electronics firms focus mainly on parts/components production and assembly, as well as export a share of their output. FDI inflows in trade, services and real estate have also increased rapidly.

Figure 1.6: Inflows, Outflows, and Net FDI, 1995–2007



Source: Bank of Thailand.
(http://www.bot.or.th/bothomepage/databank/EconData/EconFinance/index04e.htm).

[12] The growth of FDI in the post-crisis period was characterized by a dramatic increase in mergers and acquisitions (M&A) as foreign firms took over Thai companies that faced severe debt and liquidity problems. While hard statistics on this shift are not available, UNCTAD's World Investment Report 2000 revealed that cross-border M&A sales or M&A FDI in Thailand amounted to $3.2 billion in 1998 before dropping slightly to $2.0 billion in 1999 and then rising to $2.6 billion in 2000.

Table 1.12: Net Flow of FDI Classified by Sector, 2004–2007 (US$, Millions)

	2004	2005	2006	2007
Industry	3,786.0	3,429.9	4,058.9	3,791.1
Food & sugar	337.3	-24.8	156.9	41.3
Textiles	38.0	77.9	-1.4	35.0
Metal & non metallic	480.1	221.4	315.9	246.1
Electrical appliances	797.0	908.3	1,173.8	1,357.4
Machinery & transport equipment	1,280.3	1,370.0	1,331.6	1,028.8
Chemicals	387.3	472.4	168.5	-116.0
Petroleum products	22.5	-72.6	338.5	157.1
Construction materials	45.1	21.7	10.0	14.1
Others	398.4	455.6	565.1	1,027.4
Financial institutions	221.7	1,550.9	2,036.2	675.7
Trade	182.9	295.2	716.7	468.9
Construction	70.7	29.9	12.0	79.3
Mining & quarrying	192.3	-111.0	230.9	73.5
Agriculture	5.7	12.6	-3.1	-0.3
Services	303.3	330.9	694.5	834.7
Investment	-236.7	173.6	2,133.3	283.2
Real estate	-344.0	43.3	247.5	1,197.3
Others	774.1	747.8	-96.0	716.5
Total	4,956.0	6,503.2	10,031.0	8,120.0

Source: Bank of Thailand
(http://www.bot.or.th/bothomepage/databank/EconData/EconFinance/index04e.htm)

Beyond providing capital and generating employment, FDI tightens connections with international production networks (including agro-industry networks), improves working conditions and strengthens local capabilities through enhanced shop floor management, quality assurance, product certification, training, assisting with policy reforms, industrial restructuring, and to some extent, by bringing in new technology.

As a potential site for outsourcing of services, Thailand ranks 6th out of 40 countries surveyed by the AT Kearney's Global Services Location Index (Table 1.13). Needless to say, India leads the others in this regard but China is not far behind. Many firms now regard China as a low-cost services provider serving Asian markets. Other Southeast Asian economies also rank highly in this regard.

Table 1.13: A.T. Kearney Global Services Location Index, 2005

Rank	Economy	Financial Structure	People and Skills Availability	Business Environment	Total Score
1	India	3.47	2.14	1.26	6.87
2	China	3.21	1.76	1.17	6.14
3	Malaysia	2.95	1.12	2	6.07
4	Philippines	3.58	1.15	1.05	5.78
5	Singapore	1.62	1.44	2.67	5.73
6	Thailand	3.27	0.94	1.51	5.72
7	Czech Republic	2.57	1.12	1.9	5.59
8	Chile	2.73	0.97	1.87	5.57
9	Canada	1.1	2.03	2.4	5.53
10	Brazil	2.91	1.36	1.23	5.5

Note: out of 40 countries.

Source: http://www.atkearney.com/shared_res/pdf/GSLI_Figures.pdf.

Global Competitiveness

In order to better understand Thailand's overall competitiveness in a global context, the country's recent performance is compared with selected regional competitors, using the IMD and the World Economic Forum's (WEF) annual rankings.

Table 1.14: Thailand's Global Competitiveness Rankings 2003-2006

IMD 2006	2003	2004	2005	2006
Overall Ranking	30	29	27	32
1. Economic Performance	14	9	7	21
- Domestic Economy	16	26	44	55
- International trade	4	18	18	15
- International investment	19	53	45	47
- Employment	2	3	2	6
- Price	4	4	7	9
2. Government Efficiency	18	20	14	21
- Public Finance	7	33	18	21
- Fiscal Policy	3	9	2	4
- Institutional Framework	5	13	11	25
- Business Legislation	10	29	27	33
- Societal Framework	8	27	30	39
3. Business Efficiency	28	23	28	28
- Productivity & Efficiency	20	45	56	48
- Labor market	4	5	5	6
- Finance	13	36	46	41
- Management Practices	8	24	27	26
- Attitudes and values	11	12	16	20
4. Infrastructure	49	50	47	48
- Basic Infrastructure	14	41	38	38
- Technological Infrastructure	20	45	45	48
- Scientific Infrastructure	26	55	56	53
- Health and Environment	18	48	46	48
- Education	21	48	46	48

Source: IMD 2003; IMD 2004;IMD 2005;IMD 2006.

Thailand's overall ranking declined between 2003 and 2006, even though some improvements were achieved in 2004 and 2005 (Table 1.14). The big drop in 2006 was in the areas of economic performance and government efficiency. Government efficiency is deteriorating because the institutional framework and business legislation have both become unfavorable. The overall rankings of the country's business efficiency and infrastructure remain almost unchanged.

A cross-country comparison reveals that Thailand's overall competitiveness in 2006 was lower than that of most of its regional competitors. Malaysia, China, Taiwan (China), Japan, Singapore and Hong Kong (China) all had higher rankings in most of the areas (see Table 1.15). Only Korea, which suffered a big drop in 2005, was ranked lower.

Table 1.15: Global Comparisons between Thailand and its Regional Competitors 2005–2006

IMD 2005-06	Thailand	Korea	India	Malaysia	China	Taiwan	Japan	Singapore	Hong Kong
Overall Ranking	32	38 (29)	29 (39)	23R (28)	19 (31)	18 (11)	17 (21)	3 (3)	2 (2)
1. Economic Performance	21	41 (43)	7 (12)	11R (8)	3 (3)	27 (18)	15 (21)	4 (5)	5 (4)
2. Government Efficiency	21	47 (31)	35 (39)	20R (26)	17 (21)	24 (19)	31 (40)	2 (2)	1 (1)
3. Business Efficiency	28	45 (30)	19 (23)	20R (25)	30 (50)	14 (6)	23 (35)	7 (5)	1 (1)
4. Infrastructure	48	24 (23)	54 (54)	31R (34)	37 (42)	20 (18)	2 (3)	5 (6)	16 (20)

Source: IMD 2005; IMD 2006.
Note: Figures in parentheses are rankings for 2005.

The WEF's annual competitiveness rankings measure the global competitiveness (GCI) based on nine factors grouped in three sub-indexes. In 2006, Thailand outranked only China among its major East Asian competitors (see Table 1.6). However, if the size effect is considered, Thailand might not have the advantage over China now that China is not as much of a technology laggard as the data suggests (Sigurdson 2005; Zhou and Leydesdorff 2006; Yusuf and Nabeshima 2007).

Table 1.16: WEF's Global Rankings of Thailand and its Major Competitors

WEF 2006-07	Thailand	Korea	Malaysia	China	Japan	Singapore
Global Competitiveness Index	35	24	26	54	7	5
Basic Requirements sub-index	38	22	24	44	49	2
Institutions	40	47	18	80	22	4
Infrastructure	38	21	23	60	7	6
Macro-economy	28	13	31	6	91	8
Health and Primary Education	84	18	42	55	1	20
Efficiency Enhancers sub-index	43	25	26	71	16	3
Higher Education and Training	42	21	32	77	15	10
Market Efficiency	31	43	9	56	10	4
Technological Readiness	48	18	28	75	19	2
Innovation Factors sub-index	36	20	22	57	1	15
Business Sophistication	40	22	20	65	2	23
Innovation	33	15	21	46	1	9

Source: Lopez-Claros and others (2006).

Doing Business in Thailand

Overall, Thailand is ranked 18th out of 175 economies in the World Bank's "Doing Business" survey for 2007. Within East Asia, Thailand ranks fourth behind Singapore, Hong Kong (China), and Japan (see Table 1.17). While Thailand fares better than other economies in East Asia according to many of the criteria, few indicators are associated directly with technological capability or innovation. While starting a business in Thailand is relatively easy allowing promising new firms to enter an industry,[13] the shedding of redundant workers and closing businesses are the most costly in Thailand relative to both other economies in East Asia and the OECD countries. That is, firms face problems when attempting to exit.

[13] The conditions facing an entrepreneur in Thailand are not significantly different from those in OECD countries, except for the number of days it takes to obtain permission (33 days in Thailand and 17 days in OECD countries).

Table 1.17: Ease of Doing Business in Selected East Asian Economies, 2006

Rank	Economy
1	Singapore
5	Hong Kong (China)
11	Japan
18	Thailand
23	Korea
25	Malaysia
47	Taiwan (China)
93	China
104	Vietnam
126	Philippines
135	Indonesia

Source: World Bank (2006a).

Patenting by Thai Firms

An assessment of patenting activity offers another means of gauging innovation capability. However, this is certainly only a partial measure. Data from the U.S. Patent and Trademark Office (USPTO) provides a convenient way of doing this and comparing outcomes with other countries.[14] There are a number of ways to define the country origin of a patent using the USPTO database.[15] The patents can be classified by the residence country of an inventor. This requires assigning the same patent to different countries and therefore, can lead to a double counting of the same patent if inventors come from multiple countries. However this method gives an overall picture of a country's innovation capability including of its citizens (or residents). The most commonly-used approach is to classify a patent as invented in the same country as the first-named inventor's country of residence. But the listing of the

[14] Thais also applied for patents in Japan and EU, but the number is small with 17 application in Japan and 14 in EU in 2005 (NSTDA 2006).

[15] There are also four different types of patents: utility, design, plant, and reissue patents. A utility patent is often what people refer to when they talk about "invention". In this report, we use both the broad definition of patents and utility patents.

authors can depend on their relative contribution or it can be purely alphabetical. A more stringent way of classifying patents is to assign the patents to the assignees. This provides a sense of patenting ability of national firms in a country, excluding the patents granted to MNCs' local subsidiaries.

All three different approaches were used to extract data from the USPTO data base so as to assess Thailand's patenting ability.

When patents' country origin is linked to the nationality of any of the inventors, Thailand received 565 patents between 1976 to June 2006. Of these, close to 80 percent were assigned to foreign firms (often the right is transferred to their HQ), indicating the dominance of foreign firms in the innovation activity that takes place in Thailand (see Table 1.18). Most of the patents were granted in the last ten years. The number of patents granted increased steadily until 2002, but since then it has been on a downward trend. The latest data showed that a total of a total of 37 patents were granted in 2005, down from the level reported for 1998. The small number of patent applications in 2001 and 2002 may be the reason behind this, but the short time-series of the application data makes it difficult to judge.

If the first-named inventor's country of residence is used as the origin of a patent, there are signs that the dominance of foreign firms in the granting of patents has diminished. The percentage of patents with foreign assignees declined to around 60 percent from 1976 to 2004 (see Table 1.19). This suggests that using any inventor's country of residence as a way of assigning patents' country of origin inflates Thailand's total patents, but also distorts the dominance of foreign firms in patenting.

Table 1.18: Thailand's Patents and Patent Applications

Year	Patents Granted				Patent Applications			
	Total # of patents granted	# of patents granted to Thai assignee	# of patents granted to foreign assignee	% granted to foreign assignee	Total # of patents applied	# of patent applied by Thai firms	# of patent applied by foreign firms	% of applications filed by foreign firms
1995	10	1	9	90	n.a.	n.a.	n.a.	n.a.
1996	12	5	7	58.3	n.a.	n.a.	n.a.	n.a.
1997	18	3	15	83.3	n.a.	n.a.	n.a.	n.a.
1998	37	14	23	62.2	n.a.	n.a.	n.a.	n.a.
1999	49	13	36	73.5	n.a.	n.a.	n.a.	n.a.
2000	41	6	35	85.4	n.a.	n.a.	n.a.	n.a.
2001	63	9	54	85.7	64	2	62	96.9
2002	81	16	65	80.2	57	10	47	82.5
2003	64	12	52	81.3	77	9	68	88.3
2004	49	8	41	83.7	79	9	70	88.6
2005	38	7	31	81.6	42	5	37	88.1
2006	37	10	27	73	n.a.	n.a.	n.a.	n.a.
1995-2006*	499	104	395	79.2	319	35	284	89
1976-2006	565	119	446	78.9	n.a.	n.a.	n.a.	n.a.

Note: Patents are classified as Thailand-invented if the residence of any of the inventors is in Thailand. 2006 data is as of 07/06/2006.
* The patent application data is from 2001 to 2005.
Source: USPTO Patent Full-Text Database and USPTO Patent Application Full-Text Database; author's calculation; author's calculation as of 07/06/2006.

Table 1.19: Foreign Ownership of Asian-Invented Patents, 1976-2004.

	% of patents with foreign assignees, 1976-89	% of patents with foreign assignees, 1990-99	% of patents with foreign assignees, 2000-04	% of patents with foreign assignees, 1976-04
Asian NIEs				
Hong Kong (China)	22.1	30.8	29.1	28.8
Singapore	61.5	57.1	43.6	48
Korea	16.7	4.1	3	3.6
Taiwan (China)	31.6	10.4	5.4	7.3
NIE	25.2	10	7	8.6
China	47.1	59.5	63.2	61.7
India	74.3	57	32.9	43.1
ASEAN-4				
Indonesia	94.1	60.6	33.3	53.1
Malaysia	66.7	76.5	67.6	70.4
Philippines	62.5	98	96.4	93.3
Thailand	84.6	47.8	65.8	60.2
ASEAN-4 Total	74.4	72.7	67.7	70.1
Australia	18	23.7	23.3	22
New Zealand	18.5	27.8	27.2	25.2
Total	23.2	14.7	12.1	13.7
Total (excl Aust, NZ)	32.6	12.9	10.9	12.2

Source: Wong 2006.
Note: Asian-invented patents are so-classified based on the residence of the first inventor. Patents are classified as belonging to foreign assignees based on the first-named assignee.

The data from USPTO also permits a breakdown of patents by class and by country of origin (see Table 1.20). The table below shows the top six classes of Thailand's utility patents: a) drugs, bio-affecting and body treating compositions; b) bottles and jars; c) active solid-state devices; d) electricity: measuring and testing; e) refrigeration; f) and semiconductor device manufacturing process.

Table 1.20: Thailand Utility Patents by Class 1963–2004

Current US Classification	Total
Drugs, Bio-Affecting and Body Treating Compositions (includes Class 514)	12
Bottles and Jars	6
Active Solid-State Devices (e.g., Transistors, Solid-State Diodes)	6
Electricity: Measuring and Testing	6
Refrigeration	5
Semiconductor Device Manufacturing: Process	5
Brushing, Scrubbing, and General Cleaning	4
Metal Fusion Bonding	4
Registers (e.g., cash registers, calculators, devices for counting movements of devices, etc.)	4
Pipe Joints or Couplings	4
Land Vehicles: Bodies and Tops	4
Communications: Electrical	4
Agitating (e.g., of articles and materials)	4
Image Analysis	4
Games Using Tangible Projectile	4

Source: USPTO Patenting By Geographic Region (State and Country), Breakout by Technology Class.
Note: Patent origin is determined by the residence of the first-named inventor.

Using patents granted to Thai assignees allows for a closer examination of local firms' innovative activities. The USPTO Patent and Patent Application Full-Text Database, allows for a retrieval of 141 patent records with Thailand as the assignee's country.[16] However, the majority of these patents fall into the category of industrial design. Only 33 of these patents can be counted as serious 'inventions' – i.e. utility patents.

Among the 33 patents that better represent Thailand's innovation capability, close to 30 percent fall into the category of electricity (see Table 1.21). Another 12 percent consists of patents related to: a) chemical processing technologies, and b) superconductivity, life and agriculture. These

[16]http://patft.uspto.gov/netacgi/nphParser?Sect1=PTO2&Sect2=HITOFF&p=1&u=%2Fnetahtml%2FPTO%2Fsearchbool.html&r=0&f=S&l=50&TERM1=TH&FIELD1=ASCO&co1=AND&TERM2=&FIELD2=&d=PTXT

numbers support the earlier statistics about the areas of strength for Thai firms even though the classification levels are not the same in the two tables.[17]

Table 1.21: Thailand's Utility Patents by Sectors

Sector	Number	As percentage of total patents
Body Treatment Care, Adornment	1	3.03
Buildings	1	3.03
Chemical Processing Technologies	4	12.12
Compositions And Synthetic Resins; Chemical Compounds	1	3.03
Dispensing	3	9.09
Electricity	9	27.27
Information Storage	1	3.03
Measuring, Testing, Precision Instrument	1	3.03
Miscellaneous Treating	2	6.06
Organic Compounds	1	3.03
Superconductivity; Life And Agriculture	4	12.12
Tools	3	9.09
Vehicles	2	6.06

Source: USPTO Patent Full-Text Database; authors' calculations.

Foreign vs. Local Firms: During 2000-06, subsidiaries of foreign firms accounted for about 30 percent of all the patents (i.e. 9 out of 33) (see Table 1.22) granted to assignees in Thailand. Delta Electronics, Inc. (TW) has a total of seven patents (6 in electricity). This company is the single largest recipient (domestic or foreign) of patents. Its Thai subsidiary, Delta Electronics (Thailand) Public Company Limited, is also the co-assignee in all of its patents. Aeroflex International Co., Ltd and NS Electronics Bangkok Ltd are the leading domestic firms in innovation with four and three patents, respectively.

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[17]The 3-digit level classification is used in Table 1.20 while in Table 1.21, a more aggregated description is used as there are only a few data points.

Patent data from Thailand provides an additional perspective. Foreign firms and foreigners are still the driving force behind domestic patent applications and grants (see Table 1.23). The share of patents issued to Thai residents has increased from close to zero to around 11 percent in 2000. Consumer goods and equipment, agricultural food processing, medical technology, and chemical engineering are the leading industries in terms of domestic patents granted.

Table 1.22: Number of Utility Patents Granted by Assignees, 2000–2006

Domestic Firms	# of Patents	Percentage (%)
Aeroflex International Co., Ltd.	4	12.1
Alphatec Holding Company Limited	1	3
Aqua Sonic Service Co., Ltd.	1	3
Biophile Corporation	1	3
Chiang Mai University	1	3
Chulalongkorn University	1	3
Eastern Polymer Industry Co., Ltd.	1	3
Kasetsart University	1	3
L. Electric Glass Co. Ltd.	1	3
Manica-Thai Corp., Ltd	1	3
Millennium Microtech (Thailand) Co., Ltd	1	3
NS Electronics Bangkok (1993) Ltd.	3	9.1
NSTDA	1	3
Safety Inventions, Ltd., Part.	1	3
Sahachol Food Supplies Co., Ltd.	1	3
Salom Electric Co., Ltd.	1	3
Siam Safety Premier Co., Ltd.	1	3
Thajchayapong; Pairash	1	3
The Government Pharmaceutical Organization	1	3
Foreign Firms		
Delta Electronics, Inc. (TW)	7	21.2
Lin; Chuan-Hung (TW)	1	3
Mannesmann AG (Dusseldorf, DE)	1	3

Note: TW – Taiwan (China); DE – Germany.
Source: USPTO Patent Full-Text Database; author's calculation.

Table 1.23: Top 12 Sectors in Terms of Domestic Patent Applications and Grants in Thailand, 2000–2006

Applications		Grants	
Consumer goods and equipment	1033	Consumer goods and equipment	74
Agricultural and food processing machinery and apparatus	390	Agricultural and food processing machinery and apparatus	46
Agriculture, food chemistry	383	Agriculture, food chemistry	42
Transport	360	Medical technology	22
Electrical devices, electrical engineering, electrical energy	334	Chemical engineering	21
Handling, printing	302	Handling, printing	18
Pharmaceutics, cosmetics	270	Environmental technology	17
Chemical engineering	261	Materials, metallurgy	17
Thermal processes and apparatus	255	Engines, pumps, turbines	16
Analysis, measurement, control technology	252	Pharmaceutics, cosmetics	15
Engines, pumps, turbines	237	Chemical industry and petrol industry, basic materials chemistry	15
Mechanical elements	227	Mechanical elements	15

Source: Department of Intellectual Property, Ministry of Commerce.

In addition to data on patents and R&D, the World Bank Institute has also developed a benchmarking system – known as the Knowledge Assessment Methodology (KAM) - to measure a country's competitiveness from the knowledge and innovation perspective. The methodology uses 81 variables covering the four pillars of a knowledge economy – economic incentive regime, innovation, education, and information & communications technologies (ICTs). Each variable is normalized on a scale of zero to ten relative to other countries in the comparison group. The KAM data makes it possible to derive a country's overall Knowledge Economy Index (KEI) as a composite measure. According to the KAM, Thailand has managed to strengthen its knowledge economy over the last decade. However, its overall score is well below the average for East Asia. Furthermore, compared to other regional competitors, Thailand's pace of change is slow. Although Thailand's current knowledge score is still higher than that of the Philippines, China, Indonesia, and Vietnam, it is being overtaken very rapidly (see Table 1.24) and could soon be surpassed by China.

Table 1.24: Knowledge Economy Index, 1995 and 2004-2005

	Knowledge Economy Index	
Region/Economy	1995	2006
East Asia	4.33	6.03
Singapore	7.42	8.2
Taiwan (China)	6.37	8.12
Hong Kong (China)	7.2	7.85
Korea	5.87	7.6
Malaysia	4.79	5.69
Thailand	4.26	4.88
China	2.67	4.26
Philippines	2.99	4.03
Indonesia	2.34	2.96
Vietnam	1.49	2.69

Source: World Bank, K4D program.

From the table, we can see that although Thailand's economy has recovered from the 1997-98 Asian economic crisis, a more competitive global environment and pressures arising rising energy costs, interest rates, and labor costs pose fresh challenges. In some of the key export sectors, including rice, textiles, electronics, and machinery, Thailand's export competitiveness is declining when measured by its global market share and revealed comparative advantage. An analysis of the sources of growth also shows that Thailand's growth still heavily relies on capital and labor inputs instead of TFP growth. The analysis of patenting data shows that the number of patents granted is low and the share of patents granted to Thai nationals and Thai firms is small. If Thailand wants to maintain and enhance its global competitiveness, it must move from the current labor-intensive and resource-based economy towards a knowledge- and technology-based economy. This will entail a much greater emphasis on knowledge accumulation, technology development and its commercialization.

Part 2
Aspects of the KE: International Experience

What can Thailand learn from international experience and how might this be applied locally? In the first section of Part 2 we illustrate the role of a few of the components of the innovation system with the help of specific country experiences that are relevant to Thailand. The components that are dealt here with include: 1) secondary and tertiary education; 2) university-industry linkages; 3) public research institutes and industrial clusters; and 4) organizations or associations which serve as intermediaries for the germination and diffusion of technology. In the second section we present the development of two industries which could serve as Thailand's leading sectors in the coming decade: software and fashion garments.

I. Attributes of a Knowledge Economy

Building Human Capital: Secondary and Tertiary Education

Almost all the countries with world class innovation systems have achieved universal primary education, as well as secondary schooling for two-thirds or more of the population. Access to secondary education for the majority of the relevant cohort is the foundation of a country's innovation system. The quality of a country's secondary education is measured by: 1) completion and repeater rates; 2) by the scores on standardized international science and mathematics tests (TIMSS); 3) by computer literacy; 4) by the numbers of students who go on to the tertiary level; and 4) by the Program for International Student Assessment (PISA) (see Table 2. 1).

India, which is emerging as an innovative economy in a few areas, lags in terms of enrollment rates at all levels. By contrast, China has succeeded in raising its gross tertiary level education enrollment rates sharply, while starting from a lower base.

Most East Asian economies, even those with high secondary level math and science scores based on international tests, are dissatisfied with the quality of their education systems which often emphasize rote learning to the exclusion of analytic and problem solving skills and creative thinking. In addition, while East Asian economies are striving to enhance their technological capability nearly all of the countries in the region – with the exception of Singapore – are still struggling to improve their English language and communication skills, especially since this area is frequently identified as a shortcoming by local firms and MNCs. In this regard, Thailand's reading scores are quite low when compared with other East Asian economies (World Bank 2005a).

Tertiary level education is the second vital element of a country's innovation system. Building technological capability requires a university system of a scale sufficient to generate a critical mass of skills. The volume and quality of available skills, especially in science and engineering (S&E), are necessary ingredients if a country's technological capability is to advance. The industrialized countries have, of course, all passed this threshold as have Thailand's industrializing competitors in East Asia. The supply of available skills is not a binding constraint, although in some of the East Asian economies the quality of tertiary education provided remains an obstacle for technology absorption and innovation.

A strong university system is a stepping stone to the third necessary ingredient for a successful innovation system, namely R&D. This includes R&D conducted by leading universities, research institutes and corporate labs. Yet a focus on R&D is not feasible without a high level of technical skills, which is why raising the quality of at least a network of core universities is intrinsic to efforts to build an innovation system. Although corporations do the bulk of R&D, universities are responsible for basic R&D and some of the related applied research. In general, only the large, elite universities engage in significant amounts of research whether basic or applied. Such R&D activities — and their quality— depend on a variety of incentives and institutional mechanisms, including competition among universities, funding for research, as well as ownership of intellectual property rights. In East Asia, with the exception of a handful of universities in Japan, China, Singapore, and Taiwan (China), few universities do much research or engage in forward linkages with the business sector. Informal links between universities and the business sector can be numerous and fruitful via contract research, consulting, co-authorship of papers, internships and joint research with corporate researchers. These are the avenues through which research oriented universities generate knowledge spillovers that contribute to the knowledge economy. Again, with the exception of the aforementioned countries, universities acquire and license very few patents, and have few spin-offs even when they have established incubators. This is no different from the situation in the U.S. (Yusuf and Nabeshima 2007).

Taiwan (China) invested heavily in higher education from the 1950s and into the 1980s, with an emphasis on S&T skills and on sending students abroad for higher education. The sector experienced a massive expansion from 1952 to 1989: the number of tertiary education institutions rose from four universities and four junior colleges to 42 universities and 75 polytechnics or colleges with a total enrollment of 462,500 students (Hou and San 1993). The increased supply of human capital, especially in the S&E field, played a significant role in raising Taiwan's industrial and export performance (Lin 2004). Likewise, starting in the mid-1980's The Republic of Korea poured resources into tertiary education that included a focus on engineering skills for targeted industries. As a result, by the turn of the century Korea's higher education enrollment rate surpassed that of the U.S. (Mowery 2005; Mazzoleni 2005; Mathews and Hu 2007). This surge can be attributed to the realization that underinvestment from the 1960s until mid-1980s had negatively affected the quality of both education and research, as well as resulted in a lack of highly trained scientists and engineers. Supporting this build up was the training of Korean students overseas with the help of foreign aid which became available in the 1950s. By the early 1990s, the ratio of foreign-trained post-secondary students to all post-secondary students in Korea was twice as great as in Argentina, Brazil, and India, and higher than in Mexico (Kim 1993).

China and India, the two largest developing countries in the world, have been also attempting to enlarge their stock of human capital. From 1998 to 2005, the Chinese government dramatically expanded the country's higher education system. The annual incoming cohort of students jumped from one million in 1998 to five million in 2005, an average increase of 20 percent per year.[18] China's gross enrollment rate for higher education rose from 5 percent in 1998 to 21 percent in 2005. Emphasis is also being placed on the quality of teaching and research by increasing competition for faculty positions, such as through more exacting promotion policies, merit pay and greater flexibility in personnel management.

[18] A total of 4.1 million students graduated in 2006.

Meanwhile, India's higher education system has experienced relatively modest expansion, with student enrollment growing by about 5 percent annually over the past two decades. The country's gross tertiary level enrollment rate was 11 percent in 2003. Despite persistent problems in the higher education sector, the quality of India's elite universities has impressed the world. Indian Institutes of Technology (IITs) are among the finest in the world, on par with MIT and the California Institute of Technology (Caltech). The National Law School (Bangalore) is the best in India and many of its students have won Rhodes Scholarships to Oxford, while the All India Institute of Medical Sciences is consistently rated as the top medical school in the country and one of the best in the world. The Indian School of Business (Hyderabad) and the Indian Institutes of Management (IIMs) are the top management institutes in India and also on par with the world's leading international business schools.

University-PRI-Industry Linkages

Korea, Taiwan (China), and Singapore, and now China and India, are all promoting their universities and public research institutes (PRIs) as champions of a new style of innovation by encouraging patenting, publishing in key scientific and technical journals, as well as the spinning off new enterprises.

The government of Taiwan (China), for example, laid down a general "Basic Law on Science and Technology" in 1999 which reorganized the management of Intellectual Property Rights in public institutions in approximately the same manner as the Bayh-Dole Act in the US. This had a significant impact on the transfer of technology from Taiwanese universities to private industry. The number of technology licensing agreements in Taiwan rose from 40 in 2001 to 1,341 in 2004, while licensing revenues also increased dramatically to reach US$ 4.6 million in 2004 (Mathews and Hu 2007).

The Chinese government views the commercialization of scientific research results as a means of generating more revenue for education, in addition to the contribution this makes to industrial technology. University faculty members and staff at the country's PRIs are allowed to spend one day per week consulting. Since the urban reform in the mid-1980s and particularly since the early 1990s, many spin-off companies from universities and PRIs have emerged. Despite ill-defined property rights and the reluctance of the parent institution to surrender control, these Chinese spin-offs have managed to survive and gain considerable market share. One of the most famous cases is Lenovo Group Limited, the largest personal computer manufacturer in China which acquired the PC division of IBM in 2005 and went on to become the world's fourth largest producer of laptops in 2007.[19] In 1984, Lenovo (or Legend as it was then known) was spun off from the Institute of Computer Technology at the Chinese Academy of Science (CAS), which serves as the national academy for the natural sciences of China, with a US$ 25,000 loan and office space for a staff of 10 people. The founders remained employees of the CAS even though they worked primarily at the firm (Lu and Lazonick 2001).

Two spin-off companies, the Founder Group and the Tongfang Group from Beijing University and Tsinghua University, respectively, went on to generate revenues of close to US$3 billion each in 2005. As of 1999, 15 firms from 13 different university research institutes (URIs) were listed on the Shanghai and Shenzhen stock markets. This figure increased to 29 firms in 2003. Although only 45 percent of all URI -affiliated enterprises are in high-tech fields, the URI-firms in high-tech produce more than 80 percent of the total revenue (Chen and Kenney 2007).

Public Research Institutions (PRIs) as Technology Incubators

Given the heavy load of teaching and administrative responsibilities, as well as the inadequate capacity of most universities to engage in scientific research, governments have often relied on newly-established PRIs to absorb or generate cutting-edge technologies and diffuse them to the relevant industrial sub-sectors.

In East Asia, PRIs with technology 'sentinel,' assimilation and development functions are quite common. But their track record is mixed. Many of these PRIs, especially the smaller ones in Korea, Japan, Vietnam, and Malaysia, have failed to achieve critical mass, and the level of quality and heterogeneity of their staff were insufficient to produce any significant results (Kim 1997). Also, the weak incentive mechanisms at government laboratories

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[19] The emergence and growth of Legend (later Lenovo) in the late 1990s and the early 2000s, is well described by Ling (2005) with special emphasis on the leadership of Liu Chuanzhi.

frequently discourage research initiatives that are deemed to be risky, as well as the commercialization of findings.

However, PRIs can sometimes achieve remarkable results if they have the right leadership, adequate funding, sufficient scale and the appropriate focus. For example, ITRI in Taiwan (China), and to a lesser extent KAIST/KIST in Korea, have acquired legendary status and spurred the creation of a host of imitations. ITRI (see below) through its Electronics Research Services Organization (ERSO) single-handedly galvanized the electronics industry in Taiwan (China) through the transfer of semi-conductor production technology from the U.S. (Mowery 2005; Huang 2006). ITRI is the cornerstone of Taiwan's innovation system, and has assisted thousands of firms to identify and develop technologies through search, assistance with product development, design and troubleshooting. The Chinese Academy of Sciences (CAS) in China has also been a valuable source for research and product development that has resulted in numerous spin-offs (See Yusuf and Nabeshima 2006a; Sigurdson 2005).

PRIs in Taiwan (China)

The Industrial Technology Research Institute (ITRI) was established in 1973 with five major divisions with the aim of supporting various categories of industrial technology. In 1974, the Electronic Research and Service Organization (ERSO), ITRI's first laboratory, was created to advance the development of the electronics and information technology industry in Taiwan (China). This was followed by the establishment of the Institute for Information Industry (III) in 1979 to introduce and develop software technology and its applications.

PRIs in Taiwan (China) have played a decisive role in absorbing and diffusing state-of-the-art technology, as well as upgrading Taiwanese firms' technology. One of the mechanisms used by Taiwanese PRIs for diffusing technology has included the transfer of new technology to individual firms through licensing agreements that provide for the levying of royalty charges on the recipient firms. Moreover, in cases where there is sufficient market potential, a new joint venture would be spun off by ERSO with the support of ERSO's engineers and funding from the government. Subsequently, a new private company would be organized with the non-government share rising to at least 60–70 percent as soon as conditions permitted (Nelson 1993).

Soon after it was created, ERSO was entrusted with the task of helping to build Taiwan's semiconductor industry. After reviewing the options, and with the assistance of overseas Chinese advisers, ERSO was able to enter into a contract with RCA in 1976. Under this contract, RCA transferred its earlier generation 7 micron micro chip technology, helped train 40 engineers and set up a demonstration plant in 1977 (Huang 2006). From RCA's perspective, this 7 micron technology was far behind the then frontier 2 micron technology. Nevertheless, the equipment and training that ERSO received enabled it to enter the world of advanced semiconductor production technology.

However, the private sector still viewed the semiconductor business as too risky (Mathews and Cho 2000). In 1980, this induced the Ministry of Economic Affairs to spin-off a privately owned IC manufacturing firm, United Microelectronics Corporation (UMC), which took possession of ERSO's production facilities. By 1982, UMC was able to undertake mass production of 4 inch wafers.

By the mid-1980s, ERSO had shifted its attention to the development of 1.5 micron VLSI technology and entered into a cooperation agreement with Mosel-Vitelic, an American company set up by overseas Chinese. At that time the idea of a dedicated silicon foundry came to the fore. By 1987, the ITRI was able to spin-off a second company – Taiwan Semiconductor Manufacturing Corporation – with the support of Philips (Huang 2006). TSMC and UMC created a freestanding silicon foundry business in Taiwan which produces chips under contract for "fabless" design houses. Today, TSMC and UMC are the country's dominant global silicon fabricators that together with other spin-off companies[20] and private companies, were responsible for the rise of "a silicon valley of the East" (Mathews and Cho 2000).

Korean PRIs

The Korean government established the Korea Institute of Science and Technology (KIST) in 1966 to initiate the development of technology and the recruitment of a core foreign trained Korean scientists and engineers. These efforts to upgrade technology were intensified with the setting up of the Korean Advanced Institute of Science in 1971. The latter merged with KIST to form the

[20] These include Winbond and Vanguard (Breznitz 2005).

Korean Advanced Institute of Science and Technology (KAIST), which also provided employment for locally trained S&E workers. Throughout the 1970s, few linkages with industry materialized largely because researchers lacked the expertise to develop prototypes and other manufacturing know-how that were in high demand at that time. But KAIST did facilitate technology transfers from foreign companies to Korean firms by strengthening the latter's bargaining power.

Other more specialized PRIs were set-up in the 1970s. For example, the Korean Institute of Electronics Technology (KIET) was established in 1976 to focus on the development and transfer of semiconductor technology to Korean firms, as well as to carry out market research. KIET was responsible for Korea's first VLSI pilot wafer-fabrication facility, a joint venture with Silicon Valley based firm known as VLSI Technology. Some observers believe that KIET acted much like the ITRI/ESRO by making it possible for private firms such as HEI and Gold Star to gain traction and acquire production capabilities (Department of Commerce 2003). By contrast, others think that KIET was for the most part inferior in terms of the quality of its skill base and research capability and that most of the credit for Korea's successes in the electronics field should instead be attributed to the efforts of private electronics firms (Kim 1998). Similar questions have arisen regarding the contribution of Korean PRIs that specialize in chemicals, machinery and biotechnology. The results have been fairly mixed and for this reason most observers agree that Korea's technological advances have been driven mainly by the R&D carried out by private sector firms.

Brazilian Agricultural Research Corporation

Brazil's national network of agricultural research centers closely resembles the land grant universities in the U.S. The Brazilian Agency for Research on Agriculture and Animal Husbandry (EMBRAPA) was established in 1973 and is headquartered in Brasilia. It is tied to the Ministry of Agriculture and partly funded by taxes levied on agro-industrial firms. It has 40 research centers scattered across Brazil and its 2,221 researchers work on projects linked to animal husbandry, the agro-industry and the environment.[21] EMBRAPA's R&D efforts are coordinated with the activities carried out by Sistema Nacional de Pesquisa Agropecuária (SNPA), a national network comprised of several public institutions, universities, private firms and foundations that have a broad research mandate ("EMBRAPA" 2006).

EMBRAPA and its sister organization in Argentina are examples of successful, public sector-led agricultural technology development institutes that have nurtured and harnessed the capabilities of the private sector. One of EMBRAPA's achievements was the breeding of a tropical soybean adapted to a shorter day length and a milder climate. Others successes include the development of corn and cotton varieties that are ideally suited to Brazil's soil conditions.

Malaysian Palm Oil Board

The palm oil industry in Malaysia is an example of how a country can leverage its comparative advantage in a resource-based product and develop an entire value-chain (Rasiah 2006).[22] Much of the research needed to improve production techniques and the development of new products based on palm oil was conducted by the Malaysian Palm Oil Board (MPOB).[23] The MPOB was established in 2000 following the merger of the Palm Oil Research Institute of Malaysia and the Palm Oil Registration and Licensing Authority. The MPOB's budget is comprised of taxes on palm oil and palm kernel oil, as well as budgetary allocations from the government. The governing board of MPOB consists of representatives from the related industries and various government ministries. The Program Advisory Committee, which is made up of prominent scientists (domestic and foreign) and experts in the palm oil field, make recommendations to the board on the direction of the MPOB's research

[21] Through a similar network of mainly public institutions Argentina is becoming a world leader in the production of agricultural mechanized seeders.

[22] The first commercial planting of palm oil began in 1917. In the late 1960s, the Malaysian government encouraged the palm oil industry to diversify its exports from rubber and tin. Since then the planting of palm trees increased dramatically, covering 3.3 million hectares as of 2000. Furthermore, the transition from the export of crude palm oil to processed palm oil was highly successful to where Malaysia now accounts for more than two-thirds of global exports of processed palm oil (Rasiah 2006).

[23] Malaysian universities and the Malaysia Agricultural Research and Development Institute also conduct research in this area (Rasiah 2006).

activities. Currently, the MPOB's research activities are focused on three areas: 1) to raise the income of palm oil farmers through improving yield; 2) to find uses for the waste materials from palm oil production; and 3) to add value to palm oil products (Malaysian Palm Oil Board 2006).

With a much larger pool of resources than any other single public research entity and with consistent attention to feedback from industry to ensure that its research activities are in line with industry needs, the MPOB has contributed significantly to the development of Malaysia's palm oil industry such as through the introduction of weevils to improve pollination (Pletcher 1991). Drawing upon the largest collection of palm oil germplasm in the world, the MPOB is developing various planting materials such as PS1 and PS2, which are higher yielding and shorter in height than normal commercial planting material. The MPOB is also applying the tools of biotechnology and gene technology in order to multiply the range of downstream products derived from palm oil, such as vitamin E pills, personal care products and edible oils. More than 300 new technologies have been developed in-house and many are being pressed into commercial use (Malaysian Palm Oil Board 2006). Furthermore, development of bio-diesel based on palm oil has gained momentum in recent years due to concerns about global warming.

The MPOB's research activities are actively supported by government funding. Researchers who are interested in palm oil-related research can access RM1 billion that was allocated for the Intensification of Research in Priority Areas (IRPA). This program was initiated in 1986 and is still an important component in Malaysia's Ninth Plan. In addition to funding for research, the Second Industrial Master Plan also promoted the development of industries associated with the palm oil industry, such as packaging and machinery, along with the promotion of higher value-added activities in the palm oil industry including biotech research (Rasiah 2006).

Industrial Clustering

Industrial clusters are concentrations of firms in one or a few industries that benefit from synergies created by a dense network of competitors, buyers and suppliers, as well as shared labor markets. Such industrial clusters make investment more efficient and increase returns via technological spillovers (Yusuf and others 2003; Cooke 2002; Bresnahan and Gambardella 2004). The clustering of firms introduce competitive pressure for constant innovation, while participants also benefit from reciprocal exchange and collaboration (Yusuf and others 2003).[24]

Happenstance, local institutions, locational advantages and market forces clearly constitute a large part of the story underlying the most successful innovative clusters (). The industrial clusters in Silicon Valley and in Silicon Fen in Cambridge, UK were buoyed by successful entrepreneurial activity arising out of the corporate sector and world class universities, with some assistance from government R&D and procurement policies.

For latecomer countries, institutional failures and coordination problems make it difficult for industrial clusters to emerge autonomously. Cross country experience suggests that industrial clusters can be induced through collaboration among business, academia, national and local government, as well as developers. However, there are no universal rules on what works in forming industrial clusters. Policies need to be tailored to a location's unique characteristics, and in the absence of well-tried formulae the majority of initiatives do not lead to viable industrial clusters.

Necessary Conditions for Clusters and Government Policy

Most industrial clusters, especially in low-tech fields, trace their origins to traditional craftsmanship, abundant natural resources, the presence of universities or a peculiarly advantageous geographic location. These advantages accumulate over decades or even centuries. The Tsubame silverware and kitchen utensil cluster in Japan originated in the Edo period (1603–1865), when it produced traditional Japanese-style nails, making use of the copper mines nearby. The shoe industry around Marikina City in the northeast of the Manila Metropolitan Area germinated over a century ago (Scott 2005). Government cannot invent a history or tradition for a location, but it can help to retrieve the history through research or by identifying a particular market niche.

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[24] Recent econometric research on the spillover effect of FDI in the UK and Ireland shows that pre-existing industry clusters not only have a significant role in attracting FDI but also facilitate the technology transfer from MNCs to local firms (Barrios, Bertinelli, and Strobl 2006; De Propris and Driffield 2006).

Financing: Resources which can give rise to an industrial cluster can take the form of personal savings, remittances from expatriates, foreign direct investment, angel investors, commercial lending, government preferential loans, etc. But for high-tech industrial clusters venture capital and angel financing (public or private) assumes an increasingly dominant role. In most latecomer countries, the government has helped launch venture capital activities. However, after an initial stage the government's role should probably focus on encouraging the development of a venture capital industry through tax policy rather than directly allocating loans or venture capital.[25]

University and/or Research Institutes: Universities and research institutes are integral elements and focal points of an industrial cluster because the success of an industry hinges on the availability of entrepreneurs and skilled workers. University graduates and trained professionals are ideal candidates. High quality research and teaching skills at universities enhance the reputation of an institution and an urban center. These help attract the brightest students, releases them into the urban region when they have finished their studies, and assists with the development, diffusion and commercialization of both existing and new knowledge (Intarakumnerd and Chairatana 2003). Universities and research institutes can serve as technology incubators that facilitate technology transfer and generate spin-off companies equipped with state-of-the art technology (Breznitz and Anderson 2006). However, their respective roles in the formation of industrial clusters and importance can differ from place to place (Intarakumnerd and Chairatana 2003).

Professional Intermediaries and Suppliers: Professional intermediaries such as accounting firms, law firms, consulting firms, industry, professional associations, as well as numerous suppliers of inputs and technical or support services, assist in the growth of industrial clusters but are not essential to their formation. They contribute to the forming and functioning of an industrial

[25] Public provision of venture capital, widely practiced in East Asian countries, has not yet had much effect on high-tech employment, and it risks crowding out essential private venture capital (Wallsten 2000). The Israeli government did provide the seed money through the Yozma Program for its venture capital industry to thrive, but subsequently sold the Yozma Program to the private sector (Avnimelech and Teubal 2006; Frenkel, Shefer, and Miller 2005).

cluster by controlling the transaction costs and facilitating information flow (Bresnahan and others 2001; Intarakumnerd 2005).

External Skills and Talents: Developed countries have long reaped the benefits of a large and growing skilled work force by attracting people from all over the world. Recent evidence from the development of the semiconductor industry in Taiwan (China) and Korea defines the contributions made by foreign-educated expatriates, as well as the large diaspora of technical workers and entrepreneurs. Developing countries will constantly face the challenge of competing with developed countries, as well as NIEs, for talented brains. Governments of NIEs such as Thailand must both encourage students to study abroad and at the same time formulate policies that attract them as well as foreign nationals back.

Furthermore, governments can contribute significantly to the development of urban clusters by investing in physical infrastructure, as well cluster-specific technological information and labor training services. These are public goods that individual firms have no incentive to produce.

II. How Intermediaries Can Contribute

Intermediary organizations can provide invaluable inputs and help catalyze technology diffusion by fostering ties between universities and firms, links among firms in a region and providing access to key business services to SMEs. There are many examples of intermediary organizations in other countries that have made such contributions. Here we examine three cases from the U.K., Canada and Japan which could serve as models for similar organizations in Thailand.

Knowledge Integrating Community (KIC)

The concept of a Knowledge Integrating Community (KIC) is an initiative orchestrated by the Cambridge University-MIT Institute (CMI). A KIC involves academia, industry partners and policy makers. Rather than involving the unidirectional transfer of knowledge from universities to industries, KIC projects consist of a team-based, multidisciplinary and multidirectional approach that bring in diverse sets of people who may not have had the opportunity to interact with each other if it were not for the KIC. CMI views each project as an experiment, grounded in analytical and investigatory methods derived from the sciences to study "the process of how knowledge exchange encourages innovation, and to codify and disseminate the outcomes of each experiment" (Acworth and Ghose 2006, p.14). A project typically has industry-wide implications and is grounded in science and research based solutions,[26] and substantial funding is required for each project, a minimum of £1-2 million per annum. There are six key components to a KIC: 1) research universities; 2) industry; 3) government; 4) education; 5) knowledge exchange; and 6) the study of innovations in knowledge exchange. Naturally, research entities lead the research component of the project. These entities have been universities (especially Cambridge University and MIT), but they can be any research oriented organization such as a central corporate R&D lab or public research institute. Since the focus is on "consideration of use", each project needs to be aligned with industry's needs and participation by the industry is essential to identify the issues that need to be tackled. Government participation is needed for projects that may involve regulatory and policy issues. Even beyond these aspects, participation by public officials is beneficial to guide the development strategies of an industry or an economy. Involvement of education institutions builds human capital, and provides opportunities to engage in hands-on experience, as well as training in entrepreneurship (Acworth and Ghose 2006).

The knowledge exchange component is the main theme of the KIC model in order to facilitate the multidirectional exchange of ideas. To achieve this goal, KIC projects typically include annual or semi-annual workshops that bring all of the stakeholders together, the exchange of personnel, web spaces, e-newsletters, videoconferences and other opportunities for interaction. The

[26] Other forms of support typically focus on either the funding of research conducted mainly at universities and other research institutes (for instance, the National Science Foundation (NSF) in the United States and various research councils in the United Kingdom) or acting as a network agent to facilitate the formation of partnerships between firms and universities without providing much funding. Funding can also come from other sources (such as the NSF or research councils) once a suitable collaborative project is identified. Such collaborative work tends to be only a one-to-one engagement (Acworth and Ghose 2006). For instance, the Council for Entrepreneurial Development in Research Triangle Park in North Carolina comprises of members from universities, from industry and from government agencies who assist in the development of new companies, as well as provide practical training, education and mentoring to local firms (Smilor and others 2005). However, they do not possess the financial resources of KIC type bodies.

final component assesses the impact of a KIC in order to further improve the KIC's model. This comprises of two parts: impact evaluation and dissemination of best practices (Acworth and Ghose 2006).

Each KIC project has three top-level management teams. Two principle investigators are responsible for overseeing research activities, similar to the function they provide under any research funding situation. The third, a KIC manager, is not responsible for research activities, but is instead responsible for coordinating various activities within a KIC project and managing non-research components of the KIC. The experience so far suggests that a KIC manager is vital for the success and sustainability of KICs. A KIC manager should have budgetary authority at least for the non-research component) and also be responsible for performance incentives to raise enough additional outside funding (Acworth and Ghose 2006).

Depending on the nature of the project this partnership can be virtual, though the physical distance that often separates the participants can pose difficulties despite the advances in telecommunication technologies (Acworth and Ghose 2006).

The KIC model is particularly well-suited for cross-disciplinary initiatives that require multiple types of specialized inputs. Universities are often the only entity with a wealth of experts in many different fields.

Remaining Challenges:

One of the challenges identified so far is the difference in the time-horizons of stakeholders over the lifecycle of a given project. Many participants involved in KICs are tenured university faculty members who have rather long time horizons. By contrast, their students and the participants from industry do not have such long time horizons. Government agencies also have different time horizons.

Another issue is the assignment of intellectual property (IP) rights. The US model, which gives IP rights to universities, was found to be unsuitable for a KIC because it is costly to administer due to the involvement of multiple parties with multidirectional flows of knowledge.

Co-op Program at the University of Waterloo

The University of Waterloo has an extensive co-op program that involve 11,000 students (equivalent to 60 percent of the student body) and 3,000 firms each year. This program enables students to divide their time between the university and an employer's work site. The typical work period is four months out of the year.[27] From the firm's perspective, this co-op program offers several benefits. The co-op program is a source of new hires since firms can evaluate the would-be graduates before actually hiring them. Furthermore, these students are the sources of the latest knowledge. From the student's point of view, the program offers valuable work experience and an opportunity to evaluate a would-be employer. Moreover, students act as the conduit for bi-directional knowledge transfer between the university and local firms. A student in the co-op program often works on an applied technical problem at a local firm. Such first-hand experience can also influence the material presented in the classroom once these students return to the university. In addition, the students who participate in this co-op program are often the entrepreneurial driving force behind spin-off firms (Bramwell and Wolfe 2006).

TAMA Association

The TAMA Association was established by the Kanto Regional Bureau of International Trade and Industry (a regional bureau of the Ministry of International Trade and Industry (MITI))[28] in Japan to promote linkages between universities and industries, and among firms in the region, as a part of its industrial cluster program. The TAMA Association also established a technology licensing office in 2000. The membership of the TAMA Association includes 362 corporations (including financial institutions), 39 individual researchers, 40 universities and other tertiary institutes, 84 chambers of commerce and other industry/trade association, 22 local governments, as well as 137 TAMA coordinators. TAMA coordinators are experts who provide specialized services to members such as business consulting, engineering

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[27] http://www.cecs.uwaterloo.ca/students/prospective/

[28] After the reorganization of ministries in Japan, MITI was renamed as the Ministry of Economy, Trade, and Industry.

consulting, IT solutions, finance/accounting/tax services and patent administration (Kodama 2006).[29]

The responsibility for funding the TAMA Association's activities comes in equal portions from membership fees, consigned tasks from public and private organizations (33%) and various government subsidies (Kodama 2006).

The TAMA Association's main activities include:

- The dissemination of information among members on products, technologies, and research activities.
- Provision of TAMA coordinators to member firms to solve specialized problems at hand.
- Supporting R&D activities of member firms by assisting with the application process for various R&D subsidies offered by various government agencies, coordinating joint research between firms and universities, as well as coordinating the formation of R&D consortia.
- Networking events for member firms, universities, entrepreneurs and venture capitalists.
- Matching of workers with relevant skills to local industries.
- Sharing of existing research equipment at various locations (universities, firms, public research institutes) among members.
- Assistance for the sale and marketing of products developed in the TAMA region both domestically and internationally.

The TAMA Association is able to reduce the search costs by matching firms that need some assistance with their R&D activities and universities that could potentially offer required inputs. Furthermore, by having a number of universities and research institutes as members, the TAMA Association has suitable equipment that can be shared among members. In addition, having financial institutions as members helps to enhance the credibility of the TAMA

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[29] Similarly, the University of California, San Diego (UCSD) has a program called UCSD CONNECT, which has about 1,000 members with 50 new firms starting up every year. Its main activity is the "springboard" program where entrepreneurs can present their business ideas to local professionals for their feedback. UCSD also provides workshops, conferences, networking events, venture fairs and investment seminars (Smilor and others 2005).

Association and its collaborative R&D projects since the fruit of its research can be financed by member banks (Kodama 2006).

III. Lessons for Thailand's Software and Fashion Industries

Universities and PRIs have a valuable complementary role to play in the development of an industry's technological capability. From Thailand's perspective, the experiences accumulated the software industry in India and the global fashion industry can provide valuable lessons on how to best design a national innovation system.

India's Software Industry: Lessons for Thailand

Since the mid-1980's the IT-ITES (or Information Technology Enabled Services) industry in India has experienced spectacular growth. In FY2006, the IT-ITES industry in India achieved revenue of US$36.0 billion and exports of US$23.4 billion. Since 2000, the industry's annual growth in turnover and exports has been remarkable, averaging at 30 percent and 31 percent, respectively. The industry's strength is in services, which were initially provided on-site. Today, however, much of the industry's revenues are generated by services that are provided by Indian companies on an offshore basis. The ITES industry has grown alongside the development of the software industry to provide back office support for firms in developed countries, mainly in the United States. Indian firms have also emerged as global players in the consulting industry to where they now compete head-to-head with established MNCs (see Table 2. 1).[30] The IT industry employs about three million workers, mainly concentrated in six urban centers, of which Bangalore is the best known.[31]

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[30] The success of the Indian IT industry has been strongly influenced by the unusually dynamic performance of a small number of firms, with Wipro, Infosys, TCS and Satyam being the most prominent. These firms have succeeded not only because of the keen entrepreneurship of their capable CEOs, but also because of their manpower policies and their ability to continuously diversify and upgrade their services so as to meet and to create market demand. A detailed account of the winning formula adopted by Wipro can be found in Hamm (2006).

[31] The software sector in Europe employed 2 million workers in 2001 (Steinmueller 2004).

Table 2. 1: Major ITES companies in the Offshore Outsourcing World

Business Services	Software Development	Call Centers
1. Hewitt Associates (U.S.)	1. Tata Consultancy Services (India)	1. Convergys (U.S.)
2. ACS (U.S.)	2. Infosys Technologies (India)	2. Wipro (India)
3. Accenture (U.S.)	3. Wipro (India)	3. ICICI OneSource (India)
4. IBM (U.S.)	4. Accenture (U.S.)	4. ClientLogic (U.S.)
5. EDS (U.S.)	5. IBM (U.S.)	5. 24/7 Customer (India)
6. Hewlett-Packard (U.S.)	6. Cognizant Technology Solutions (U.S.)	6. SR.Teleperformance (France)
7. Wipro (India)	7. Satyam (India)	7. eTelecare International (U.S.)
8. HCL Technologies (India)	8. Patni Computer Systems (India)	8. SITEL (U.S.)
9. Tata Consultancy Services (India)	9. EDS (U.S.)	9. Teletech (U.S.)
10. WNS Global Services (India)	10. SC (U.S.)	10. CustomerCorp. (U.S.)

Data: Gartner Inc. Ranking is based on the frequency of queries from Gartner's 10,000 global clients.
Source: "The Future of Outsourcing" 2006.

What are the policy actions associated with the emergence and the growth of the software industry in India? Broadly speaking, five key factors were responsible for the development of the software industry in India.

- Abundance of skilled workers with good English skills.
- Global linkages.
- Establishment of software parks and preferential polices towards the IT industry.
- Investment in physical infrastructure.
- E-government initiatives.

Human Capital

Following an early and key strategic decision made in the early 1950s, the Indian government went on to invest significant resources in the country's elite science and engineering education system. The first Indian Institute of Technology (IIT) modeled on MIT was established at Kharagpur in West Bengal. This was followed by the creation of six more IIT branches, including one in

Hyderabad, after the passing of the Indian Institute of Technology Act in 1956. These seven IITs have a total student body of close to 30,000 (17,000 undergraduates and 13,000 graduate students). In addition, six Indian Institutes of Management (IIMs), the recently founded Indian Institutes of Information Technologies (IIITs) and the universities have supplied workers equipped with engineering, management and IT skills along with a good command of English. India's capacity to train accredited engineers rose from 60,000 in 1987-8 to 340,000 in 2003. Moreover, the number of IT professionals in the country rose from 25,800 to 250,000 over the same period (Arora and Gambardella 2004).

Recently, the government of India, the Indian software industry association (known as NASSCOM), the state government of Karnataka and several transnational corporations established the Indian Institute of Information Technology (IIIT) in Bangalore. The IIIT aims to link academic technical training with hands-on business experience. A similar institute has been established in Hyderabad (Biswas 2004). Bangalore's IIIT is located in the "Electronics City", which was created by the government in 1985 to encourage close academic-business interaction with IT firms, including firm-specific training (D'Costa 2006), while the IIIT in Hyderabad is located in HiTEC city (Biswas 2004).

Initially, many of the industry's highly-trained workers needed to work abroad because of the limited market for software development within India and the lack of computer hardware domestically. India-trained engineers and scientists acquired a good reputation for their quality and training, thus creating a positive image for Indian workers in general. Furthermore, many of these former graduates deepened their education and experience abroad. The cost of telecommunications declining and advances in telecommunication technologies made it possible to outsource a host of services such as data entry, back office services, information processing of all kinds, as well as some types of engineering, retail and medical services. The former graduates utilized this overseas experience to set up their own businesses or to work for firms, local and multinational, operating in India.[32] The Indian diaspora with professional

[32] In fact 71 of 75 MNCs operating in Bangalore's software park were headed by an Indian who had lived overseas, and many of the smaller companies are owned by Indian entrepreneurs residing in the U.S. (Saxenian 2006). Close to 10 percent of IT firms located in the Software Technology Park in Hyderabad were founded by such returnees (Biswas 2004).

and business backgrounds was also instrumental in creating global networks connecting US-based and India-based firms, and the funneling of contracts to them (Saxenian 2006).

Few countries could match India's mix and volume of English speaking skilled workers. Moreover, Indian companies and IT professionals had the added advantage of a long exposure to and involvement with leading companies U.S. companies in the fields of IT, reengineering corporate structures and outsourcing services. This experience was reinforced by the presence of thousands of Indian professionals in the U.S. that began in the 1980's. As a result, Indian IT firms had a head start in the outsourcing market, which accounts for their heavy dependence on exports, especially to the US market (at nearly 65 percent) (D'Costa 2006).

Global Linkages

At the beginning, key multinational corporations played a role in the development of India's IT industry. The establishment of Citibank Overseas Software Ltd. in 1984 was probably the first example of the outsourcing of business processing (Giarratana, Pagano, and Torrisi 2003). In 1985, Texas Instruments (TI) established a facility in India to develop and support electronic data automation software.[33] TI also brought a dedicated satellite link with them when they entered the market, and the company leased out the excess capacity to local firms. The success of TI's case demonstrated to other firms in the United States that offshore development work could work and soon thereafter Microsoft, GE, HP and Motorola entered the market. This motivated Indian firms to take advantage of the offshore servicing model by working with MNCs, when domestic demand was still small. Thus, many of the firms that have emerged were already outward-oriented and derived the bulk of their revenues from exports (Giarratana, Pagano, and Torrisi 2003).

TI was attracted to Bangalore because of an abundance of S&T workers with English language skills. This was related to the presence of research oriented defense facilities and training institutions, as well as the fact that Bangalore was the center of India's fledgling aircraft industry (Basant and

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[33] Bangalore was one of the few cities in India that expatriates working for IT firms were willing to live (Lateef 1997).

Chandra 2005).[34] The foreign presence and American companies' increasing familiarity with India and Indian S&T workers enabled Indian firms to build up contacts, usually via on-site work, carried out by Indian professionals for American firms. This included software enhancement and maintenance, the writing of code, engineering design and other related projects which harnessed specific skills that were plentiful and very low priced.[35] MNCs also assisted in the development of the software sector by way of start-ups. After learning the ropes and acquiring contacts in India, former employees at IBM and TI branched out and went on to build their own thriving businesses (Giarratana, Pagano, and Torrisi 2003).

Software Parks

A second complementary strategic decision by the Indian government was to create software technology parks (STP) in a number of cities, starting with one in Bangalore in 1988 (Thatchenkery, Kash, and Stough 2004). Under this scheme, a package of incentives was offered and today some 18 parks are operating in cities across India (Sen and Frankel 2005).[36]

The Software Technology Parks of India (STPI), under the Department of Electronics of the Ministry of IT and Communications, were successful in attracting investment from MNCs, as well as medium and large-sized Indian firms. These software parks provide special incubator facilities for SMEs. Firms located within these software parks were granted generous fiscal incentives, such as income tax exemption for profits generated from software exports (1991); exemptions from sales tax on IT goods (2000); exemption of stamp duty and registration tax for property; preferential loans; and favorable zoning policies for IT firms located within the park(s) (Mitra 2003).[37]

These fiscal incentives were coupled with the liberalization of the IT industry in general. Of importance in this area was the reduction in tariffs

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[34] Hindustan Aircraft Ltd. later merged with Aeronautics India to become Hindustan Aeronautics Ltd. in 1964 (Basant and Chandra 2005).
[35] During 1999–2001, roughly half of the petitions for H1B visas (work authorization for skilled workers in the United States) were granted to Indians (Cooper 2006).
[36] The number of software technology parks increased from 164 in 1991–92 to 1,400 in 1999–2000 (Giarratana, Pagano, and Torrisi 2003).
[37] Such tax incentives was used extensively in Ireland to lure MNCs to locate their facilities to serve European markets (Arora and Gambardella 2005).

associated with software imports. At the highest, the import duty was 114 percent, but this was gradually reduced to zero. In addition, the EXIM Policy of 1999 made it possible to import computers without obtaining licenses, thus stimulating the adoption of PCs within India that was critical for the writing of software (Mitra 2003).

A third inadvertent strategic decision was "benign neglect" of the IT sector by the government, which enabled software firms to avoid the stifling regulatory embrace of the government under a regime which has come to be known as the "license raj" (Arora and Gambardella 2005). A survey conducted in 2001 identified procedural bottlenecks and customs clearance as two major impediments faced by Indian manufacturers. The software industry has been able to avoid these because of the nature of their products (services) and was able to export without much interference (Contractor and Kundu 2004).

Investment in Physical Infrastructure

India has invested steadily in telecommunication infrastructure and internet connectivity. Since the bulk of India's software exports are services oriented, communication infrastructure is the key component to ensure the seamless collaboration with external clients (Mitra 2003). The state government of Andhra Pradesh (AP), where Hyderabad is located, took the lead in creating a fiber-optic backbone, a dedicated satellite link and also encouraged private firms to expand their fiber-optic networks (Biswas 2004).

Bangalore's "Electronics City" houses numerous software firms, including one of India's largest and most successful firms, Infosys. A group of companies from Singapore, led by Ascendas Land (International) Pte. Ltd., together with Tata Industries Ltd. (the investment arm of the Tata Group) and the government of Karnataka, have also established an international, export-oriented high-technology park known as ITPL that is host to 107 foreign and domestic firms. Many of ITPL's clients are global organizations that are in need of the state-of-the-art information, communication and physical infrastructural facilities that national and state governments in India have begun to provide (D'Costa 2006).

E-Government

Both at the central and the state-level, the public sector in India has promoted various e-government initiatives. From 1998 onward, between 1-3 percent of the budgets of every ministry/department at the central and local level has been earmarked for incorporating IT (including hardware, software, services and training). The active promotion of e-government initiatives has created demand for the procurement of IT hardware and software, including services.

The Fashion Industry: International Lessons for Thailand

Innovation, design, and quality workmanship bring uniqueness to the ephemeral world of fashion. Whether it is haute couture, or today's prêt-à-porter fashion, the industry now faces the technological and competitive challenges of globalization and e-business. The fashion capitals of Paris, Milan, New York and London, which showcase the latest in design and innovation, offer guidance for Thailand's industry.

Developing the fashion industry requires much more than a skilled labor force, the manufacture of fine textiles and silks, or even the acquisition of mass-production capabilities. This is an industry which depends upon a mix of creativity, elegance, style and history. The ateliers of Paris's famous couturiers blend simplicity, good taste and the arts with an eye to evolving lifestyles of trend setters. Parisian haute couture and the panache of "Italian moda" were the creations of specialized artisans with a knack for design and a dedication to quality craftsmanship. In Italy, each region has developed a strong artisanal specialty resulting in small flexible industries sensitive to the shifting winds of fashion. For instance, Biella is known for its threads, Prato for its woolen articles and Florence for its leather goods (Martin-Bernard 2006).[38] In much the same way, France has also developed artisanal specialties which were influenced by the cultural idiosyncracies of individual provinces outside of the dynamic Parisian fashion hub. For example, Lyon is known for its silks, Calais

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[38] From these small Italian industries emerged famous brands such as Cerruti, Etro, Loro Piana, and Zegna, specializing in high quality weaving; Ferragamo in shoe-design, Fendi in furs, Brioni for its custom-tailoring, Gucci, Prada and Trussardi in leather goods, and Missoni in textile prints (Martin-Bernard 2006).

and Valenciennes for its lace, St. Etienne for its ribbons and trimmings, Limoges for its porcelain and Grasse for its perfume (Scott 2000).

Thailand satisfies some of the necessary conditions for becoming an emerging fashion hub. The country is rich in history and creativity. It also has the skills and sizable domestic market needed for a fashion industry, as well as a couple of regionally established "branded" firms: Jim Thompson and Shinawatra. However, Thailand must be quick to step up and compete with both the changes in the world's industrial dynamics and the fashion industries that are springing up in Hong Kong, Seoul, Shanghai and Singapore, not to mention the long-established fashion industry in Tokyo. Thailand has the advantage of relatively low-cost craftsmanship and fine fabrics, as well as a refined, well-honed capacity to welcome and absorb foreign influences. In addition to having a rising monied-class, Thailand is also a magnet for tourists (there were 14.5 million foreign visitors in 2007) that provide a large potential market for the country's fashion industry.[39] The Bangkok Fashion City marketing initiative, driven by both government agencies and the private sector, aims to unite the participants in the fashion industry (including companies in the textile, leatherwear and jewelry sectors). This initiate also aims to promote Bangkok's image as the creative capital of Asia. Part of this initiative also involves increasing export volume, facilitating enterprise growth and educating fashion professionals.

Much like Paris and Milan did in the past, Bangkok needs to foster and encourage the agglomeration of all the elements of the fashion-related industry,[40] from design schools to fashion houses, to attracting fashion professionals, to magazines and hosting regular fashion week shows. A good indicator of the progress Thailand is making in the fashion industry is the continuous increase in fashion design schools around Bangkok. Most of these schools are subject to strong foreign influences, including foreign faculty and linkages with institutes abroad.[41] These linkages are a means for Thailand to

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[39] The tourism industry accounts for 6 percent of Thailand's GDP.

[40] A conglomeration of mutually interdependent production networks comprised of skilled workers, active professional and trade associations, along with solid infrastructure will be highly conducive to the development of Thailand's fashion industry (Scott 2000).

[41] For instance, the Chanapatana Institute, a top internationally recognized design school founded by monk Luangphor Viriyang Sirintharo, is run by the Accademia Italiana design

face the challenges and evolving trends in the fashion industry so that it can respond to the idiosyncrasies of global consumers.[42]

Some of the hurdles faced by the industry may be attributed to its creative nature. The industry's dynamics dictate the evolutionary phases of competitiveness and innovation in the sector. Companies such as Zara and H&M are leading the fashion industry with their forward-thinking flexibility, responsiveness and readiness to reach young fashion conscious consumers with limited budgets.[43] The industry faces demand uncertainties, as consumers are exposed to an array of garments all varying in color, texture and design. The timing factor with respect to product innovation is also crucial to avoid product imitation and thus maximize the returns on creativity. Organizational adaptability is another key component which determines whether firms and their brands survive in the fickle fashion market.

Examples from the Italian experience are likely to better illustrate the path Thailand might follow. Italian fashion developed in small regional clusters, usually headed by entrepreneurial, family-owned fashion houses. The favorable concentration of industrial activity in northern Italy helped Milan become one of the top fashion capitals of the world and home to some of the leading luxury brands (see Table 2.1). Thus, Bangkok may need to first shed its image of being an "imitation capital" and instead position itself as a preferred destination for outsourcing by foreign fashion houses that could serve as a stepping stone to becoming a fashion production center in its own right. Thailand's fashion industry also needs to encourage Thai designers to come up with fresh designs—creating a mélange of cultural flavors with no distinct consumer in mind. The outlook of Thailand's fashion industry will heavily depend on its ability to compete against growing threats from the international market.

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institute based in Florence. Foreign faculty teach techniques rather than actual style or design ("Bangkok's Fashion School" 2004).

[42] Thailand needs to play up to the fashion tastes of global consumers by carefully analyzing fashion trends, ensure that its product quality meets global demand, as well as build a strong database of fashion industry information.

[43] The Spanish-based Zara Group operates an integrated production and retail system fashion business. The entire production process (from design to manufacture) usually takes four to five weeks, and Zara rarely restocks old styles as new styles are always on tap; H&M, on the other hand, outsources its fashion lines (Tran 2006).

Instead of focusing on exports the industry needs to innovate and create fashion goods under Thai brand names.

Table 2.1 Percentage of Consumers Who Would Buy the Brand if Money were No Object

Brand	Percent (%)
Giorgio Armani	31
Gucci	30
Versace	26
Christian Dior	25
Chanel	23
Ralph Lauren	21
Louis Vuitton	21
Yves Saint Laurent	19
Prada	16
Emporio Armani	15

Source: AC Nielsen, internet survey of 21,000 consumers in 42 countries, "Number in the News" 2006.

Moreover, as in Italy, a diversity of skilled inputs needs to be artfully combined in the manufacturing process and allied with a marketing strategy which matches specific products with targeted consumers. An important development that the fashion-industry needs to capitalize on is the globalization of design and marketing. Local design talent should be supplemented and leavened by contracting with designers around the world. Likewise, marketing talent is a global industry and if the Thai fashion industry can produce fashion items of quality, international marketing firms can help the industry become a global force.

Part 3
Developing Technological Capability in Thailand

The first reference to innovation and science-oriented policies was in Thailand's Constitution of 1949.[44] This was followed by the establishment of the National Research Council in 1956. Since 1974, the term "technology" has appeared in every volume of the Constitution. The Fourth National Economic and Social Development Plan (1977-1981) made specific reference to technological development for the first time with the goal of improving product quality and production processes as a part of an export-oriented development strategy.

In the past, there was no national innovation policy. The country's investment policy, especially to attract foreign direct investment, was aimed at employment generation and capital inflow rather than the development of indigenous technological capabilities. This changed with the introduction of the new ten-year Science and Technology Action Plan (2003-13)[45] coupled with the focus on developing clusters around five priority industries: automotive, food, tourism, fashion and software (Intarakumnerd 2006b).

Here we examine, describe, and discuss seven elements of the innovation system in Thailand against the backdrop of the international experience discussed in Part 2. These topics addressed include: 1) organization infrastructure; 2) fiscal incentives; 3) secondary and tertiary education; 4) university based research and university-industry linkages; 5) industry clusters; 6) ICT in Thailand; and 7) the nature of research by major Thai corporations.

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[44] This section is based on Emery, Ellis, and Chulavatnatol (2005).

[45] The main aim of this plan is to develop and strengthen: 1) the national innovation system; 2) human resources; 3) the business environment; and 4) the country's capabilities in four priority areas (including ICT, biotechnology, materials science and nanotechnology). As part of this strategy a number of quantitative indicators are used to measure the progress being made with the goal of increasing the proportion of innovative firms to 35 percent of total firms (the proportion was 6.7 percent in 2001) and to have 50 percent of GDP derived from knowledge-based industries and services.

I. Organizational Infrastructure

In recent years the four major objectives of Thailand's science and technology development efforts have included: 1) human resource development; 2) R&D; 3) technology transfer; and 4) infrastructure development. In pursuit of these objectives a number of government agencies have been created to encourage innovation. The first was the establishment of National Research Council of Thailand (NRCT) in 1956. This was followed by the creation of the Thailand Science and Technology Research Institute in 1963 and the Ministry of Science, Technology and Energy in 1979.[46] Following the adoption of the Fifth National Economic and Social Development Plan, the Science and Technology Development Committee was established. The 1990s saw the creation of the National Science and Technology Development Agency and the Thailand Research Fund (TRF). Following the announcement of the National Science and Technology Vision Strategy 2000–20, the National Science and Technology Policy Committee (NSTC) was set up in 2001. Then in 2003 the National Innovation Agency (NIA) was established by combining the Innovation Development Fund and the Revolving Fund of Research and Technology Development. The current organizational structure places both the NSTC and the NRCT at the supra-ministry level in order to coordinate various technology-oriented policies implemented by core ministries, which is similar to the structure adopted in other East Asian economies (see Figure 3.1).

The NSTC is chaired by the Prime Minister who oversees the implementation of the Science and Technology Strategy for Thailand (2006–13). The strategy has five sub-strategies that are supervised by five sub-committees of the NSTC.

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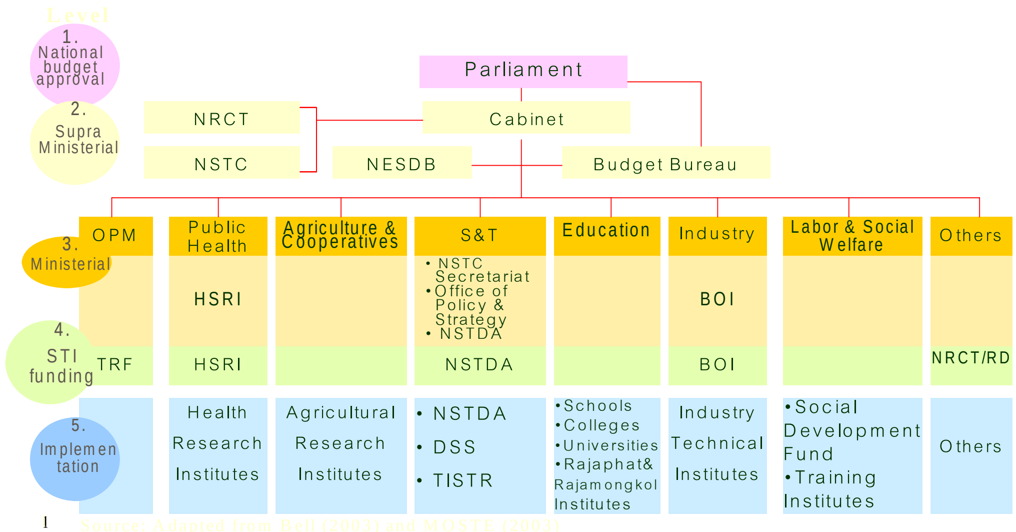
[46] This ministry was split into two entities in 2002: the Ministry of Science and Technology and the Ministry of Energy.

Figure 3.1: Thailand's Governmental Organizational Structure for STI Policy Formulation and Implementation



Source: Intarakumnerd (2006a).

Although the NSTC and the NRCT are supposed to provide a supra-ministerial coordinating role and define an overall technology strategy, in practice they are less than effective in making technology a central strand of government policy. Also, they are less than effective in coordinating the activities of different ministries and agencies with respect to technology development in many different spheres. Moreover, unlike other East Asian economies (including Japan), the private sector is only nominally included in policy formulation. By the time representatives from the private sector become involved, the agenda has already been set by the government (Intarakumnerd 2006a).

This approach fails to intertwine the country's science and technology policy with its economic policies. Moreover, this approach does not view firms as the active users and generators of technology. Also, it does not try and induce the participation of the private sector in the decision making process (Intarakumnerd 2006a).

The NESDB, NRCT and TRF report directly to the Prime Minister. The OPS and the NSTDA are under the Ministry of Science and Technology.

The NRCT was established through the National Research Council Act B.E. 2502 (1959) to serve as an academic advisor to the government. Its duties include national research policy making, national research planning, research promotion and research coordination. It also serves as a research information center. The OPS is responsible for formulating science and technology (S&T) policy for the Ministry of Science and Technology.

The TRF is an autonomous agency, the main functions of which are to grant research funding and coordinate the activities of research networks. Its other functions are to build up professional researchers and strengthen research institutes, to disseminate research findings and to promote the utilization of research results. One of the TRF's programs is the Royal Golden Jubilee Ph.D. program offered in cooperation with the NSTDA and the Ministry of University Affairs. The program was started in 1998 and aims to produce 5,000 Ph.D. students in 15 years to strengthen Thailand's research capabilities and to foster international linkages. By 2007, the program had produced close to 800 Ph.D.s degree holders with another 2,000 Ph.D. students sponsored by the program in their various stages of study. The impact of the program on the volume of academic research publications is large. The recipients of such grants account for 20% of the international academic publications produced by Thai nationals.

The NSTDA focuses on S&T developments in specific areas. It has four national research centers: 1) the National Center for Genetic Engineering and Biotechnology (BIOTEC); 2) the National Metals and Material Technology Center (MTEC); 3) the National Nanotechnology Center (NANOTEC)[47]; and the National Electronics and Computer Technology Center (NECTEC). These centers have fully-equipped laboratories, pilot plants and incubators to encourage start-ups.

In 1992, the NSTDA implemented a pilot project, the "Industrial Consultancy Service", to provide specialized expert services to assist firms to improve their technology. Private sector firms are responsible for 25 percent of the cost of the experts, while the NSTDA picks up the balance (up to 500,000

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[47] Only three of NANOTEC's nine staff are researchers.

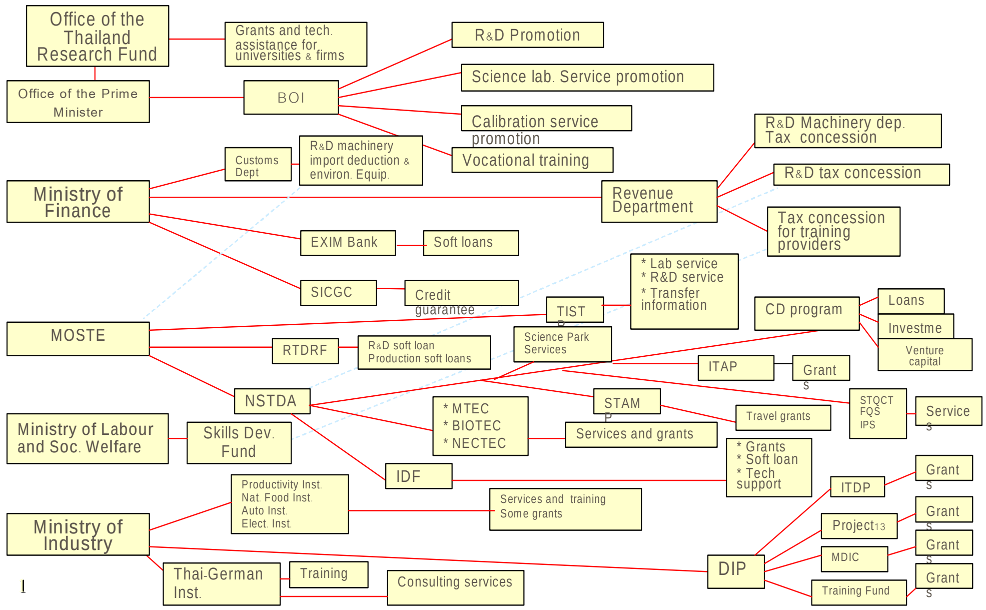
baht) so as to encourage SMEs to upgrade their manufacturing capabilities. In its first nine years this project provided assistance to 176 firms by enabling them to improve their product quality, production processes, as well as their ability to introduce new products. The success of this project led to a larger one, the “Industrial Technical Assistance” program that supported 2,500 industrial firms during 2002-06.

In 1997, the NSTDA created the Software Park Thailand (SPT). Now more than 30 firms, mainly Thai, occupy the space provided by the SPT along with IBM, HP, Sun Microsystems and Oracle. Training and certification (i.e. Capability Maturity Model, or CMM) are offered jointly by the NSTDA and Carnegie-Mellon University. Many of the firms involved in the SPT are globally-oriented.

II. Fiscal Incentives:

The Thai Government offers close to 50 incentives to promote innovation activities by private sector firms (see Figure 3.2). However, these are spread across four different ministries and the Office of the Prime Minister (OPM) that each have their own objectives and mandates. Moreover, there is no mechanism for coordinating their activities, which makes it hard for firms to receive timely assistance. Because of the complexity and the rigidity of the system, only a handful of firms take advantage of such incentives. A survey conducted in 2000 shows that only 2-3 percent of the firms surveyed knew about the existence of these fiscal and financial incentives. Furthermore, individual incentives are sometimes too narrowly defined for firms to utilize them as a means to develop their technological capabilities (Intarakumnerd and Virasa 2004).

Figure 3.2: Illustrative Map of the Current System of Financial Incentives



Source: Intarakumnerd (2006a)

Even where private sector firms have identified a potential incentives package that could benefit their activities, the slowness of the application and approval process can be frustrating. For instance, applying for a soft loan from the Ministry of Science and Technology takes more than one year. Although the Board of Investment (BOI) provides tax reductions for importing machinery used for R&D activities, firms may have to wait for up to three years for approval. The NRCT assists firms with the registration of patents, but can take many months.

The BOI, the NSTDA, the Ministry of Science and Technology, the Ministry of Finance (MOF) and the TRF provide tax incentives, depreciation allowances, soft loans and grants. The BOI was the first to encourage private R&D activities back in 1989 by offering duty and tax reductions or exemptions depending on the location of the R&D investment activities. Tax concessions on R&D expenditure were introduced by the MOF in 1994. These concessions allowed firms to deduct 150 percent of their R&D expenditure from their taxable income. In 1996, this rate was increased to 200 percent. Depreciation allowances for machinery and equipment used for R&D have been offered since

1991. This program includes a depreciation rate equal to 40 percent of the price of capital, which is double the normal depreciation rate of 20 percent. The machinery and equipment must be used for R&D activities only and must be new with a minimum price of 100,000 baht or more.

The NSTDA provides soft loans and grants to private sector firms. Priority is given to firms in bioscience and biotechnology, materials science, applied electronics and computers. The maximum soft loan for a project is 20 million baht with a maturity of up to 7 years. Half the funding must come from the firm.

The TRF was created in 1992 with a funding base of 1,200 million baht. Currently, an annual budget of 1,000 million baht is allocated to the TRF by the government. The TRF also raises funds by itself and each year an additional 300-500 million baht is provided to the TRF by other government and private agencies to support research. The TRF then uses its annual budget and interest earned on their saving deposits to support research activities. However, the Policy Board of the TRF has given a guideline that at least 1,000 million baht must be kept on deposit to guarantee TRF's financial security.

The Ministry of Science and Technology provides more than 300 million baht for the support of private sector R&D activities by means of soft loans through the National Innovation Agency (NIA). The eligible activities are divided into the following categories: 1) "commercializable" R&D activities; 2) infrastructure investment such as laboratories; 3) improvements to and development of production processes to increase efficiency/value-added; and 4) investment in production arising from the findings of R&D that lead to commercial outcomes. Activities funded from this source need to have a positive impact on either export promotion or import substitution. A total of fourteen industrial product categories have received support under this scheme: agro-industry, food, machinery, metals and materials, electrical equipment and electronics, chemicals, pharmaceuticals, biotechnology, computer, ceramics, plastic products, rubber and rubber products, toys and construction materials. For the R&D activities in first and second categories noted above, the maximum loan amount is 10 million baht with an interest rate of 4 percent per annum and a maximum maturity of 8 years. For the third and fourth categories, the maximum loan amount is 20 million baht with an interest rate of 6 percent per annum and a shorter maturity of 5 years. However, these loans need to be secured by collateral, which acts as a significant disadvantage for SME and start-up firms.

Although this wide array of incentives are comparable to those offered by Thailand's neighbors (see Table 3.1), in a survey conducted by the National Innovation Survey of the National Science and Technology Development Agency in 2003 it was found that most Thai manufacturing firms invest little in R&D. Moreover, those that move up the innovation ladder do so through an incremental process rather than product innovation (Emery, Ellis, and Chulavatnatol 2005).

In 2004, R&D spending in Thailand as a share of GDP was 0.25 percent,[48] as against 0.11 percent in 1996. Private sector firms accounted for the largest portion at 36 percent of R&D spending, while tertiary institutions (including both public and private) and the government accounted for 31 percent and 23 percent, respectively (see Table 3.2). Relative to other economies in East Asia, Thailand's aggregate R&D expenditure is low, as is the share of R&D performed by the private sector (see Figure 3.3). In Japan, private sector firms account for 75 percent of R&D spending. The corresponding figures for other countries in the region are also quite high, i.e. 70% in the Republic of Korea, 76 percent in Taiwan (China), 82% in Malaysia, 64% in Singapore and 62 percent in China. Likewise, the number of personnel engaged in R&D in Thailand is much lower than in other economies in East Asia with the exception of Malaysia (see Figure 3.4). Although Thai firms conduct some basic R&D, the proportion that do is small as would be expected. The bulk of their R&D is geared towards experimental development (53 percent) and applied research (38 percent). Universities are responsible for much of the basic research, supplemented by the government sector. However, most of R&D carried out by Thai universities consists of applied research. The distribution of research expenditure by the public sector is divided between private enterprises and universities with an emphasis on applied research, followed by experimental development.

[48] The R&D spending was 16,571 million Baht in 2004 (NSTDA 2006).

Table 3.1: Fiscal Incentive for Corporate R&D: Cross-Country Comparison

	Tax Credit	Depreciation	Investment allowance	Tax concession on training	Import Duties reduction
China	100% for the first two years for foreign high-tech firms and JVs in HTIEs; 50% in the following six years for foreign firms	Accelerated depreciation for high-tech firms since 1991	2.5 billion Yuan in electronics and IT during 1986-2001; 2 billion Yuan in direct grants in bio-tech	100% for consulting and technical services conducted by MNC's R&D centers;	Exemption for targeted industries such as electronics
Finland	25%; additional 10% up to 454 million Euros; 50% of growth in R&D.	n.a.	n.a.	n.a.	n.a.
Korea	10-25%	100%	80%-90% cap. for SMEs; 50% cap. otherwise	15% cap.	n.a.
Japan	20% (max. at 10% tax lib.)	100% or 5 yr cap	n.a.	n.a.	n.a.
Malaysia	100% up to 10 years	200%	60% of capital expenditure up to 5 years	100% before business start-ups and thereafter 200% for training at approved institutions	n.a.
Taiwan China	15-20%	100%	Loans for high-tech firms	30%	n.a.
Thailand	Tax holidays for R&D labs for 8 years; 200% of R&D expenditure for tax computation	40% in the first year and lower in the following years	Not more than 50% of total budget that must be higher than 10 million Baht	150% for expenditure on employee training; tax exemption for certified training providers	5% or less on R&D equipment, a 10-40 percentage point reduction.
US	20%	100%	n.a.	n.a.	n.a.

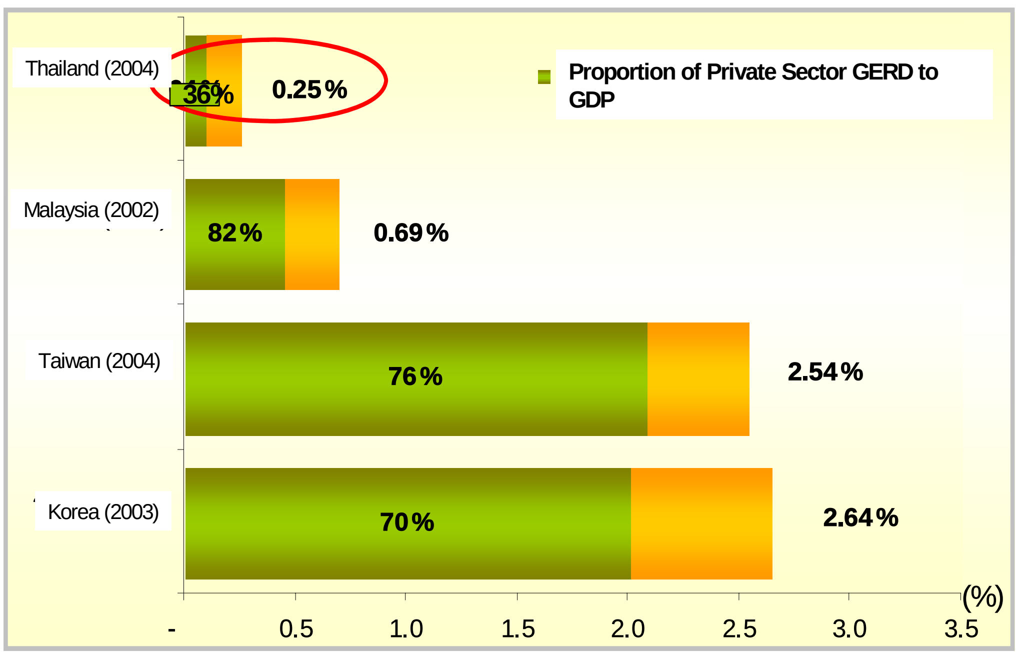
Source: Yusuf, Wang, and Nabeshima (2005); "Ministry of Economic Affairs, Taiwan" 2006; "Ministry of Science and Technology, Korea" 2006; The International Institute for Sustainable Development 2004.

Table 3.2: Share of R&D spending by Sector and Types of R&D

		Type of R&D		
Sector of performance	Share (%)	Basic research (%)	Applied research (%)	Experimental development (%)
Government	22.54	16.08	54.5	29.42
Higher ed. (Public)	30.06	35.35	51.22	13.42
Higher ed. (Private.)	0.94	50.08	40	9.92
Public enterprise	5.66	4.33	26.31	69.31
Private enterprise	38.24	9.28	37.7	53.02
Private non- profit	2.56	4.42	92.51	3.06
Total	100	18.63	45.33	35.04

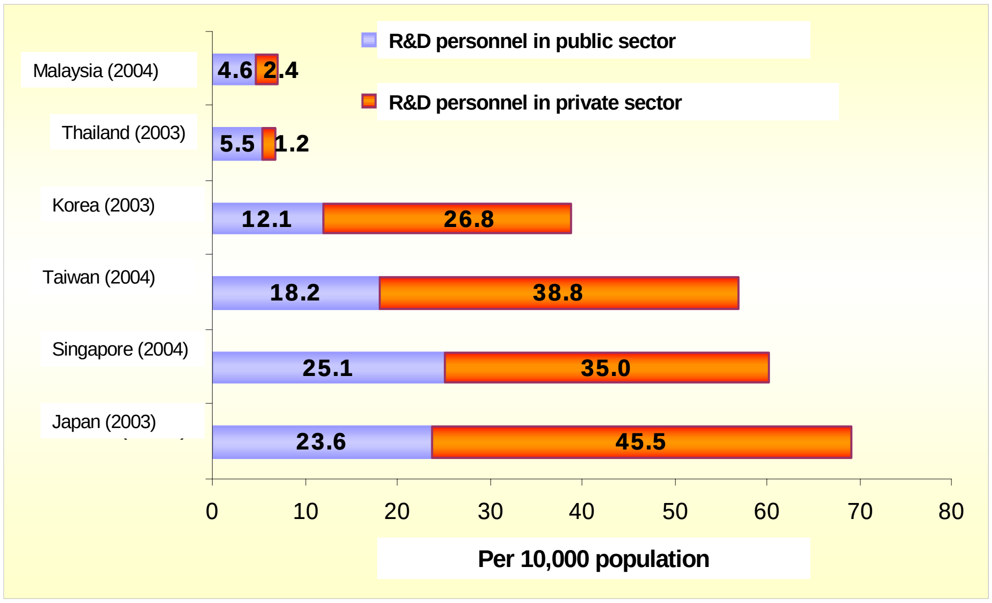
Source: National Research Council of Thailand.

Figure 3.3: Gross Expenditure on R&D (GERD) bf the Public and Private Sectors



Source: NSTDA

Figure 3.4: Personnel in R&D per 10,000 population



Source: NSTDA

Overall, the share Thailand's R&D spending that is devoted to applied research is the largest, at about 45 percent, followed by experimental development (35 percent) and basic research (20 percent). The outlay for basic research as a percent of total R&D spending compares favorably with other countries. It is just that the overall amount of R&D spending in Thailand is well below the level of other economies in East Asia.

Only large firms in Thailand (i.e. subsidiaries of MNCs or domestic corporations), along with a small number of SMEs, have the capacity to conduct any significant R&D. According to the innovation surveys conducted in Thailand and The Republic of Korea in 2002, fewer Thai firms innovate (11 percent) compared to Korean firms (42 percent) (see Table 3.3). However, since 1997 some Thai firms have begun nurturing in-house technological capabilities that could enhance their innovativeness. (Intarakumnerd 2006b).

Table 3.3: Share of Innovating Companies in Thailand and The Republic of Korea (%)

	Thailand	Korea
Innovating	11.2	42.8
Product and process innovation	2.9	21
Only product innovation	4.1	17
Only process innovation	4.3	4

Source: Intarakumnerd (2006b).

Table 3.4: Importance of External Information Sources

Thailand		Korea	
Clients	77.4	Customers	77.7
Internet	63	Competitors	69.3
Parent/associate company	61.2	Exhibition	65.5
Locally-owned suppliers	59.9	Internet	64.9
Specialist literature	56.6	Component suppliers	61.7
Professional conference & meetings	55.2	Patents	59.8
Foreign-owned suppliers	54.8	Equipment suppliers	57.7
Fairs and exhibitions	53.1	Universities	53.6
competitors	42.1	Enterprises within the group	52.9
Technical service providers	40.2	Public research institutes	52.6
Universities or other higher education institutes	35.8	New personnel	51.9
Business service providers	33.1	Trade Associations	44.2
Patent disclosures	32		
government or private non-profit research institutes	29.5		

Source: Intarakumnerd (2006b).

III. Secondary and Tertiary Education in Thailand

Thailand's current education framework derives from the 1997 Constitution and the 1999 National Education Act (NEA), which provide the principles and guidelines for the knowledge-based economy which Thailand is seeking to create (Bhangananda 2003). The Constitution establishes the right of every citizen to receive a free basic education for 12 years. Note that the 1999 NEA extended compulsory education from six to nine years. These mandates reflect the government's increasing concern over the level of educational attainment. As Table 3.5 shows, in 1999 the average number of years of education for population aged 15-59 was only 7.7 years. In other words, the majority of Thailand's labor force is comprised of people with at best a primary education (see Table 3.6).[49]

Table 3.5: Average Years of Education Attainment of the Thai Population, 1999-2003

	1999	2000	2001	2002	2003
15-21	9.4	9.5	9.5	9.7	9.8
15-59	7.7	7.8	7.8	7.8	7.9
60 and over	3.5	3.6	3.6	3.8	3.9

Source: Office of the Education Council 2004.

[49] Of 1 million workers employed in manufacturing industry, only 12 percent have a bachelor's degree or above (NSTDA 2006). The sector with the largest share of graduates and S&T workers are the food industry with 20 and 13 percent respectively (NSTDA 2006).

Table 3.6: Education Attainment of the Thai Labor Force: 2001–05

	2001	2002	2003	2004	2005
			(percent)		
None	3.6	3.8	3.5	3.5	3.5
Less than Elementary	40	39.3	37.7	36.2	34
Elementary	22	22	22.5	22.3	22
Lower Secondary	12.6	12.8	13.2	13.9	14.5
Upper Secondary	9.7	9.8	10.5	11	11.6
Higher Education	11.9	11.9	12.2	12.7	13.9
Others	0	0	0.1	0.1	0.1
Unknown	0.1	0.3	0.3	0.3	0.5

Note: Figures are for first quarter only.
Source: National Statistical Office 2005.

Secondary Education

The government's response to this situation was to raise public expenditure on education as a percent of GDP from 3.3 percent in 1995 to 4.0 percent in 2004, as well as increasing the share of the budget spent on education from 18.8 percent to 24.4 percent (Ministry of Education of Thailand 2004) over the same period. The additional expenditure on education has resulted in a significant improvement in secondary school enrollment, particularly at the upper secondary level and to a lesser extent in tertiary education (see Table 3.7). Data collected by the Ministry of Education shows that such gains in enrollment have been largely sustained until students reach the point of transferring to the next level of education. In 2002, the repetition rate was around 1–2 percent at the primary education level and almost zero for secondary education, while the dropout rate was around 2 percent for basic education each year (World Bank 2005b). Longitudinal data that followed three cohorts of students over time (e.g. students enrolled in 1st grade in 1990–92) showed that most dropout cases took place between education levels rather than between grades. There is also evidence that students are extremely vulnerable in the first year of their schooling as evidenced by the fact that the number of students dropping out is at least as large as the number of students dropping out between levels (World Bank 2005b).

Table 3.7: Education Enrollment Ratios by Level of Education in Thailand

	Age Group	1998	1999	2000	2001	2002
Pre-School	3-5	94.5	96.8	95.8	93.1	96.5
Primary School	6-11	102.5	102.4	103.2	103.8	104.1
Lower Secondary	12-14	83.4	83.5	82.8	82.2	84.6
Upper Secondary	15-17	51.9	55.3	57.3	59.3	60.1
-General Education	15-17	29.8	33.2	36.6	38.9	39.3
-Vocation. Education	15-17	22.1	22.1	20.7	20.4	20.2
Higher Education	18-21	21.5	22.7	24.9	26.1	26.5

Source: Makishima and Sukisiriserekul 2003.

While tertiary and upper secondary enrollment levels have risen (see Table 3.7), the quality of education has not and the mismatch between the supply of and the demand for skills persists.[50] Moreover, the longer term implications of a low quality basic and secondary education are damaging. This is because with a weak foundation workers benefit much less from future training (Heckman 2005).[51,52]

Recent results from international assessments, such as PISA the Trend in International Mathematics and Science Study (TIMSS), show that Thai students at the secondary education level perform poorly when compared with their peers in other countries (see Table 3.8 and Table 3.9).

[50] About 1.63 million workers are employed as operators in metal, machinery and related trade fields, or as general managers, salespersons, demonstrators and fashion models despite their background in S&T (NSTDA 2006).

[51] Schofer and Meyer finds that larger expansion in tertiary education over the last century was seen in those countries with higher enrollment in secondary school and where the state had less control over the tertiary education sector, allowing private universities to expand (Schofer and Meyer 2005).

[52] Also the quality of education affects student's ability to move from, say secondary to tertiary levels (Hanushek and Woessmann 2007).

Table 3.8: PISA Score 2003

	Math	Science	Reading
Japan	553	548	598
Korea	552	538	534
Hong Kong (China)	558	539	510
Indonesia	361	395	382
Macao (China)	528	525	498
Thailand	424	429	420
OECD Average	496	500	494

Note: The score of 400 is considered to be the minimum literacy level (Hanushek and Woessmann 2007).
Source: Program for International Student Assessment, OECD from World Bank (2006e).

Table 3.9: TIMSS Test Score in Selected East Asian Economies

	1995		1999	
	Math	Science	Math	Science
Hong Kong (China)	568.89	509.73	582.06	529.55
Indonesia	n.a.	n.a.	403.07	435.47
Japan	581.07	554.47	578.6	549.65
Korea	580.72	545.78	587.15	548.64
Malaysia	n.a.	n.a.	519.26	492.43
Philippines	n.a.	n.a.	344.91	345.23
Singapore	608.59	580.35	604.39	567.89
Taiwan (China)	n.a.	n.a.	585.12	569.08
Thailand	516.22	510.04	467.38	482.31

Source: Mullis and others 2000.

Thai students not only underperformed their counterparts in neighboring countries, but also their raw scores declined substantially from 1995 to 1999. Thai students' average score in science fell by 28 percentage points over this period, while their average score in mathematics fell by 48 percentage points (World Bank 2005b). Thailand trailed far behind the leader, Singapore, and Thai students were also outclassed by students from Malaysia.

The most significant constraint that Thai students face in advancing to secondary education is funding. The government provides loans to upper secondary and tertiary level students, but not for lower secondary education where the need is strong. Even for the upper secondary and tertiary education, the student loan scheme needs to be better targeted. Currently, only 33 percent of students from poor households receive loans. In addition, the repayment rate in Thailand is rather low – at 21 percent as compared with 55 percent in Korea and 79 percent in China. In terms of reading skills, Thai students received the second lowest score ahead only of their counterparts in Indonesia (World Bank 2005b).

There are a number of policy instruments that Thailand could use to improve the quality of the country's education at the secondary level (World Bank 2005b). On the resource side, class sizes could be made smaller so that each student will receive more attention from teachers. School hours could be lengthened to provide more learning opportunities to students. In addition, incentives as well as training could be provided to enhance the performance of teachers and students alike.[53] All of these will entail spending more on education, as well as the recruitment of additional and more qualified teachers (Webbink 2005).[54] More competition among schools could be introduced, possibly through the use of vouchers if this is appropriate under the circumstances prevailing in Thailand. However, in order to reap the full benefit from the competition, each school needs to be able to differentiate itself. This entails more autonomy for public schools coupled with greater accountability to parents and school governing bodies. Without accountability, school autonomy itself can be detrimental. In order to obtain the best results, these reforms

[53] Some research reported in Yusuf and others (2003) shows that it is the home environment which is a more important determinant of performance, not longer school hours. In Finland, for example, the school year is unusually short but considerable emphasis is given to reading and learning in the home.

[54] Webbink (2005) surveys the literature on factors associated with improving the quality of secondary education, focusing on the effect of controlling for endogeneity. Controlling for endogeneity leads to more consistent results on the policy instruments identified above.

need to be introduced simultaneously as a policy package (Hanushek and Woessmann 2007).

Higher Education

Thailand's first university, Chulalongkorn, was established over 80 years ago. The establishment of more universities, each specializing in a specific field, followed: 1) Thammasat University in social sciences (law, political science and liberal arts); 2) Silpakorn University in Fine Arts; 3) Kasetsart University in agriculture; and 4) the University of Medical Sciences (now known as Mahidol University). In the 1960s, a number of new comprehensive universities were founded: Chiangmai University, Konkaen University, as well as the Prince of Songkla University. During the same period, the traditional one-field universities began to expand to offer degrees in other fields. In that same decade, three technical colleges at Thonburi, North Bangkok and Ladkrabang were merged into one, and upgraded to a higher educational institute, the King Mongkut's Institute of Technology.

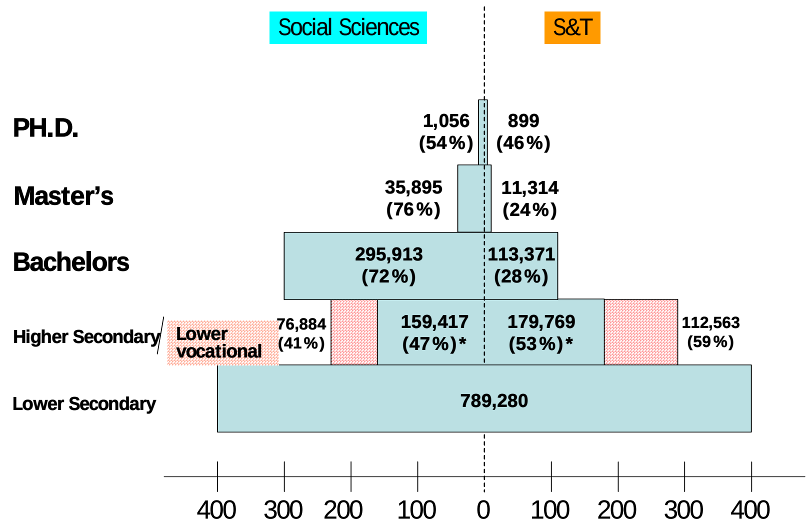
In the 1960s, there were eight public universities offering baccalaureate engineering programs. When the shortage of engineers became acute in the 1980's other universities introduced programs in engineering and technology, new public universities were set up and several private colleges were upgraded to universities.[55] In addition to those institutions under the Ministry of University Affairs (MUA), Commission on Higher Education (CHE) under the Ministry of Education (MOE) subsequently combined technical colleges into Rajamangala Institutes of Technology, while teacher training colleges became Rajabhat institutes, both of which offer baccalaureate programs.

The higher education system is currently dominated by 18 limited admission public universities and two open admission universities. Private universities are not important in terms of market share. Open admission universities are playing an important role in the expansion of higher education. However, the graduation rates from open admission universities are rather low. Thailand also suffers from a severe imbalance between undergraduate vs.

[55] In the 1990s, there was a movement to establish the so-called international programs, in which English is used as the medium of instruction. There was also a wave of 'special programs' in engineering, providing classes outside the traditional hours to boost the number of engineering graduates.

postgraduate education. Currently a small number of graduates enroll in master's degree programs and even fewer enroll in doctoral degree programs. In fact, the number of doctoral graduates is barely adequate to replenish retiring professors as only a fraction of the doctoral graduates choose to teach. The situation is likely to deteriorate as the number of faculty members that are expected to retire increases to around 800 lecturers per year in the next five years.

Figure 3.5: Number of new students in Thailand in 2005



Note: * proportion in year 2003

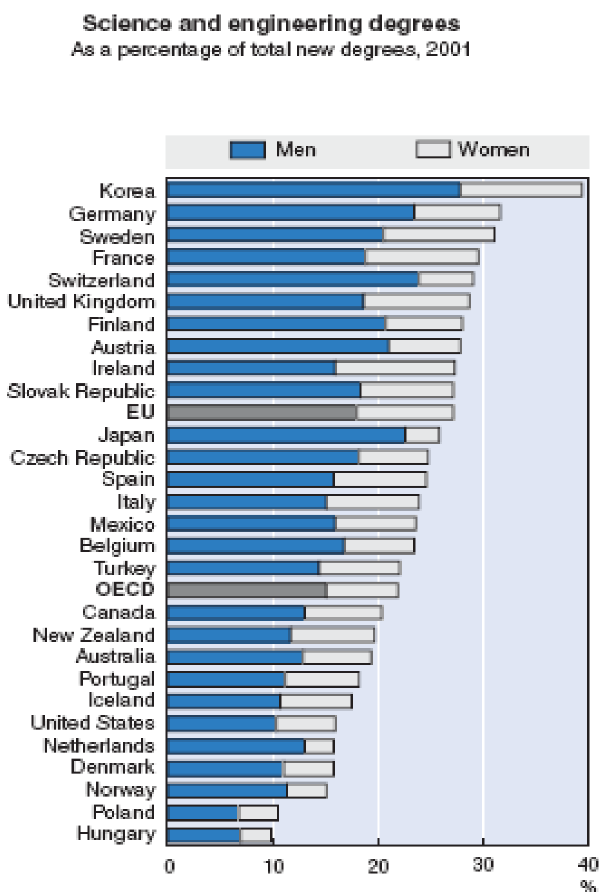
Source: Office of Basic Education and Office of Vocational Education

The distribution of students across disciplines in Thailand is also weighted much more heavily towards the humanities and social sciences than is the case in Korea, Japan or China (see Error! Reference source not found. and Figure 3.6 on the proportion of S&T degrees in Thailand and in the OECD). Korea leads in the number of students studying science and engineering, followed by Germany. Thailand has relatively few students enrolling and graduating in science and technology. The proportion of graduates in science and engineering to the social sciences graduates remains at around 30:70.[56] The situation is even worse in postgraduate education at the master's level.

[56] Of the 195,815 graduates in 2004, 68 percent was in social science (NSTDA 2006).

Here the proportion of graduates in science and engineering to social sciences graduates actually decreased from 27:73 in 1990 to 19:81 in 2004.[57] By comparison, over 40 percent of Chinese undergraduates take S&T courses, as do 30 percent of Korean and 23 percent of Japanese students (see Table 3.10). The low quality of basic and secondary education has profound legacy effects because, as noted above, it will be harder to upgrade the workforce in the future. The low percentage of S&T graduates is leading to widely remarked shortages, as well as constrains the emergence of skill and technology intensive industries.

Figure 3.6: Science and Engineering Degrees



Source: Science and Technology Statistical Compendium 2004, OECD.

[57] At the doctorate level, 95 percent of students received their degree in S&T field, although the overall number is small with 1,156 degree recipients (NSTDA 2006).

http://www.oecd.org/dataoecd/17/34/23652608.pdf.

Table 3.10: Percentage of Science and Technology Students in Selected Countries, 1995

Country	Unit: % Percentage
Korea	39
China	37[a]
Philippines	31
Indonesia	26
Japan	23
Thailand	19

Note: [a] Exceeds 40 percent in 2005.
Source: UNDP (1999).

The majority of Thailand's higher education institutions are concentrated in Bangkok and in bigger cities. Provincial higher education institutions face shortages of academic staff which compels qualified students to migrate from rural areas to Bangkok and other big cities.

The shortage of academic staff has made it harder to improve the quality of Thai higher education institutions and hindered the expansion of research and development. Only about a quarter of faculty members hold doctorate degrees, mainly at public universities (see Table 3.11). The ratio of faculty members to students was 1 to 40 as against 1 to 16 in China (National Statistical Bureau of China 2005) and 1 to 18 in Korea.[58] This problem is much worse at the Rajabhat universities where almost half of faculty members were non-permanent part-time lecturers. As a consequence of job insecurity and few career opportunities, individuals with high qualifications are seldom attracted to Rajabhat universities. As a result, only 44 percent of the faculty at Rajabhat universities have a bachelor's degree and almost 80 percent of these faculty members had no more than three years of work experience.

[58] Calculated from EduStat, http://devdata.worldbank.org/edstats/.

Education Policy Initiatives

Schools and universities are attempting to become student-centered and to promote customized-learning, as staff learn new skills and are able to lessen the emphasis on rote learning. Such efforts are making greater progress at the tertiary level with the key schools taking the lead. For instance, Siam International University has launched an MBA program that caters to students who are seeking the option to work abroad. Class instruction is conducted in English, in part because 70 percent of the student body is comprised of foreigners, and lectures are interspersed with case studies, role-playing and many other activities. Students are able to freely express their views on current business matters, and as such develop strategic decision-making skills (Emery, Ellis, and Chulavatnatol 2005).

Table 3.11: Qualification and Number of Faculty Members in Higher Education Institutions, 2003

Type of Institutes	Total	% of total	lower than degree	Bachelor	Certificate	Master	Higher Graduate Diploma	Doctorate
Total	46,679	100	36	8,484	30	28,035	9	10,084
Public	36,415	78.01%	36	6,174	30	21,381	9	8,784
(%)			0.10%	16.95%	0.08%	58.71%	0.02%	24.12%
Private	10,264	21.99%	0	2,310	0	6,654	0	1,300
(%)			0.00%	22.51%	0.00%	64.83%	0.00%	12.67%

Source: Commission on Higher Education

In an effort to raise the qualifications of lecturers in higher education, the Commission on Higher Education is targeting a ratio of 50:50 between master's and doctoral degrees by the end of the Tenth National Economic and Social Development Plan (2007-2011). Currently, only 24 percent of the faculty members hold doctoral degrees in public higher education institutions. At private higher education institutions and Rajabhat universities the corresponding figure for faculty members that hold a doctoral degree is only 13 and 7 percent, respectively.

The government is also attempting to enhance the efficiency of public universities by making them more autonomous and raising the level of competition. Although the majority of the budget for public universities is still provided by the government, this funding is in the form of block grants that are not allocated by individual line-items in the budget, as was the case in the past. University employees are no longer government officials. Consequently, the benefits package will change and the dismissal of non-performing employees (including faculty members) will be easier.

In order to raise teacher quality the government has taken a number of steps, including the establishment of the Institute for Development and Promotion of Teacher and Educational personnel supported that is supported by two funds. These include: 1) the Fund for the Development of Teachers to finance education, training and observation tours within the country and aboard for teachers, faculty staff and educational personnel of both public and private institutions; and 2) a fund for the promotion of teacher and educational personnel to enable them to invest in self-improvement.

In addition, the government is offering scholarships for master's and doctoral degrees in the fields of science and technology. Academic training activities are provided for qualified teachers through two projects, namely the Training of Teachers with Special Talents in Science and Technology program and the Development and Support of Teachers with Special Talents in Science and Technology program.

Scientific Publications of Thai Universities

The share of R&D financing by universities has been on the decline since 1997 (Schiller 2006). Concurrently, universities have shifted their research orientation towards and emphasis on basic and experimental areas instead of applied research (Schiller 2006).

One measure of research output is the number of published scientific paper. In the latter part of 1990s, the number of published scientific paper written by Thai researchers increased dramatically (see Figure 3.7). However, the same pattern was true for other East Asian economies. In 1980-84, the number of scientific papers written by Thai researchers trailed only the number written by their counterparts in China and Taiwan (China) and were actually ahead of The Republic of Korea. By 2000-05, however, the situation had changed. Now the number of scientific papers by Thai researchers is only about 4 percent of China's and less than one-tenth of Korea's (see Table 3.12).[59]

Table 3.12: Yearly Average Number of Publications by selected East Asian Economies, 1980–2005

	1980–84	1985–89	1990–94	1995–99	2000–05
Thailand	394	446	557	926	2,059
Republic of Korea	341	1,043	2,756	9,813	21,471
Taiwan (China)	642	1,644	4,326	8,608	13,307
Singapore	253	597	1,142	2,501	5,177
Malaysia	259	298	421	745	1,221
Philippines	237	207	246	329	474
Indonesia	104	141	198	366	524
China (including Hong Kong)	2,694	6,244	10,365	21,205	48,552

Source: Schiller (2006).

During 1995-2004, around 43% of the scientific papers published in Thai publications on topics in the medical science field, followed by life sciences and engineering sciences (see Table 3.13). With respect to the world share, scientific papers published in Thailand had the highest share in agricultural sciences. Consequently, the country's specialization index is also the highest in agricultural sciences, similar to that of India (see Table 3.14). Another one of Thailand's notable differences is its higher degree of specialization in the medical and life sciences compared to other economics in East Asia. However, the largest difference seems to be with respect to specialization in the engineering sciences. Although the trend in Thailand is upward, a much higher proportion of scientific papers from Korea, Taiwan (China), Singapore, Hong Kong (China) and China tend to be in engineering

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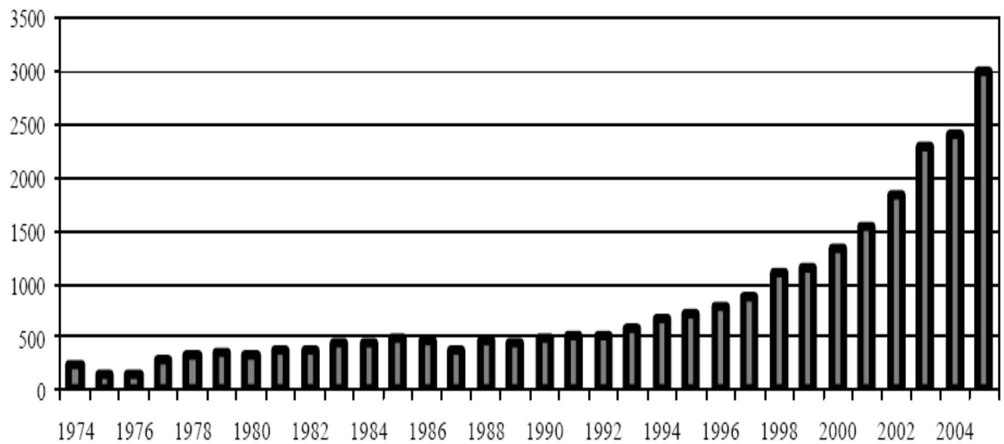
[59] In 2005, 2,795 papers were published by Thai which were included in Science Citation Index (NSTDA 2006).

fields. This specialization mirrors the manufacturing capabilities of these economies.

Figure 3.7: Number of Thai publications in the Science Citation Index (SCI) 1974–2005



Source: Schiller (2006).

Table 3.13: Thai Publications by Scientific Field, 1995–2004

Scientific Field	Share of Total			Number of Publications	Thailand's World Share	Average Impact Factor	
	1995–1997 (%)	1998–2001 (%)	2002–2004 (%)	2002–04	2003 (%)	World (2003)	Thailand (2002–04)
Total				2,120	0.3	2.373	2.101
Agricultural sciences	9.6	8.5	10	213	0.5	1.38	1.06
Medical sciences	54.9	49.8	43	912	0.37	2.864	2.793
Engineering sciences	18.1	21	26.3	558	0.33	1.153	0.977
Life sciences	27.2	28.7	28.4	602	0.39	2.995	2.19
Natural Sciences	13	13.8	18.8	399	0.17	2.154	1.812

Source: Schiller (2006).

Table 3.14: Index of Specialization for Select Asian Economies

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

Note: The index of specialization expresses the share of a scientific field in one country in relation to the share of this field in the world. It ranges from -100 to 100 and positive values indicate a specialization above the world average.
[1] Data is from 2002–04. For others, data is from 1996–2000.
[2] The Republic of Korea, Taiwan (China), Singapore, Hong Kong (China).
[3] Malaysia, the Philippines.
Source: Schiller (2006).

Thailand: The State of University-Industry Linkages

University-PRI-industry linkages in Thailand are weak. Currently, the government has no policy aimed at strengthening such linkages. Neither PRIs nor the universities are taking initiatives in this area. In 2000, the Ministry of University Affairs established seven centers of excellence in order to stimulate university-industry linkages. So far, however, the results have been disappointing because of the lack of qualified personnel to run such centers in an effective manner. In addition, the demand from businesses has been well below expectations (Brimble and Doner 2005).

There are a number of Research Technology Organizations (RTOs) in Thailand, but only small percentage of private sector firms (at most 20 percent) have ever utilized their services. Government funded RTOs mainly focus on R&D and provide technical services such as testing and calibrating. Their mandate does not include development of firms' internal technological capabilities, or non-R&D capabilities such as assimilation, adaptation, design and engineering. This contrasts with the similar organizations in Japan and other East Asian economies where the initial focus of government research institutes was to assist firms to assimilate new technologies (Intarakumnerd 2006b). In Thailand, such bodies typically define their goals and areas of research by themselves and then attempt to develop technologies which they hope to transfer to private sector firms. This approach, which is not user friendly, has inhibited firms from seeking their partnership. (Brimble and Doner 2005). Few firms have engaged RTOs either to improve and tailor the skills imparted or to establish formal channels for stimulating and diffusing university-based research. However, one of the RTOs, BIOTEC, is starting to work more closely with the private sector and aims to build such linkages. Reflecting this, fewer Thai firms identify universities or public research institutes as important sources of information compared to Korean firms (see Table 3.4).

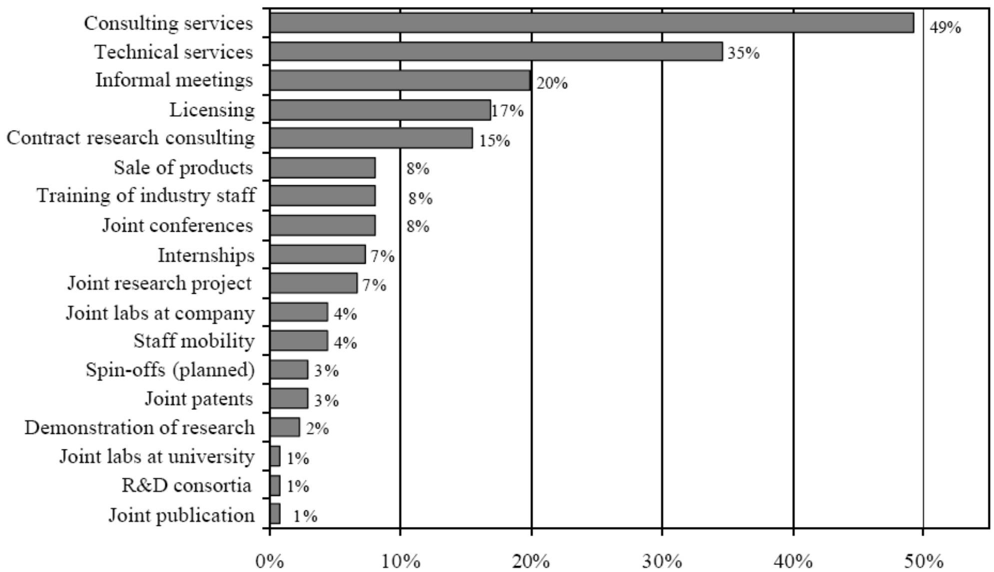
There are two important technology intermediaries in Thailand. The Thailand-Japan Technology Promotion Association (TPA) has been in operation for more than 30 years and aims to diffuse knowledge and technologies associated with manufacturing. Over one-third of firms surveyed said they have used the services provided by TPA. By contrast, far fewer firms said they have utilized the services offered by other associations (26 percent) and the government (18 percent). The Kenan Institute Asia (KI Asia) is a another agent that provides a bridge for the exchange of knowledge, expertise, and information among government, universities and industries (Intarakumnerd 2006b).

Based on survey data collected from 136 university-industry linkages projects at five universities conducted in 2004,[60] Schiller (2006) finds that the most prevalent mode of cooperation with private sector firms in Thailand is to provide consulting services (49 percent), followed by the provision of technical services (35 percent) and serving as a source of informal contacts (20 percent) (see Figure 3.8). This service provision is followed by more explicit forms of university-industry linkages, including licensing; the sale of products and contract research, followed by training components.[61] However, more research-intensive and interactive forms of university-industry linkages are few (Schiller 2006). Although the additional income that Thai professors earning from these projects is small, they are spending more time on such projects than

[60] The universities sampled were Chulalongkorn University, Kasetsart University, King Mongkut's University of Technology Thonburi, Chiang Mai University, and Khon Kaen University (Schiller 2006).
[61] Preference to this type of university-industry linkages is partly because of the recent budget cuts to universities (Schiller 2006).

allowed by current regulations (one day per week) because of the low salaries of public sector workers. For instance, the wage premium for engineers working in the private sector is estimated to be 500 percent of that of engineers in the public sector (Schiller 2006). This is reflected in the motivation for cooperation with industries (see Figure 3.9).

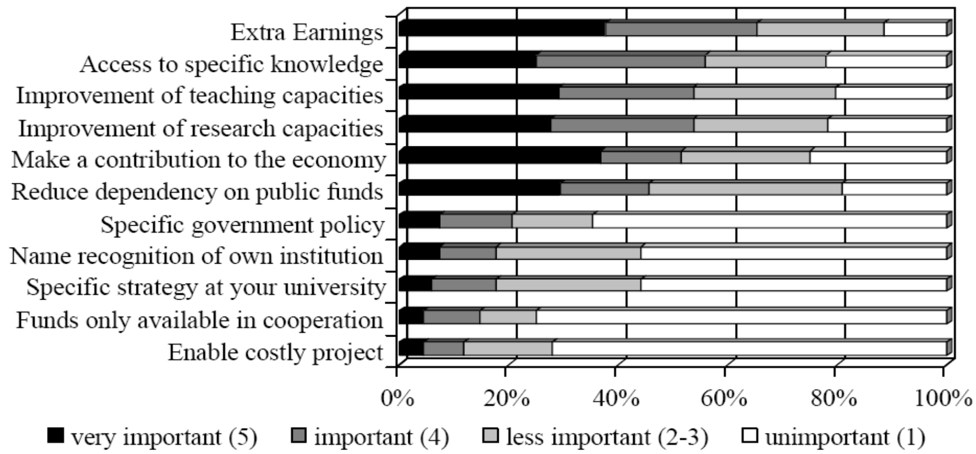
Figure 3.8: Modes of University–Industry Linkages in Thailand



Notes: Multiple answers possible.

Source: Schiller (2006)

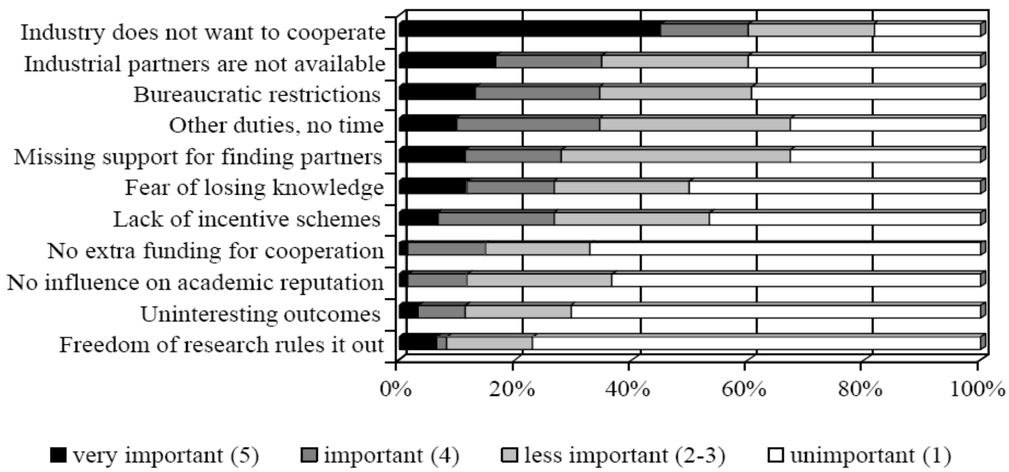
Figure 3.9: Reasons for University-Industry Linkages
at Thai University Departments



Source: Schiller (2006).

From the universities' perspective, the most significant constraint on university-industry linkages is the perception that firms do not want to cooperate with universities, as well as the inability to identify suitable partners (see Figure 3.10). However, after the identification of the partner, the next few limitations identified are all concerning internal restrictions and a lack of incentives. These are driving faculty members to engage in "moonlighting" to provide more service-oriented assistance rather than research-oriented support to industries (Schiller 2006).

Figure 3.10: Limitations for University-Industry Linkages at Thai University Departments



Source: Schiller (2006).

For the vast majority of firms, universities remain the suppliers of human capital.[62] Among the exceptions, Seagate Technology - the leading producer of hard disk drives - has established R&D centers at Khon Kaen University and Suranaree University Technology that focus on magnetic head technology (a vital component of hard-disk drives).[63] Another firm, KR Precision that specializes in suspension arm components for hard disk drives, has also sought cooperation with universities/research institutes to complement its in-house R&D efforts. Although KR Precision did contract with professors from local universities, such arrangements were typically informal and relied on personal networks. More formal and substantial linkages were established with foreign entities such as the Disk Storage Institute of Singapore, Purdue University and ITRI (Taiwan) (Brimble 2006).

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[62] Between 1979 and 2005, only 21 patents were granted to universities. Chulalongkorn University has the most patents – a total of six (NSTDA 2006).

[63] The research lab at the Department of Electrical Engineering at KKU employs five Master's students and two Ph.D. students who conduct research together with Seagate engineers. As a result, the department was able to publish select research results in an international journal. In addition, students will be familiar with the most advanced equipment and accumulate experiences that can be readily applied in Seagate's R&D programs (Schiller 2006).

A successful case of a university's active involvement in industry is the Centex Shrimp Center of Excellence for Shrimp Molecular Biology and Biotechnology established at Mahidol University with the support from the Thai National Center for Genetic Engineering and Biotechnology (BIOTEC). The aim of the center is to deepen the scientific knowledge of shrimp and fish, as well as to find ways of preventing outbreaks of disease.[64] The creation of the Shrimp Biotechnology Business Unit will help to commercialize the R&D findings (Brimble and Doner 2005). In southern Thailand there is the making of a shrimp and tuna processing cluster, the driving forces for which are faculty members from the Prince of Songkla University, four of the largest fish processors and their subcontractors (Kenan Foundation 2005).

Other promising cases include the Petroleum and Petrochemical College at Chulalongkorn University which supplies skilled workers to the petrochemical industry, in addition to providing testing and analysis services. In southeast Thailand, the Ayutthaya Technical Training Center was established in 1992 as a joint venture between the Hi-Tech Industrial Estate and King Mongkut's Institute of Technology North Bangkok with Canon as its long-term supporter. The center has assisted industry through short courses on metal working, CNC usage, factory automation and quality assurance.

Thailand's Industry Clusters[65]

The cluster concept is integral to the bi-level industrial policies of the Thai government. At the national level, the government is promoting five clusters: Kitchen of the World (food cluster), Detroit of Asia (automotive cluster), Asia Tropical Fashion (fashion cluster), World Graphic Design and Animation Centre (software cluster) and Asia Tourism Capital (tourism cluster). Each of Thailand's 19 geographical areas also has a cluster strategy focusing on a few strategic products or services supervised by CEO-style governors located in the area. At the local level, the cluster concept is being applied to increase the capacity of the grass-roots economy in the name of 'community-based clusters' that in particular is designed to help the 'One-Tambon-One

[64] Such diseases were responsible for decimating the shrimp industry in Taiwan (China) in 1988, and China lost 80 percent of their cultivated shrimp in two months (Brimble and Doner 2005).
[65] The section on these three clusters is based on Intarakumnerd 2005.

Product' program succeed.[66] Three cluster development experiences of note are connected with industries producing: hard disk drives, software and chili paste.

Hard Disk Drive (HDD) Cluster

Thailand is the world's 2nd largest exporter of hard disk drives produced by Fujitsu, Hitachi, Western Digital and Seagate. The industry relies on foreign affiliates of these MNCs for high-tech components, machinery and technology. Hence, local content is fairly low at only about 30-40 percent of total production cost.

The HDD cluster in Thailand is composed of firms specialized in: 1) HGA/HAS/HDD assembly; 2) motors; 3) suspensions; 4) base plates; and 5) flex assembly. Foreign firms dominate in all the sub-sectors (see Figure 3.11). Japanese firms dominate the motor sector whereas Singapore based firms are supreme in the base plates sector. Flex assembly and assembly are specializations where Japanese and U.S. firms coexist. The only Thai firm that can be viewed as a significant player is KR Precision which merged with Singapore-based Magnecomp in 2005. In addition, Gem City Engineering provides automation engineering services and Thai International assists with calibration. Several universities conduct research on HDDs in cooperation with the industry. These include the Asian Institute of Technology (AIT), Chulalongkorn University, Suranaree University and Khon Kaen University. The Thai German Institute offers training in automation. One of the key intermediaries in the development of HDD cluster is the International Disk Drive Equipment and Materials Association (IDEMA).[67] IDEMA spearheaded the process of promoting the HDD industry's international visibility, and since 1999 it has provided a platform for business networking, information sharing and industry promotion.

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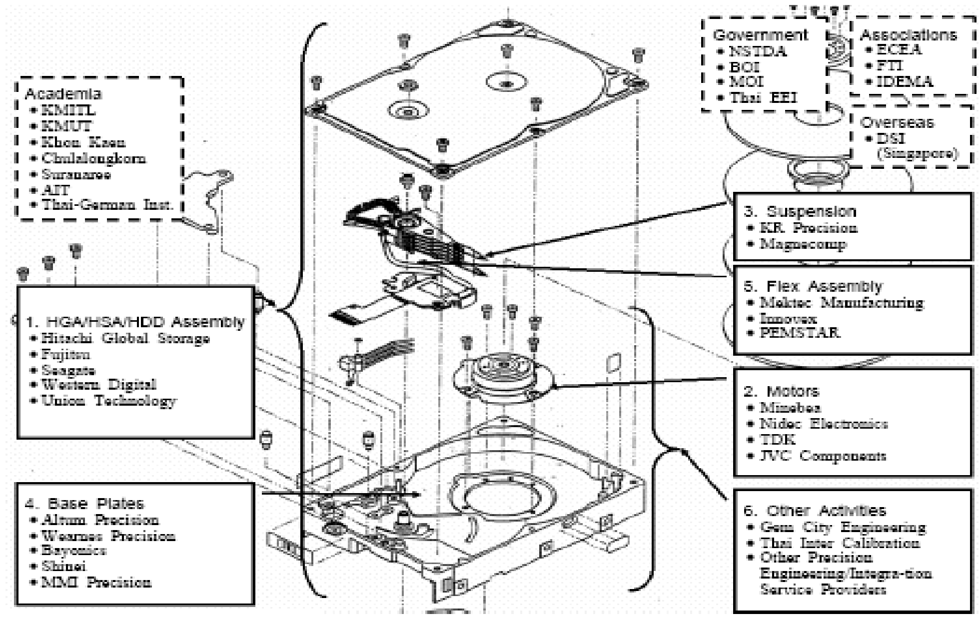
[66] Tambon is a unit of local government administration. One Tambon comprises several villages.

[67] IDEMA is an international not-for-profit trade association that represents the $22 billion HDD industry and its infrastructure. Founded in 1986, IDEMA sponsors trade shows, technical conferences, symposia, education classes, networking events and an active international standards program for its more than 500 corporate and individual members worldwide.

Figure 3.11: HDD Cluster in Thailand



Source: Intarakumnerd 2005

Surveys conducted at the private sector level indicate that thus far, Thai firms have exhibited strong capabilities in process development and industrial engineering. By contrast, Thai firms have demonstrated much weaker capabilities in product engineering and innovation, as well as in establishing linkages with suppliers, customers, universities and research institutes.[68]

Doubt has been cast on this industry's future in Thailand when in July 2006, Seagate Technology, the world's largest maker of hard-disk drive, chose Malaysia over Thailand as the location for a US$1billion dollar investment in a plant located in Senai, Johor to produce aluminum substrates for base platters ("Thailand: Seagate Technology" 2006).[69]

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[68] Ongoing research on firms in Thailand and in other East Asian countries will help to reveal the working of innovation systems within firms, their current capabilities and the approach to systematic innovation adopted by firms in the manufacturing sector.

[69] According to one NESDB official, a shortage of labor, as well as the lack of clear customs procedures and one-stop services, likely contributed to Seagate's decision. Seagate was one of several US companies to have relocated investments to other countries in the ASEAN due to Thailand's political and economic uncertainties and better investment incentives elsewhere ("Thailand: Seagate Technology" 2006).

Software Cluster

A software industry emerged in Thailand in the mid-1990s and now comprises over 170 firms employing close to 2,000 workers. Of these, 75 are fully Thai-owned, 34 are foreign companies and the others are joint ventures.[70] In contrast to the HDD industry, foreign firms have invested relatively little in this sub-sector and exports are small.

A Software Park was established in 1997 to encourage local clustering of software firms. It was supported by corporations such as IBM, HP, SUN, and Oracle. So far the Park has attracted more than 50 companies. With the encouragement of the Park's administration, firms are beginning to behave like a cluster by learning from each other, the NSTDA, participating universities and firms located outside the park, especially transnational corporations. The products and services offered by these companies are benefiting from the assistance and certification offered by NSTDA and Carnegie Mellon University. One indicator of the progress made is the increasing number of overseas customers.

Chili Paste Cluster

The Chili Paste cluster started in the Wat Tuptimdang Community at Tambon Klong Song, Klong Luang District, Pathumtani province, an old rural community dating back more than a century to the reign of King Rama V. Given its abundant maritime resources, the community has accumulated skills in farming, breeding, animal husbandry, handicrafts and food processing. This knowledge is mostly tacit. The most striking technological knowledge of this community relates to the making of grilled fish chili paste.

The Klong Song Housewife Association, established in 1992 with 19 founding members, has been instrumental to the development of the cluster. This association not only manages the production process, but also actively seeks help from the local university and research institutes for technology. In areas such as canning technology, such assistance is provided by Rajabhat Phetchaburi Wittiyalongkorn which coordinates its activities with other regulatory government agencies.

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[70] Of these, 33 licenses were issued during 2002 and 2003 and hence most firms have not started operations.

Role of Information and Communications Technology (ICT)

Research shows that investment in ICT has consistently contributed to productivity and economic growth (Jorgenson 2001), although the extent of the contribution differs among different countries/regions. For instance, the contribution of ICT capital to labor productivity in the EU was about half that in the U.S. up to the mid-1990s. Since the mid-1990s the relative contribution of ICT capital has improved, but overall EU productivity growth has been weak (van Ark and others 2003). Economic growth in Japan is dominated by investment and productivity growth in information technology, both for individual industries and the economy as a whole (Jorgenson and Nomura 2005).

Studies based on firm-level data also arrive at similar results. Firm level survey data from transition economies such as Estonia, Latvia, Lithuania, Poland and Russia indicate that ICT is one of the contributing factors to productivity gains and innovation, primarily in terms of process innovation rather than product and relational innovation. A recent World Bank survey of over 20,000 firms in developing countries reveals that firms that effectively utilize ICT show faster growth in sales and employment. In addition, these firms have higher labor and total factor productivity than firms that have not harnessed the potential offered by advances in ICT. Foreign subsidiaries that are export-oriented also rely heavily on ICT to maintain communications with their parent firms and suppliers (Neto and others 2005).[71] Trade and finance industries are found to be responsible for most of the acceleration in ICT capital deepening and TFP growth in the US (Inklaar, O'Mahony, and Timmer 2005). From the empirical evidence, it seems that the potential effect of ICT on a firm's performance is influenced by the information (or technology) intensity of the product, which involves both product characteristics and transaction characteristics. Therefore, finance, IT services and heavy industry are places where ICT contributes more to innovation (United Nations 2005).

Needless to say, for firms to integrate ICT in their operations, adequate infrastructure must be in place. Following the wave of deregulation and

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[71] ICT usage in developing countries seems to be influenced by a sector's characteristics. The study of Kenya, Tanzania and Uganda shows that the tourism sector is the heaviest user of ICT, mainly because it caters to foreign tourists, while ICT usage was low in the textile and food processing industries (Neto and others 2005).

privatization of the telecom industry in the 1990s, the private sector is the main driver of investment in telecommunication infrastructure, especially for broadband.[72] However, the regulatory environment has to be conducive to encouraging investment in this area. This requires that certain basic principles be followed, such as: 1) introducing market-based approaches and promoting ease of market entry aimed at boosting business confidence and clarity; 2) enhancing transactional enforceability; 3) ensuring interoperability; and 4) protecting intellectual property and consumer rights (Schware 2005).[73]

ICT Infrastructure in Thailand

The above argues for strengthening the ICT infrastructure in Thailand. Thailand has been fairly effective in reducing the price of ICT usage. For example, Internet access tariffs and mobile cellular tariffs account for only 2.5 percent and 5.8 percent of per capita monthly income, respectively. Internet bandwidth has been increasing over the years and so has connectivity with the outside world (see Table 3.15). However, Thailand is still lagging behind the frontrunners in the region (see Table 3.16). Thailand is also lagging behind in the provision of fixed telephone lines. The International Telecommunication Union's count of the number of fixed telephone lines per 100 inhabitants for 2005 ranks Thailand quite low at 11.34.[74] This disadvantage is to some extent offset by the use of mobile phones. Thailand's mobile cellular penetration rate is estimated at 51.3 per 100 inhabitants (NSTDA 2006).[75] The number of internet subscribers has been increasing over time (to 7.1 million users in 2005)[76], but broadband internet penetration still remains as low at 0.33 (fixed) and 0.91 (mobile) per 100 inhabitants.

Schools and universities are increasing their ICT utilization to improve the quality of teaching and learning. The government has taken several initiatives. For example, the Ministry of ICT was established in 2002 to promote the utilization of technologies for education as stated in the 1997

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[72] For developing countries lacking domestic resources, foreign direct investment in the telecommunications industry may be an attractive option (Guermazi and Satola 2005).
[73] Harmonization of the regulations across national borders may also be beneficial to ensure cross-border interoperability of internet-based applications (Schware 2005).
[74] Another estimate puts it as 14 (NSTDA 2006).
[75] This translates to 32 million mobile subscribers (NSTDA 2006).
[76] This is about 12 Internet users per 100 people (NSTDA 2006).

Constitution. And the 1999 National Education Act, as well as several other ICT-related policies, aim to encourage greater ICT use.[77] The National Education Act has established a central unit responsible for policy-making and coordination of R&D activities pertaining to the utilization of ICT technologies for education. There are several other plans, such as the National IT 2000, the National IT Policy 2010, the National ICT Master Plan (2002-06), the National ICT for Education Master Plan (2004-06) and the National Education Network (EDNET) Project (see Annex 3). In short, there is no dearth of legislative initiatives to improve the quality of education and the use of IT in the nation's schools. It will be years before the results of these efforts becomes known and international experience suggests that IT will only deliver better outcomes if it is carefully integrated into the classroom routine by teachers who are well-trained in the usage of the new tools (Emery, Ellis, and Chulavatnatol 2005; Yusuf and others 2003). Research in the United Kingdom suggests that the positive impact of IT may be greater at the primary level, as well as the teaching of English and science.

Table 3.15: Total International Bandwidth, 2004-06

Year/Month	Total International Bandwidth (Mbps)
2006/07	9315.513
2006/01	7910.671
2005/01	3354.625
2004/01	1435.875

[77] There are 3.5 million Internet users (mainly academic and commercial enterprise users). In all, there are 78,508 Internet hosts within their own domain, and there are 18 commercial Internet service providers (ISPs).

Table 3.16: International Bandwidth in East Asia, 2004

Country Name	(Mbps)
China	74,429
Hong Kong (China)	32,987
Indonesia	2,244
Japan	132,608
Korea	71,380
Malaysia	3,193
Philippines	3,215
Singapore	24,704
Thailand	3,006
Viet Nam	1,892

Note: The figure is collected at the end of the year.
Source: ITU.

Electronic linkages and information services are now available at all public and private higher education institutions both in the central and provincial regions. The modern linkage system Inter University Network (UniNET) links all university library systems together (including with foreign universities) for prompt and effective exchanges of resources, as well as to provide national and international education network services to support universities and institutions of higher learning.

In the near future, the National Education Network (EdNet), as the sole information networking system for the Ministry of Education, will serve as the core network for the distribution of information networking technology to education institutions at all levels. EdNet will enhance the capacity of the links between the national education network and local and overseas education networks. In addition, students, faculties and the general public are gaining access to international academic resources, while e-mail services are also provided for students.

IV. Thai Firms' Efforts to Innovate

Electronics industry[78]

Most Thai firms in the electronics industry are contract manufacturers for MNCs. Therefore, domestic firms mainly assemble or manufacture products required by contractors and expend little effort to develop new and innovative products. There are some notable exceptions however, which can serve as models for other firms.

Technology Transfer through Licensing: The Case of Siam United Hi-Tech Limited

In 1990, Siam United Hi-Tech Limited (SUH), a manufacturer of plastic toys, acquired the license for WN keyboard technology (101 keys) from Honeywell (the US electronics company) and began producing keyboards. When the licensing arrangement with Honeywell expired in 1994, SUH developed its own brand name and technology by employing several former Honeywell technicians and marketing experts. The first SUH designed keyboard was launched in 1994 and was sold to one major customer. Two new keyboard models were introduced in 1996 to refresh the product line and incorporate keys based on Windows 95.

SUH has steadily ramped up production and now operates four keyboard assembly lines with a production capacity of 300,000 keyboards per month. Laser engraving or sublimation process technologies are used to print graphics on the key tops and tests are performed using an automatic functional tester that depresses each key. All plastic parts are made in-house using injection mould facilities adjacent to the final assembly lines.

SUH has begun investing in R&D so as to produce higher-end products that require more sophisticated technology, designs and advanced functions, such as customized keyboards. It also has an on-site model and tool shop for building prototypes.

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[78] The two cases in electronic industry come from UNCTAD (2005).

Technology Transfer through Subcontracting: The Case of Hana Microelectronics Group

One of the Southeast Asia's leading independent "electronic manufacturing service (EMS)" companies, the Hana Microelectronics Group, was established in 1978 in Bangkok with 30 employees. It started out by assembling LED watch modules followed by liquid crystal display (LCD) watch modules. Hana then won a contract from a Swiss watch company, SMH Group, to assemble and later distribute E-modules for quartz analogue watch movements in the Hong Kong market. In 1986, the Hana Group diversified further and began producing wind coils for watch movements, as well as wind coils for other electronic industries using the technology it acquired from the SMH Group.

Hana established a subsidiary, Hana Microelectronics Co. Ltd., in Shanghai (China) with more than 1,200 employees and is equipped with fully automated machinery for Chip-on-Board (COB), chip on flex, surface-mount, micro-coil winding, printed circuit board assembly (PCBA) and several other electronic products. The group continued its product diversification and technology acquisition strategy by acquiring Olin Technologies, a division of the Olin Corporation from the United States, a producer of metal parts for the semiconductor industry. Olin Technologies was subsequently renamed as Advanced Interconnect Technologies (AIT) Company. AIT provides a comprehensive range of IC assembly and testing services. It employs over 6,000 people and produces over 100 million IC packages a month.

Hana diversified yet again by acquiring a manufacturing plant from S-Vision which assembled the new "video monitor on a chip" technology for reflective "liquid crystal on silicon" micro displays. Micro displays have a high potential as a key component in large-screen televisions and computer monitors, multimedia projectors, viewfinders for digital and video cameras, as well as video headsets and handheld devices.

Hana's sister company, Hana Semiconductor (Bangkok) Co. Ltd., assembles light-emitting diodes, optoelectronic packages and hybrid devices on a captive line basis. This company also offers services such as wafer testing and wafer back grinding, assembly, testing, dicing and drop shipment services.

Food Processing Industry

Charoen Pokphand Food (CPF)[79]

CPF, part of the gigantic Thai-based Charoen Pokphand Group, is the largest listed agricultural business in Thailand, with domestic and overseas operations in nine countries around the world. CPF is contributing to Thailand's bid to becoming the "kitchen of the world." CPF's success is underpinned by the more than US$3.5 million that it spends per annum on R&D.

CPF's research focuses on bio-security, food safety and traceability at all stages of its chicken, shrimp, pork, duck, feed mill and food processing plants. CPF opened its brand-new US$200 million integrated broiler complex in Nakhon Ratchasima that can produce 1.2 million tons of broilers per year and has set new standards for international feed safety.

CPF has been awarded the most prestigious international safety certificates, including GMP, HACCP, ISO, HALAL and EST/TH, and its products have gained the confidence of leading international marketers.

Applying this successful model to shrimp farming is one of CPF's current objectives. To breed healthy shrimp, the group has developed a unique system called pro-biotic aquaculture that controls all aspects of the breeding and growing process. For example, this process uses treated water and the ponds are lined to avoid contamination in order to make the use of chemicals or antibiotics unnecessary. Crop losses have gone down from 50 percent to 0.5 percent and CPF's frozen and processed shrimp are fast becoming export winners.

Construction Industry

Siam Cement Group (SCG)[80]

The Siam Cement Public Company Limited (SCC), under R&D which spent 486 million baht on R&D in 2005, set up the Siam Research and

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[79]This section is based on the materials from CP's website: http://www.cpthailand.com/webguest/media_outlookdetail.aspx?documentID=87fa966e-cd61-4a07-aa51-0da58844e6ef.

[80] This is based on Virasa (2005, pp.105-107).

Development Company as a subsidiary in 1997. This subsidiary's main focus is the development of new cement products. A new product resulting from this R&D effort is the CPAC roofing system, which reduces energy consumption by lowering a room's temperature by one to two degrees Celsius. Realizing the importance of innovation, SCC organizes a contest, the Siam Cement Group Power of Innovation Award, to solicit innovative ideas from its employees. A winning innovation was a ceramic tile called "Pimai" made from unique natural rocks found in the eastern part of Thailand. This has led to other innovations, such as making sandstone-replica ceramic tiles using a customized machine developed in-house.

The conventional production technology for ceramic roof tiles, as well as clay roof tiles, involves firing for long periods in tunnel kilns. This results in a huge volatility in the product's color and appearance. SCG management decided to address this challenge by applying the production processes for 'flat' ceramic floor and wall tiles. A cross-functional research team composed of R&D, engineering and kiln specialists was set up via a partnership between a dedicated R&D team from Thai Ceramic Roof Tile Co., Ltd. (TCRT) and SACMI IMOLA, a global leader in machine manufacturing for ceramic production process, and some small process-engineering enterprises from Italy in order to increase the team's effectiveness. The key challenge was that unlike ceramic wall and floor tiles with 'flat' dimensions, 'profiled' ceramic roof tiles with a wavy shape are more complicated to manufacture due to different densities along the curve. Following the development of a prototype mould the transition to a fully-automated production process and layout was successfully accomplished. This dramatically improved the tile's appearance and endurance under harsh weather conditions. This new tile, sold under the Excella brand, was marketed as a high-end product and proved to be a big success.

Auto Parts Industry

AAPICO Hitech Public Co Ltd[81]

Able Autopart Industries Co Ltd (AAPICO) was established in 1986 as a manufacturing company focusing on jigs,[82] dies and OEM (original-equipment)

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[81] This case is compiled using information from news sources through LexisNexis. See the relevant footnotes.

parts. AAPICO was relocated to Ayutthaya, north of Bangkok, in 1996. AAPICO went public in 2002 as AAPICO Hitech Public Co Ltd. The firm is considered to be one of the leading designers and manufacturers of automotive assembly jigs, dies and OEM parts in Southeast Asia and is a first-tier supplier to Toyota, Honda, Isuzu, Daimler and other carmakers.

One of the keys to AAPICO's success is its management style and its emphasis on training and research. AAPICO sends its employees overseas for training and the skills learned are then shared with other staff members at the home office ("Thai Companies" 2005).

The founder of the company, Yeap Swee Chuan, had the foresight to continue to invest in the fast-emerging automotive industry in Thailand despite the Asian economic crisis in 1997-98 when triggered the cancellation of orders and a rise in inventory levels. Instead of liquidating assets or limiting staff overheads, AAPICO did the reverse. The company managed to obtain more export orders and a lifeline of credit from the now-defunct Liam Tong Bank.[83] In addition, AAPICO won orders from DaimlerChrysler to design its car jigs and some auto components, including fuel tanks.

Acquiring competitive technologies through acquisition is also the company's top priority. One year after his company went public, AAPICO bought the local parts business of the Dana Corporation of Toledo, Ohio, for $50 million ("In a World of Car Builders" 2005). In February, 2006, AAPICO also bought a 20 percent stake in Jackspeed Corp, a maker and exporter of car parts and accessories in Singapore. This made AAPICO the second largest shareholder in Jackspeed Corp. This investment will help AAPICO expand its product line and increase its sales in Southeast Asia, China and India ("Thai Auto Parts Maker" 2006).

AAPICO also introduced lean manufacturing via a pilot program, supported by Auto Alliance Thailand and Toyota, and received the Toyota Production System (TPS) Championship Award in 2004 and 2005. Once the pilot program was concluded, the company introduced an enterprise software system

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[82] Jigs are machines that hold car parts while they are being welded together.

[83] AAPICO was able to obtain this line of credit because it cultivated its credibility with banks over the years. In addition, because AAPICO had strong relationships with other auto parts suppliers around the world, it was able to minimize the impact of the Asian economic crisis (de Meyer and Garg 2005).

to mainstream lean manufacturing and to integrate its network of facilities. AAPICO also installed software to create a demand-driven supply chain to accommodate the just-in-time manufacturing schedules of its customers, as well as to reduce inventory and fulfillment times.

The notable feature of these examples, which reinforces the data on R&D, is that these firms have innovated without much in-house R&D or the use of contracted research and university-industry links. Instead, much of AAPICO's efforts have gone into product or process development, while technology has been acquired through the takeover of firms or licensing.

Part 4
Policy Directions

Sustaining high rates of growth requires simultaneous action on two fronts. Firstly, Thailand needs to gradually raise the contribution of total factor productivity (TFP) to growth. The transfer of workers from lower productivity occupations in rural areas to higher productivity ones in urban areas is one means of achieving this. However, an increasing share of TFP must derive from technological advances and innovation. Thailand's objective over the next decade should be to raise TFP growth to close to 3 percent per annum, which would put it on par with the economies of China, the Republic of Korea and Taiwan (China). Secondly, realizing potential productivity gains also requires the pull of demand. In Thailand's case, as well as for other fast growing East Asian economies, as much as a third or more of the demand has come from the export sector. This demand is mainly for manufactured goods, as well as IT/business and tourism services. Moreover, export demand impinges on the sectors where the scope for productivity gains is highest and that have the largest consequences for growth. Hence, a virtuous spiral calls for the interplay of both supply and demand factors. Maintaining or increasing export competitiveness and economic openness more broadly, can be expected to generate competitive pressures to lower production costs, raise investment in equipment or capacity, to acquire embodied technology and to undertake various forms of innovation that together stimulate increases in productivity.

Thailand's technological capability is lagging for four interrelated reasons.

- The business sector, and in particular the medium and large-sized firms responsible for most technology development, are unmotivated, unwilling or unable to invest substantially in R&D whether in-house or through outsourcing, in order to improve/diversify products or introduce process innovations on a routine basis. This might be a function of Thailand's stage of development, the ease of access to codified technology and to technology embodied in equipment. Absorbing technology from abroad is viewed as the lower cost and preferred route to technology upgrading. It might reflect flaws in corporate strategy arising from shortsightedness, the ownership structure or managerial deficiencies. It might also be a logical response to a relatively sheltered domestic environment which blunts competitive pressures. Whatever the reasons, Thai firms do not yet see innovation as critical to their competitiveness and profitability.

- Numerous government programs to encourage R&D and technology development have failed to produce the desired effect. Thai spending on R&D hovers around 0.26 percent of GDP, there is little patenting by Thai companies, or much evidence of movement up the value chain in the key sectors of the economy. This might be related to the lack of forcefulness and consistency of government initiatives, the inadequacy of the incentives offered, or the consequence of direct budgetary allocations for research and how effectively they are distributed across a few targeted programs.

- The supply of S&T workers as a percent of university graduates is below that of Thailand's principal competitors. But perhaps more serious are the deficiencies in the training of these workers, which reflects the quality of Thailand's secondary education and its universities, even the leading ones. None of Thailand's tertiary institutions are ranked among the leading universities of East Asia. Universities engage in little research and none have adopted a proactive entrepreneurial approach to exploiting their research findings or made an effort to engage with the business community. Hence, university-industry linkages remain sparse and the tertiary education system is contributing less than it could towards the strengthening of the innovation system. Thailand also lacks world class research institutes that could serve as conduits for technology from abroad and/or a means of developing technology indigenously in specific areas that would help create local industrial clusters.

- Although technology development in Thailand has derived benefits from globalization this has mainly been in the form of technology that is embodied in equipment. FDI by MNCs has transferred amazingly little tacit knowledge and disembodied technology through vertical or horizontal spillovers.[84] Only a handful of companies have set up research facilities in Thailand and the scope of the research carried out is limited.[85] Thailand has a substantial diaspora of S&T workers in the U.S., in Taiwan (China), Singapore and Malaysia. However, this diaspora has not been a source of local entrepreneurship, venture capital, angel investors or a vehicle for the technological leadership, unlike the Chinese and Indian diasporas. Moreover, Thai companies are not making use of the globalization of research to exploit technology development capacity worldwide through outsourcing. Likewise, Thai firms have yet to take the lead in forming local consortia or joint ventures with foreign firms to pool their research assets for the purpose of joint research. Nor for that matter are Thai researchers actively collaborating with academics worldwide and with researchers in foreign corporations to produce co-authored papers or research reports.

I. Virtuous Spirals and the Business Environment

In the light of the initiatives taken and the experience gained over the past 15 years, the medium-term need is for a focused strategy with strong leadership both from the government and from the business sector. Joint and coordinated efforts are needed to embed technological change into the urban industrial economy and "routinize" the process of innovation. A sustained and consistent emphasis on technology by the government, backed by effective leadership and policies, can appropriately drive home the importance of technological dynamism for Thailand's economic future. Such an unwavering commitment contributed to the technological ascent of Korea and Taiwan (China) from a modest initial base of natural resources and human capital.

Starting in the 1970s, the governments in these two East Asian economies consistently assigned a high priority to the acquisition of technology,

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[84] This is despite the fact that the output from foreign plants accounts for the major share of manufacturing production. Foreign firms in Thailand tend to concentrate more in protected industries (except for the electrical machinery sector), thus lessening the need for transferring more advanced technology needed for the export market (Kohpaiboon 2005).

[85] A recent decision by Toyota to set up an R&D facility in Thailand was a significant development.

following the example of Japan. Influential members from the business community quickly reinforced the governments' position, and key firms took the lead in acquiring and developing technologies. The demonstration effect this generated helped to sensitize other firms and induce investment in R&D that made innovation a key strand in the competition strategies of leading Korean and Taiwanese firms. In other words, technological capability was forged gradually by creating awareness on the part of these two key players that resulted in a steady, cumulative and coordinated effort. The important lesson from the experience of these economies is that export-oriented businesses realized the significance of technology for improving their competitiveness and earnings that went on to prompt government initiatives.

A similar joint effort is needed in Thailand. Leading Thai firms, which depend on exports for a significant share of their revenues, must recognize the business case for investment in R&D for the purpose of "routinizing" technology development and basing their competitiveness more on innovation. Moreover, Thai firms must be convinced that the returns from R&D can be highly attractive. Without such a clear perception of this business case the demand for R&D will simply not materialize and government incentives will exert limited leverage.

In most cases the incentive to innovate is derived from competitive pressures that encourage firms to be knowledgeable, to monitor their competitors so as not to be late in introducing new technology and to emphasize innovation. This is clearly evident among Korean firms that regard competitors as the second most significant source of information. Innovation is also being rapidly integrated into the strategies of the leading Chinese and Taiwanese firms. Thai firms seem not to pay much attention to their competitors (see Table 3.4). One reason why Thai firms might focus more on price-based competition rather than innovation is that the supply of unskilled workers is still fairly elastic. Close to 43 percent of the labor force is still employed in the rural sector and the domestic supply of workers is being augmented by immigrants from Cambodia, Laos and Myanmar.

Under these circumstances a competition policy that is impartially enforced by the courts could influence the behavior of firms with regard to innovation (see Annex I). But three points should be noted:

Firstly, Thai firms operating in international markets are already exposed to the full blast of competition and should be cognizant of the advantages that accrue from innovation and predisposition to invest in R&D.

Secondly, while the enforcement of a competition policy tailored for Thailand's stage of development and institutional circumstances might enhance the demand for innovation, this is not firmly supported by empirical evidence. In fact, spending on R&D and the development of technological capability in East Asia is unrelated to the design of competition policies and their enforcement in Korea, Taiwan (China), Japan and China. Even where competition policies have been introduced they have not been implemented forcefully until quite recently, as in the case of Korea and Taiwan (China) (see Annex 1 on the experience of these economies and that of Thailand).

Thirdly, promoting the entry of firms that could contribute to industrial dynamism needs to be addressed. The entrepreneurial spirit in Thailand is strong. The rate of new start-ups is 15.2 percent of total establishment, which is much higher than in the United States (10 percent) and Singapore (7.2 percent), but lower than in China (16.2 percent).[86] However, the bulk of new start-ups are in the consumer services field. Although such activities are beneficial in terms of job creation and raising the incomes of entrepreneurs, it is also the case that the scale, scope and technological level of these activities are modest and any spillover effects are geographically limited to the immediate vicinity of the owners' residences (Bosma and Harding 2007). Reducing entry barriers, which would facilitate the establishment of manufacturing and technology intensive SMEs, could have a significant impact on the building of a knowledge-based economy. This is because SMEs play a significant role in introducing innovations in areas such as software, biotechnology and electronic components.

II. Skills

The broad issue of education quality and the narrow one of industrial skills are both areas which Thailand needs to tackle in a sustained fashion if the intention is to evolve into a knowledge-based economy on par with other leading East Asian economies. Our focus in this report was on tertiary level

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[86] The start-up rate has declined significantly from 20.7 percent in 2005 in Thailand.

institutions, but it must be remembered that the acquisition of S&T skills rests on the foundations laid by primary and secondary education.[87] If these are weak, then more resources must be allocated to the tertiary level in order to remedy deficiencies at earlier levels. Likewise, employers must invest more in training in order to bring their workers up to the desired standards of technical proficiency. Some of the most common complaints from Thai employers are that skilled workers are in short supply, that Thai workers are insufficiently computer and IT literate, and that few of their staff have a working knowledge of English. The high wage premium offered for such skills does point to shortages, as evidenced by the fact that workers with college degrees command starting salaries that are much higher than those of secondary school graduates.

However, the tight labor market for skilled workers is not a new development. Employers have complained of such shortages even as Thailand shifted from the production and export of resource-based low-tech products to the assembly and manufacture of many medium and higher tech items. Similar problems have been encountered by manufacturers in Korea and Taiwan (China) and are now being encountered by firms in China, Malaysia and Vietnam that are Thailand's main competitors. Where firms are determined to compete, they increase their in-house spending on training, as well as more fully utilize the training facilities and subsidies offered by the state and by private providers. In addition, through political channels business lobbies attempt to push measures to raise outlays on and the quality of the country's education system. The problem never goes away in any country — it is severe even in the U.S. — but firms learn to cope and to push for improvements. It is the use of "voice" and initiatives by firms individually and collectively that leads to change.

Such initiatives by the business sector in Thailand in the form of increased spending on training, greater utilization of public training facilities, and effective pressure through political channels to substantially raise public outlay on education (in particular S&T education), are not commensurate with the perceived extent of the shortages. If Thai businesses are losing their competitive edge, in part because they are being constrained by the supply of skills and they are doing little to remedy this, then the market failure deserves

[87] The state of secondary education in Thailand and how it can be improved is explored in a recent World Bank report (World Bank 2005b).

an explanation. Public action might be a partial answer, but such action needs to be preceded by a deeper analysis of the shortage, its persistence and the manpower strategies of firms. To what extent are skills critical to their longer term competitiveness? If skills do matter a great deal, what actions are they taking independently, through business associations and through their lobbying of government agencies, to alleviate the shortages? To what extent are individuals responding to market signals communicating the demand for skills?

III. R&D in Thailand: Learning from Others

The East Asia region is integrating fast. For most economies in the region the traded share of GDP is high, intra-regional trade and FDI are rising, and business and tourist travel among the economies in the region is trending steeply upwards. The East Asian region is also becoming more closely tied to the global economy, not the least to international production networks that serve as the relays through which information on markets, on technology and on logistics is widely distributed (Yusuf, Altaf, and Nabeshima 2004). The strength of the demonstration effect is strikingly evident in the speed with which firms observe and learn from others; in the intentness with which successful and unsuccessful experiences whether of economies, of regions or of firms are minutely scrutinized. The Japanese, the Korean and the Taiwanese models have all exerted a profound effect on the economies in the region and served to shape policies. At a regional level, the extraordinarily rapid industrialization and export growth of the Pearl River Delta and the Yangtze Basin Area in China is being closely observed by others.[88] Likewise, few firms in the electronics industry are unaware of Samsung or Sony or LG; in the consumer durables industry of companies such as Haier, Galanz, TCL and Changhong Electronics. These companies have the attention of their competitors, of potential entrants and industry participants in general. In the telecommunications sector MNCs are closely watching the progress of Huawei and ZTE. In fact, in every industry and at every level, even down to small component manufacturers, firms are aware of their competitors and ready to observe and learn. Those that are engaged in international trade have an even better sense of competition across

[88] On the performance of the Pearl River Delta, see Yusuf (2007b).

the region and beyond. Survival and growth depend on learning from and doing better than the competition.

One of the consistent empirical findings is that R&D that leads to process and product innovation, to better design, improved services and better value for consumers has a high payoff. Private returns can range between 20-30 percent and social returns can reach 90-100 percent (Wieser 2005). These aggregate level findings have been validated by evidence from firms. Among the successful firms, those which invest more in R&D and are able to effectively commercialize their research findings are also the most profitable and fastest growing. This fact is now well known across East Asia, at least among the many firms which engage in trade. Governments are also keenly aware of this and have been generous with incentives even though it is in the interest of firms to innovate, improve quality and diversify into higher value-added products.

Under these circumstances, the underinvestment in R&D by the Thai business sector is difficult to explain with reference to information gaps. As we suggest below, it is also difficult to convincingly ascribe this over a period of many years to shortages of technical skills.

The aggregate spending on R&D in Thailand as a percentage of GDP is low and rising gradually from a low base. It has been repeatedly observed that Thai firms in the automotive, jewelry, food processing and electronics industries focus on the labor intensive and lower technology areas and rely more on low labor costs and overheads to compete (Ketels 2003; Porter 2003). Few firms are attempting to move up the value chain by investing in R&D to stimulate innovations and enhance their technological capability. One good reason for this may be because that they are able to compete and achieve their desired returns on sales without having to conduct research and that the technology they require is embodied in the equipment they purchase, supplemented by the support they receive from suppliers and buyers. In other words, given Thailand's current level of development and the industrial composition, the volume and mix of research and its distribution among entities is adequate. This is supported by the transition of the export sector between 1990 and 2005. Over this 15 year period a combination of FDI and domestic entrepreneurship completely shifted the structure of exports (i.e. natural resource based products were largely displaced by exports of electronic products, components, auto parts and engineered products). And this structure could go on evolving.

The widespread perception among government agencies and external observers (see Part I) runs contrary to the above. It is that Thailand is or may be at the risk of losing ground in key export sub-sectors because of insufficient technological capability. For the same reason, Thai firms might not be able to continue diversifying into the production of new products (Yusuf 2008). Firms complain that their attempt to upgrade technology and to innovate is hamstrung by the limited supplies of S&T skills and a weak research infrastructure.

In fact, both views might be correct. Thailand may not have needed to invest much in R&D until recently, mainly because the existing mechanisms for technology transfer were enough to achieve the required level of technological capability. In fact, under these circumstances, i.e. with the easy access to codified industrial technology, investing more in R&D might well have been wasteful. However, to remain a player in its current leading industries and to advance into a more sophisticated range of products and services, Thailand will have to raise technological capability to a higher level. It may also have to do this in the span of 5-7 years because its competitors in East Asia and other parts of the world are clearly accelerating their own efforts to become more innovative. The stakes have been raised, and to remain an East Asian tiger economy Thailand must also climb the ladder of technological capability.

Increased spending on R&D is a necessary step and international experience indicates that on average both social as well as private returns are high. However, such efforts need to be coordinated with parallel efforts to augment the capacity to efficiently utilize the additional resources. To this end, both public and private entities need to institute or improve processes for planning and programming well-targeted research activities and for evaluating R&D activities on a regular basis to ensure that the funds are being well spent. In some instances, when the research is of an exploratory nature and the likely outcomes are highly uncertain, small-sized pilot R&D projects would be the way to proceed. Successful ventures could be scaled up, others discontinued, thereby minimizing waste of scarce research talent.

There are four main avenues for achieving this, including: 1) more research cooperation; 2) incentives for R&D; 3) university-industry linkages; and 4) the catalytic role of intermediaries. All of these will require greater public and private sector cooperation and partnerships under which each side will have to do its share.

Research Cooperation

Firstly, cutting-edge research is now a multidimensional activity and because costs are on the rise, such research efforts are increasingly a cooperative effort. Achieving quality results has always involved a combination of basic research and applied reach, but with the scientific content of new technologies on the rise the basic research component is inching upwards. Research is becoming more interdisciplinary with many important findings now occurring at the intersection of several disciplines (Foray 2007). Because of the spread of IT, globalization and the deepening pools of S&T workers in many industrialize countries, R&D is also becoming a "globalized" activity with many firms conducting research in linked labs located in a number of different countries (Carlsson 2006). The outsourcing of research enables firms to save money and tap the best expertise wherever it might be. Researchers also routinely collaborate with geographically dispersed partners. Hence, elite universities are no longer closed shops. Researchers in these universities co-author papers with widely scattered colleagues (Kim, Morse, and Zingale 2006).

Cost considerations and the advantages of pooling diverse specialized skills are behind the frequency of research alliances among firms, joint projects and the formation of research consortia. Such efforts involve the stretching and combining of limited S&T resources and the harnessing of the best researchers. This is particularly true in the case of the most able research managers.

In other words, the choices for firms are much wider and they are also wider for able researchers. The S&T resources of a firm need not be a binding constraint, especially for larger firms. Research can be outsourced, off-shored and carried out collaboratively. This requires the willingness to search for the necessary financial resources and to develop the managerial capacity to conduct and utilize research done in novel ways with different partners.

Second, Thai firms need to strengthen their own in-house research. The government can assist in this regard through fiscal incentives and measures that enhance the supply of talent, which is discussed in greater detail below.

Incentives for R&D

Incentives for R&D in Thailand are generous and comparable to those offered by its neighbors (see Table 3.1). The important next steps would be to make these incentives better known and more accessible. Channeling incentives through a small number of agencies and programs would be one way forward. Currently, there are far too many such agencies and programs. Consolidation of available resources could increase the impact of these programs and reducing red tape would ensure that such resources are actively sought and quickly released.

Government could encourage joint research programs and the forming of research consortia by tailoring incentives accordingly. The public sector should also provide targeted assistance for SMEs, as they have a harder time defining a technology acquisition strategy, pooling their limited resources, and where appropriate, outsourcing research.

Given Thailand's current circumstances, such efforts would augment the country's effective technological capability assuming that the latent demand for technology is present but frustrated by skill shortages and mismatches.

Role of Universities and University Industry Linkages

As countries master codified technologies and strive to catch up with their rivals, technological capability is becoming more dependent upon basic science and upstream applied research. These are areas where universities and dedicated research institutes have a comparative advantage and can add value to corporate research. But much depends on the quality and scale of these institutions, as well as the mix of the incentives that influence collaborative research.

Relatively few universities or research institutions can sustain productive research programs that result in substantial commercial outcomes. This is the case whether one looks at the U.S., China or Korea. The reason for this has to do with disciplinary breadth, the capacity to assemble a critical mass of researchers in several fields, the heterogeneity of the researchers and students in a university, a source of fission out of which new ideas are born, the quality of the students and faculty, as well as the ability to combine teaching and research with linkages to the business sector.

While it would seem desirable for the leading universities in Thailand to engage in research, it is an open question as to whether they should be actively induced to cultivate linkages with business, do contract research and consulting and seek to spin-off firms. Depending on a university's organization, the existence of incentives and the philosophy that is followed such policies might be neither desirable nor workable. What would be advantageous are four sets of actions which to varying degrees are already being implemented in Thailand.

- Give greater autonomy to universities, particularly the leading public ones, to manage their hiring strategies and pay scales so that they can compete with each other for students and teaching staff; and experiment with new technologies for teaching that includes different combinations of research and teaching. In a words, universities should have more flexibility and be disciplined by competition.

- The government should gradually step up the funding for research facilities and basic research at universities. This could include block grants, grants for specific programs, as well as scholarships for science, math and engineering studies for Thai and for foreign students, as is done in Singapore. It might be far better to focus such funding on the leading universities and merge some of the specialized research institutions with the universities—as is happening in France. The rational for this is that universities have the interdisciplinary range, the continual access to new talent, and are less likely to suffer from the "lock in" and weak incentives for launching start-ups of specialized institutes which have an uneven record in the region. Rather than spreading funds thinly across many entities a better strategy for Thailand might be to concentrate research funding in a few universities and build quality, critical mass and interdisciplinary research where the pay off is high.

- Create science parks and incubator facilities adjacent to the selected universities so as to maximize the likelihood of spillovers and start-ups, as well as support such measures with generous incentives.

- Make university-industry linkages more attractive for universities and firms by offering grants to universities conditional on the university pursuing collaborative ventures with firms. Also, encourage firms to link with universities by tying some government procurement contracts, such as for IT, software and computers, to the condition that firms engage with university researchers.

- One approach, variants of which have been adopted in the U.S., the U.K., Canada, Korea, Israel, and other countries, is to fund a program which helps finance post-doctoral internship positions in participating firms. These public-private programs ensure that there are immediate employment opportunities for graduates, which give them a foot in the door and lessen the risks of unemployment. More importantly, because many of these schemes are subsidized – or the post-doctorate students are paid relatively low wages – firms are in a position to benefit from an infusion of fresh research talent from universities which can energize their own research activities. Also, this would allow firms to evaluate individuals before making them an employment offer for the longer term. Such programs are appealing to firms in the pharmaceutical and biotech fields, as well as in software. Moreover, such programs are more likely to spur research in smaller firms which generally do less research and have a weaker research orientation. By providing a channel linking universities and firms, such programs provide a means for diffusing technical knowledge. Beyond that, they can be a way of catalyzing research in firms which do little by way of R&D. They can also, through the infusion of new blood, induce larger companies with on-going research to diversify their activities. For students enrolling in doctoral courses in science and engineering, these programs provide insurance and thereby induce more of them to seek such training.

Catalytic Intermediaries

In many cases, firms, especially small and medium enterprises, lack information on potential partners. They simply do not know which universities (or faculties) are engaged in relevant research activities that may be of use to them. Similarly, university faculties often lack the first-hand knowledge on technical constraints faced by firms. Intermediary organizations can help bridge such gaps that would help stimulate university-industry linkages. Initially, many of these intermediary organizations in other countries arose in universities seeking to commercialize research findings. The U.S. was a leader in this regard and gradually universities in other countries adopted similar strategies.[89] For instance, Tohoku University established the Office of Research Promotion and Intellectual Property in 2004 following the reform of the public university system in Japan (Jiang, Harayama, and Abe 2006).[90] However, these technology licensing offices tend to view the knowledge transfer as a unidirectional movement, from universities to firms. Increasingly, the multidirectional nature of knowledge transfer is being recognized and the other types of intermediaries have emerged as described in Part 2 above.

Many of these intermediaries rely on universities to provide high quality research of relevance to local industries.[91] This does not need to be focused solely on high-tech industries. The Georgia Institute of Technology in Atlanta has established several centers of innovation that specialize in technology for pulp and paper, food processing, textiles and the carpet making industry through joint university-industry research efforts, technology transfers and technology incubation. Such extension services have resulted in increases in sales, job creation and earnings (Youtie and Shapira 2006).

Intermediaries such as the CMI KIC (Cambridge-MIT Institute Knowledge Integrating Community) recognize the fact that knowledge transfer can be multidirectional and their organizational composition includes representatives from universities, the business community and government

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[89] University extension services also fall into this category. For instance, Georgia Tech Industrial Extension Services provide manufacturing assistance to local firms through the provision of manufacturing specialists who brings in new knowledge - may not be new at global level, but new locally - to the local firms with assistance from faculty members at Georgia Tech (Youtie and Shapira 2006).

[90] Other examples include VentureLab that assists faculties at Georgia Tech to commercialize their research findings (Youtie and Shapira 2006). Around the University of Austin there are a number of organizations that facilitate start-ups and technology transfer from universities such as the IC^2 Institute, the Austin Technology Incubator, The Texas Capital Network, the Austin Technology Council, the Digital Media Collaboratory, and the Wireless Networking and Communications Group, as well as the Clean Energy Incubator (Smilor and others 2005).

[91] To improve the quality of research at universities the U.S. has pursed several policy initiatives. The Georgia Research Alliance (GRA) was established in 1990 as a collaborative research initiative among six research universities in Georgia to build up the research infrastructure in key areas that are thought to have a large economic impact locally. So far $400 million has been invested in the GRA by the state of Georgia. This seed funding is estimated to have attracted an additional $2 billion in research funding from the federal government and private industries (Youtie and Shapira 2006).

agencies. Such a composition of participants, if reflected on the governing boards of universities in Thailand, could help to enhance communication among the three parties (as in Singapore) and make universities more responsive to the needs of the better understand the needs of business community.

In addition to the multidimensional nature of knowledge transfer, effective intermediaries recognize that most new knowledge is often tacit knowledge embodied in people and that the transfer of such knowledge is difficult without interaction between researchers and the potential recipient of the new technology. Moreover, the preparedness of the recipients, i.e. their absorptive capacity, is often essential for knowledge transfer to be consummated. Intermediaries can help to identify those firms that are both doing their own R&D and are prepared and actively seeking specific kinds of technologies (Kodama, Kano, and Suzuki 2006). Hence, intermediaries often help provide channels for interaction among technology developers and users.[92]

In many cases, intermediaries also generate their own revenue stream, although they can benefit from partial public funding. This ensures the long-term viability of such organizations, while giving them time to raise funds from other sources.

None of the above policy proposals can make much of a difference overnight. But they will prime the pump by showing that the government is serious about making a credible commitment to building up Thailand's technological capability. As we noted earlier, success will depend on the business sector's demand for this capability and its readiness to work hard to strengthen it.

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[92] In addition to providing support for early-stage firms, the Georgia Tech Advanced Technology Development Center hosts semi-formal "brown-bag lunches" and CEO roundtables to provide opportunities for interactions between university personnel and business communities (Youtie and Shapira 2006).

Annex A
Competition Policies in East Asia and Thailand

International Experience

Competition policies refer to the body of laws and regulations which govern the scope for competition and the channels of competition. The purpose of such policies is to identify measures that limit market competition through restrictive practices and the formation of monopolies and cartels. Economists traditionally argue that the primary benefit of competition is that it increases consumer welfare by lowering prices, as well as increasing the quality and range of available goods and services. These benefits also accrue to businesses because many buyers are other firms rather than final consumers. This line of argument has been widely recognized and accepted. Regulations that lower entry barriers also increase productivity and technological innovation. A study of the impact of pro-competitive regulatory reform on several industries in the United States found that annual welfare gains amount to more than 7 percent of GDP with 90 percent of the benefits flowing to consumers (World Bank 2006b). Moreover, the European Union's competition policies are based on the view that greater competition increases the rate of innovation (Lloyd, Vautier, and Crampton 2004). Reducing market entry barriers also encourages the development of small and medium-sized enterprises that are among the drivers of technology innovation. Another benefit of strengthening competition laws, is to address the income inequality issue, especially in developing countries where monopoly industries tend to be dominated and controlled by a small group of well-connected elites.

Design of an Effective Competition Policy Framework[1]

Although economic theory and empirical evidence lend some credence to the efficacy of competition policies, designing a well-functioning competition legal framework is a complex undertaking. Such a framework must take into account the individual characteristics of the legal system, economic structure and business practices in a specific country. Moreover, the design of the framework must take cognizance of tradeoffs between independence vs.

[1] This section is based on Trembilcock and Iacobucci (2002).

accountability, expertise vs. detachment, transparency vs. confidentiality, administrative efficiency vs. due process and predictability vs. flexibility. All of these tradeoffs act as key guidelines for the creation of an effective competition policy framework.

The independent status and administrative power of the competition authority are prerequisites for an effective competition policy. A recent report from the World Bank suggests that the head of the competition authority should be appointed by the parliament rather than by the administrative branch. The competition authority should also be independent of the relevant government ministry and have its own budget. At the same time, giving investigative, enforcement and adjudication functions to a single agency may raise risks or at least the perception that its adjudicative function will be compromised or biased by the agency having these other functions (i.e. being the judge of its own actions).[2]

Competition policy matters, such as the review of mergers, require a high level of expertise and industry experience. However, having an intimate acquaintance with a business and its involvement in an industry can compromise the "detachment of the regulators."

Transparency certainly enhances the credibility of competition policy and forestalls anti-competitive behavior. At the same time, the agency empowered with administering competition policy must guard against the inappropriate disclosure of information about the parties involved in order to avoid causing serious damage to their legitimate business interests.

Moreover, many matters within the purview of the competition authority may be time-sensitive. Protracted delays and uncertainty may also prejudice key employee, supplier and customer relationships. But timeliness as a value can be in conflict with the value of due process (and detachment, as described above), which provides all affected or interested parties (including interveners) with the right to voice their position.

Lastly, the predictability and consistency with which competition laws are applied is of critical importance in order to be sure that affected parties can

[2] Vesting the adjudicative function in the courts may alleviate the problem but it will increase the burden on the judicial system and lead to lengthy law suits, which will be discussed later.

adjust their practices. However, predictability must be balanced against the importance of flexibility in order to take into account the idiosyncrasies of particular industries, their transactions or practices, the changing nature of the domestic economy, the international economic environment, the role of technology, as well as advances in the theories that underlie a country's competition policy.

Experience of Taiwan and the Republic of Korea

The Republic of Korea and Taiwan (China) shared many similarities in the development of their competition policies. Both countries adopted import substitution policies to protect and encourage the development of labor-intensive light industries in 1950s and 1960s. But from the late 1960's onwards both economies pursued export-oriented strategies. The policy instruments that were employed in the import substitution and export-oriented phases (i.e. currency devaluation, low-interest preferential loans for selected industries, high tariff and non-trade barriers and limits on FDI) were not generally supportive of competition. These policies contributed to the economic takeoff of both economies, but not without a cost. In Korea, such policies resulted in an oligopolistic market structure and the concentration of economic power in the hands of large business groups known as "chaebols". These groups were able to derail the Korean government's attempts to enact a fair trade act on at least four occasions (Kang 2005). Nevertheless, both countries started to liberalize their economy in the 1980's. The Korean Monopoly Regulation and Fair Trade Act, which was patterned after antitrust regulations in the US, was enacted in 1980 and implemented in 1981. This Act prohibits unfair cartel practices and mutual investment among the chaebols' affiliates, sets a ceiling on credit transfers among the chaebols' affiliates, as well as regulates their vertical and horizontal integration (Kim 1993). The Korean government also significantly slashed tariff rates, lifted limits on FDI and established "sanctuaries" for SMEs.

The situation only began to change in 1995, when the Korean Fair Trade Commission (KFTC) became an independent central administrative agency under the Office of the Prime Minister. A year later the status of the KFTC was elevated to the ministerial level, thus making it possible to monitor the market and deter anti-competitive behavior more effectively (Kang 2005). Enforcement of competition policies only began in earnest in 1998 after Korea was hit by the East Asian economic crisis and a new government came into office.

Starting in the early 1980's, the government of Taiwan (China) also moved towards pro-competition policies and also adopted a series of economic reforms to deregulate the economy and liberalize trade. Between 1984 and 1994, there were seven rounds of self-initiated tariff reductions that resulted in a 70 percent reduction in average tariff rates. Taiwan's Fair Trade Act was enacted in February 1992. The Act covers a wide range of anti-trust and unfair competition practices. The anti-trust part of the Act regulates monopolies, mergers and concerted actions. In general, the Act permits the existence of monopolies as long as they do not abuse their market power. In the initial stages some anti-competitive practices of state enterprises, public utilities and transportation enterprises were exempted from the Act. The relevant provisions were deleted after their exemption expired in February 1996.

Before 1999, regulatory power to enforce the Act was within the jurisdiction of other agencies and the Free Trade Commission (FTC) was required by Act to refrain from exercising its power. Even under such circumstances, by exercising its consultative power under the same Act, the FTC was able to work with other agencies with a view to reducing regulatory control which, in the FTC's view, served to restrain competition (Shin 2005).[3]

Current Situation in Thailand

The Thailand Trade Competition Act (hereafter called "the Competition Act") began with the enactment of the Price Fixing and Anti-Monopoly Act of 1979. The Act consists of two parts, one devoted to preventing price fixing and another that focuses on anti-monopoly measures. The anti-monopoly part of the Act aims to promote fair competition. The Act empowers the Central Committee to look at business structures that may create monopolies or that

[3] Between January 1992 and June 2005, the FTC handled a total of 26,882 cases, including 18,338 complaints; 129 applications for approval of concerted action; 6,165 combination applications or filings (with 156 combination applications); and 2,250 requests for interpretation. As of the end-June 2005, 2,403 cases resulted in dispositions issued against respondents found in violation of the Fair Trade Act. In order to maintain a fair trading environment, the FTC cracked down especially hard on major cases that are particularly damaging to the public interest ("Fair Trade Commission, Executive Yuan Taiwan" 2006).

result in restrictive business practices. But because of enforcement problems the Department of Internal Trade made an adjustment to the Act by separating it into two parts: the Price of Goods and Services Act and the Competition Act. The Competition Act came into effect on April 30, 1999. The Competition Act applies to all types of business operations except those under central, provincial and local administration. Also exempted from the Competition Act are: 1) state enterprises under the law on budgetary procedure; 2) groups of farmers, co-operatives or co-operative societies conducting businesses for the benefit of the farmers; and 3) businesses prescribed under the Ministerial Regulation.

For several reasons, the enforcement of the Competition Act has been weak (Nikomborirak 2003). The most significant reason for this is resistance from big business groups. The situation has been made worse by provisions permitting members of business groups to serve as “expert members” of the Fair Trade Commission (FTC). The rational behind this set-up is based on the belief that only representatives from the business sector “understand” how business is done and know how the law should be implemented. As a result, the Fair Trade Commission is highly susceptible to the influence of interest groups associated with big business, which makes conflicts of interest inevitable. A second reason is that the Competition Act lacks transparent procedures and clear rules for implementation. Therefore, the FTC has too much discretionary power, while the administration as well as the enforcement of Competition Act can be arbitrary and discriminatory. The third problem is the lack of protection extended to confidential information belonging to the informant/complainant. Enforcement of the Competition Act is complaint driven. In other words, for the most part an investigation is launched when the competition authority receives a complaint from affected parties, be they competing businesses or consumers. But those who complain are mainly small businesses or consumers against large businesses that are in a position to defend their interests. The lack of expertise, financial resources and public awareness has also contributed to the slow progress in the enforcement of the Competition Act.

Annex B
ICT and Economic Growth

Research on the development of information technology shows that IT (or ICT) investment has been a consistent source of productivity growth and economic growth (Jorgenson 2001). Evidence for this can be seen in the contrasting experience of the EU and the U.S. Although real investment and capital service flows in the EU have increased just as rapidly as in the U.S., the share of ICT investment to total investment and capital service flows in the EU have been approximately half to two-thirds of the level in the U.S. throughout the 1990s. In relative terms, the contribution of ICT capital to labor productivity in the EU was about half the level seen in the U.S. up to the mid-1990s. Since the mid-1990s, the relative contribution of ICT capital has improved, but overall productivity growth in the EU has been weak (van Ark and others 2003). In the U.S. both the trade and finance industries were found to be responsible for most of the acceleration in ICT capital deepening and TFP growth (Inklaar, O'Mahony, and Timmer 2005). Meanwhile, research has shown that economic growth in Japan is dominated by investment and productivity growth in information technology, both for individual industries and the economy as a whole (Jorgenson and Nomura 2005). Furthermore, firm level survey data from transition economies such as Estonia, Latvia, Lithuania, Poland and Russia shows that ICT is one of the factors that has contributed to productivity and that ICT is an important contributor to innovation, particularly in the case of process innovation rather than product and relational innovation. The potential effect of ICT on a firm's performance will be determined by the information intensity of the product, which involves both product characteristics and transaction characteristics. Therefore, finance, IT services and the health industry are sectors where ICT contributes more to innovation (United Nations 2005).

Recent World Bank surveys of over 20,000 firms in developing countries reveal that firms that effectively utilize ICT show faster growth in sales and employment. In addition, these firms have higher labor and total factor productivity than firms that have not harnessed the potential offered by advances in ICT. Foreign subsidiaries that are export-oriented also rely heavily on ICT to maintain communications with their parent firms and suppliers

(Neto and others 2005).[4] Needless to say, for firms to integrate ICT into their operations the appropriate organizational, training and physical infrastructures must be in place. Following the wave of deregulation and privatization of the telecom industry in the 1990's, the private sector is the main driver of investment in telecommunication infrastructure, especially for broadband.[5] However, in order to increase investment in this area the regulatory environment has to be conducive. This requires following that basic several principles be embedded in policy reforms. These basic principles include: 1) market-based approaches and promoting the ease of market entry; 2) promoting business confidence and clarity; 3) enhancing transactional enforceability; 4) ensuring interoperability; and 5) protecting intellectual property and consumer rights (Schware 2005).[6]

I. Sector-specific Experience and Recommendations

Telemedicine

Advanced technologies such as computers, diagnostic imaging, robotics, voice-activating machines and remote controls have begun changing the manner in which hospitals operate and provide care, as well as the quality of their care and standards of operating theatres around the world (Latifi 2004). While developed countries have begun to introduce tele-robotic remote surgical services, developing countries such as India, Nepal and Bangladesh have opened up to telemedicine to address various issues being faced by their healthcare delivery system (Sood and Bhatia 2005). One successful example is India's use of tele-consultation, primarily in the fields of tele-radiology, tele-pathology and tele-cardiology. When a patient's doctor feels the need for a second opinion, he/she uses a special software called Sanjeevani to consolidate relevant clinical information for that patient into an Electronic Patient Record

[4] ICT usage in developing countries seems to be influenced by the sector characteristics. The study of Kenya, Tanzania, and Uganda shows that the tourism sector is the heaviest user of ICT, mainly because they cater to foreign tourists, while ICT usage was low in the textile and food processing industries (Neto and others 2005).
[5] For developing countries lacking domestic resources, FDI in the telecommunications industry may be an attractive option (Guermazi and Satola 2005).
[6] Harmonization of regulations across national borders may also be beneficial to ensure cross-boarder interoperability of Internet-based applications (Schware 2005).

(EPR) that can then be used to obtain a specialist's opinion using tele-consultation (Sood and Bhatia 2005).

E-tourism

With the deployment of ICT in developing countries and the relatively improved access to the Internet in recent years, many national destination management organizations (DMOs), such as national tourism offices, have developed e-tourism websites with the objective of reaching consumers worldwide directly.

Contributing factors for the successful integration of local tourism enterprises into international tourism markets include adequate e-tourism strategies that focus on tourism innovation in terms of tourism products and adoption of e-business tools such as destination management systems (DMSs). DMSs provide the IT infrastructure used by DMOs for the collection, storage, management and distribution of information, as well as a means of handling reservations and other commercial transactions. The main beneficiaries of a DMS are potential travelers, the providers of tourism products and services, national travel agents and outbound travel agents, national tourism institutions, IT providers and investors.

So far developing countries have mainly developed simple e-tourism websites offering information that could satisfy consumer expectations in travel planning. But these e-tourism websites do not offer secure booking or payment facilities.

The growing adoption of the Open Travel Alliance (OTA) standard based on Extensible Markup Language (XML) greatly facilitates the exchange of information between tourism enterprises such as airlines, hotels, car rental enterprises and travel integrators such as Cendant, Sabre, Expedia, Orbitz and SITA. The OTA XML standard enhances the ability of consumers to search and book using a single on-line operation session, as well as increasing aggregation processes in the tourism industry.

E-tourism websites should be consumer-centric. Consumers are increasingly looking for customizable travel that must be supported by technological innovations, such as flexible personalized options that depend on the type of activities, accommodation, duration of stay and price, or on-line advice for recreation based on similar requests/profiles (UNCTAD 2005).

ICT and the Auto Industry[7]

Product Development

Advances in product development processes have been more significant than changes in product architecture. Product cycles continue to grow shorter as more companies adopt the simultaneous engineering approach pioneered by Japanese automakers. Simultaneously, advances in Computer-Aided Design (CAD) and Computer-Aided Engineering (CAE) tools allow 3D models and simulations to replace physical prototypes and testing processes.

Global Supply Networks

The establishment of the industry consortium Covisint to develop a gigantic B2B hub is the other major technological development in automotive supply networks. Furthermore, the involvement of IT firms (most prominently Commerce One and Oracle) will intensify the auto industry's interaction with the high-tech sector's markedly different approach to product development and industry standards. Creating an XML overlay compatible with existing (proprietary) Electronic Data Interchange (EDI) systems used by the major automakers and their suppliers will be a major conversion effort and remains as the major incentive for Covisint's existence. Many obstacles stand in the way of achieving one standard set of XML labels throughout the industry, which is necessary to achieve the most optimistic savings estimates from information transparency during procurement and order fulfillment.

Service

The 3-Day Car program has revealed that the principle source of delay during the order fulfillment process in the automotive industry is information processing rather than manufacturing. This suggests that ICT can be crucial in re-shaping the automotive industry’s structure towards customer responsiveness and building-to-order (Howard 2005). ICT permits the bundling and customizing of existing services for customers, allowing the automaker to control the integration of these services and to maintain the customer relationship during the increasingly longer period between vehicle purchases; and to use the vehicle as a platform for tele-matics, i.e. new information

[7] This section is based on MacDuffie and Moavenzadeh (2001)

services provided to drivers and passengers that can potentially monetize the phenomenal number of hours that individuals devote to commuting.

Logistics

The continued diffusion of just-in-time inventory systems and in-sequence delivery of parts by suppliers to reduce the level of complexity at assembly plants still drive much of the action in logistics. IT support for both trends continues to grow in sophistication, although these effects are still largely confined to first-tier suppliers and their automaker customers. Much of the potential impact of Covisint on the efficiency of logistics will come from providing firms throughout the supply chain, both large and small, with rapid and simultaneous access to timely production and delivery scheduling information -- all without costly investments in proprietary EDI systems. As in the IT and electronics sectors, more and more logistics tasks are outsourced to specialized providers, and this trend is likely to continue. Both UPS and Federal Express are working in alliances with major automakers to develop order tracking and delivery management tools that can be accessed through the Internet. Some logistics providers are likely to expand their services to include inside-the-factory tasks such as inventory replenishment.

Software Innovation

While innovation continues on the hardware side (most notably in drive trains), more and more innovation occurs via software. The various sub-systems of an automobile increasingly depend on microprocessor control of functionality. The performance of braking systems, the feel of the suspension and steering and visual information available to the driver can vary under various driving conditions, based on software algorithms that operate upon real-time data collected through sensors and/or expressed as a driver preference. In the future, automakers and large suppliers might give greater importance to their control of key algorithms, outsourcing more of the design and manufacturing of the physical product.

E-Government

“E-Government” refers to the use by government agencies of information technologies (such as Wide Area Networks, the Internet and mobile computing) that have the ability to transform relations among citizens, businesses and other arms of government. These technologies can serve a variety of different ends, including better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management. The resulting benefits can be less corruption, increased transparency, greater convenience, revenue growth and/or cost reductions. Analogous to e-commerce, e-government aims to make the interaction between government and citizens (G2C), government and business enterprises (G2B), and inter-agency relationships (G2G) more friendly, convenient, transparent, and inexpensive (World Bank 2006b).

Table B.1: E-Government Readiness Rankings: South and Eastern Asia

Rank	Country	Index	Global rank in:		Change
		2005	2005	2004	
1	Republic of Korea	0.8727	5	5	0
2	Singapore	0.8503	7	8	1
3	Japan	0.7801	14	18	4
4	Philippines	0.5721	41	47	6
5	Malaysia	0.5706	43	42	-1
6	Thailand	0.5518	46	50	4
7	China	0.5078	57	67	10
8	Brunei Darussalam	0.4475	73	63	-10
9	Mongolia	0.3962	93	75	-18
10	Indonesia	0.3819	96	85	-11
11	Vietnam	0.364	105	112	7
12	Cambodia	0.2989	128	129	1
13	Myanmar	0.2959	129	123	-6
14	Timor-Leste	0.5212	144	174	30
15	Lao, P.D.R.	0.2421	147	144	-3
	Average	0.4922			

Source: United Nations 2005

Thailand was ranked in 46^{th} place in the UN's e-government readiness survey in 2005, up from 50^{th} place in 2004. However, with an Internet penetration rate of just 29 percent, which is limited to the most affluent Thais, access to the Internet in Thailand has not yet reached a point at which it can begin driving e-governance. The key barrier facing most potential Internet and ICT users in the country is the lack of Thai-centric content. In order to address this problem and to help spur interest in the Internet, companies such as Microsoft, Terra Lycos and M-Web have begun initiatives to incorporate Thai into their program and portal designs. M-Web in particular, by purchasing the most popular Thai portal, Sanook.com, intends to incorporate Thai content into its websites and browser software. Improving Thai's knowledge of the English language may also be a means for the government to increase accessibility (United Nations 2005).

Annex C
Thailand ICT Policy and Performance

Evolution of Thailand's ICT Policy[1]

Year	Activities
1986	Thailand establishes the National Electronics and Computer Technology Center (NECTEC) which has been given the mission of transferring technology to Thai's countrywide.
1987	NECTEC initiates the Interuniversity Network Project
1989	The Thai government initiates the SchoolNet project to provide Internet access to every school in the country. Currently, 4,758 schools around Thailand access the Internet through SchoolNet.
1992	NSTDA establishes National Information Technology committees, which formulate two National Information Technology policies: IT 2000, a short-term policy for 1997 through 2001, and IT 2010, a long-term policy for 2001 through 2009.
1996	The first National IT Policy, called IT2000, was announced by the NITC and later endorsed by the Cabinet. IT2000 put forward the vision for the country to properly exploit IT to achieve economic prosperity and social equity. To this end, the policy emphasized three main development agendas: 1) to build an equitable national information infrastructure (NII); 2) to invest in people to accelerate the supply of IT manpower and to develop an IT-literate workforce; and 3) to achieve good governance through the use of IT in delivering public services and in government administration.
May 1999	NECTEC Software Park, which was approved by the Cabinet in 1997, commences operation with 3,000 square meters of space at the Software Park Building. By 2003, Software Park Thailand houses 50 companies with 17 companies having international business links, employs over 560 workers that in return helps generate around US $10 million per year in income for the domestic economy. Collaboration with major companies like IBM,

[1] Most of this information Thailand's ICT policies comes from "Thailand's Road to Better ICT and Software Industry" (Runckel 2004) and ICT Human Resources Development within Thailand ICT Policy Context (Thuvasethakul and Pooparadai 2003)

	Sun, HP and Oracle as well as major universities and Thai companies is well-entrenched. Software Park Thailand is located on Chaeng Wattana Road, Nonthaburi province.
March 2002	The Thai government announces new ICT policies, including IT2010 (Fundamental Plan for Information and Communication Technology of Thailand). It's key development objectives are to exploit the benefits of information and communications technology to move Thailand to the "Knowledge-Based Society and Economy (KBS/KBE)". To this end, IT2010 identifies three cross-cutting principles: 1) building human capital; 2) promoting innovation and investment in information infrastructure; and 3) promoting the information industry. Under this framework, three specific development goals based on "technological and social indicators" were identified. These are: 1) To raise the technological capability of the country, as classified by the UNDP Technological Achievement Index from being in the "Dynamic Adopters" group", to the "Potential Leader" group, by 2010; 2) To increase proportion of "Knowledge Workers" in the country from 12 percent in 2001 to 30 percent by 2010; and 3) To increase the share of "Knowledge-Based Industries" within the overall economy to 50 percent by 2010. This new Plan sets out for the ICT Ministry five key development goals: e-government, e-commerce, e-industry, e-education and e-society.
September 2002	NECTEC and NESDB jointly develop the first National ICT master plan for the year 2002-2006. This master plan is developed in accordance with the IT 2010 policy framework, as well as the 9th National Economic and Social Development Plan (2002-2006). Under this plan, three prime-movers are identified as short-term goals to be accomplished within the first two years: 1) promotion of the software industry;

	2) development of various e-government applications; and 3) promotion of ICT usage in Small and Medium-sized Enterprises (SMEs).
2003	▪ E-Government policies are as follows: ▪ The Multi-Application Smart ID Card ▪ The card will be the main mechanism for promoting e-government as it can be used for personal identification and dealings both within the government and between the private and public sector. ▪ E-Procurement plans to utilize electronic processes for all government procurement, increasing their efficiency, achieving savings and making the system more transparent. ▪ The Government Data Exchange ▪ The National Spatial Data Infrastructure program aims to promote the use of Geographic Information System in the government's strategic management of domestic resources. ▪ Software for Back Office will address the interoperability of software applications throughout the government. ▪ The e-Government Institute will provide continuing education and training for all government officers so that they can work efficiently in the e-government environment. ▪ The ICT Ministry and Government Savings Bank initiate a loan program for low-cost computers which are priced at US$250.

Annex D
Financial Incentives for R&D Technology Development and Innovation in Thai Firms

Activities Related to Implementation Guideline 4-3:
Supporting Investment for the Development of Skills, Technology and Innovation

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
1.	NSTDA Investment Centre (NIC)	NSTDA	To promote R&D spending by the private sectors in S&T with a focus on human resource development, capital funding and S&T management	1. NSTDA will co-invest in projects, which support the national S&T policy, such as projects which require advanced technology to create innovative products in order to reduce R&D risks of private firms. 2. The projects must have the potential to be commercialized and have reasonable returns on investment. 3. The projects must enhance value-added products in order to	1. NSTDA will invest less than 50% of the total investment. 2. NSTDA will be part of the management team based on its share of investment in the project. 3. NSTDA will withdraw funding from the project if the project is determined to be ineffective or if its funding is no longer necessary.	

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
				reduce imports. The projects also have to support the transfer of technology, as well as preserve the environment.		
2.	Investment Development Policy for Enhancing Technology and Innovation	BOI	To stimulate and provide incentives for firms to improve their technology capabilities	To support direct S&T investment in potential industries: 1. Manufacturing of pharmaceutical and medical equipment. 2. Manufacturing of S&T equipment. 3. Manufacturing of aviation spare-parts. 4. Electronic designs. 5. R&D 6. S&T testing services 7. Calibration 8. Human resource development	1. Exemption of R&D machinery import duties. 2. Tax-based incentives: increase corporate tax holidays for 1 year but not more than 8 years in total.	

3.	"Good Innovation – Zero-interest" Scheme	NIA	To provide investment opportunities for the private sector to innovate by co-absorbing risks	To provide soft loans for start-up firms in order to create prototype products or pilot projects.	1. The soft loans rates will be issued by the NIA and participating financial institutes. The maturity is less than 3 years. 2. The firms will be responsible for the collateral.	In 2005, a total of 22 projects were supported in the total amount of 23.65 million baht. The projects' cumulative as of 2005 value was 1,172.5 million baht.
4.	Technology Capitalization Scheme	NIA	To support the private sector in applying knowledge to create new products or patents	To provide grant support and carry out distinguished innovation projects with a high-degree of novelty.	1. The private sector has to invest not less than 25% of the total investment. 2. Grants amount not more than 75% of total investment and lesser than 5 million baht per project. 3. The maturity is less than 3 years.	In 2005, a total of 13 projects were supported in the total amount of 16.58 million baht. The projects' cumulative as of 2005 value was 54.38 million baht.

5.	Innovation Cluster Grants	NIA	To promote the private sector doing R&D as a cluster	To provide grants for potential clusters, such as manufacturing clusters and regional clusters ranging from pilot projects to commercialization.	1. Grant amount is less than 5 million baht per project. 2. The maturity is less than 3 years.	In 2005, a total of 6 projects were supported in the total amount of 9.04 million baht. The projects' cumulative as of 2005 value as 80.89 million baht.
6.	Venture Capital Scheme	NIA	To promote investments in industries with high potential	NIA and joint-venture institutes will invest in the project with a total amount of not more than 49% of the project's registered capital. The NIA will hold a smaller share than joint-venture institutes.	The total amount of the NIA's investment will not exceed 25 million baht.	Between 2004 and 2006, a total of 6 projects were supported in the amount of 39.5 million baht. The projects' cumulative as of 2006 value at 325 million baht.

Activities Related to Implementation Guideline 4-4:
Expanding Support Programs for Enhancing Technology in Industry

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
1.	Industrial Technology Assistance Program: ITAP	NSTDA	Set up a mechanism to form linkages between technology providers and technology users by providing technical experts to assist in undertaking research and development, giving consultancy and solving problems at factory location including matching local demand in technology with external suppliers	1. Providing technology consultancy services in order to enhance levels of production and R&D that is provided by experts in the country and overseas 2. Organizing seminars in areas of technology that aim to enhance the capability of personnel in organizations 3. Searching for appropriate technology/information technology 4. Conducting quality assessments	1. Supporting the payment for experts in diagnosing general technical problems at full cost (100% of expert's costs incurred) 2. Supporting funding for hiring experts for the project on technology development at 50% of costs incurred but not over 500,000 baht and this provision can be given to only two projects/firm/year.	During 1992-2001, there were 630 projects from 562 firms/companies of which 346 projects (284 firms) were dealt with that diagnosed general technical problems and 319 projects (270 firms) that dealt with hiring experts.

2.	Company Directed for Technology Development: CD	NSTDA	Providing funds for R&D by the private sector (i.e. conducting R&D to improve products and production processes that are based on appropriate technology)	Soft loans for: 1. Conducting R&D and commercializing the findings 2. Improving technology or production processes and products 3. Setting up or upgrading research labs	1. Maximum loan is 30 million Baht and not over 75% of the project's total cost. 2. Interest rate is ½ of the general deposit rate in one year plus 2.25. 3. Payment period is 7 years (without principle payments in the first 2 years)	N/A
3.	Company Directed for Technology Development to Improve Competitiveness Program: MDICP	Department of Industrial Promotion	1. To develop industry throughout the value chain i.e. from production processes, quality assurance, R&D in products, financial management and marketing	Selecting 40 SMEs firms to join with consultants in 5 programs: 1. Developing and improving production processes 2. Improving standards and products so as to ally with ISO 9000 3. Enhancing capability on planning, technology management, strategic planning and marketing for competing in international markets	Providing financial support in part at 60% of consultancy costs but not exceed 9000,000 baht	In 2005, the amount of 40 million baht was allocated to the program that resulted in an increase in sales of participating firms at 2,605.2 million baht.

			2. To promote technology transfers from universities/research institutes to the private sector to enhance productivity at the firm level			
4.	Consultancy Fund: CF	Department of industrial promotion	Providing consultancy services as to enhance productivity at the firm level	1. Hiring consultants to provide general supervision to the firms 2. Hiring consultants to provide technical diagnosis to the firms 3. Monitoring the firms	Providing funds for financial support in part i.e. 50% of consultancy costs but not exceeding 200,000 in the case of the procurement procedure is by bidding; and not exceed 100,000 baht in the case of the procedure is direct selection.	In 2006, the amount of 16.8 was allocated
5.	Knowledge Creation Fund	Office of the Higher Education Commission	To help support private sector and government agencies in R&D investment	Providing funds to the projects related to knowledge creation and knowledge application	-	The process of setting-up the Fund is underway.

Activities Related to Implementation Guideline 4-5: Revising the Policy on Intellectual Property

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
1.	Intellectual Property Services	NSTDA	1. To encourage private sector R&D 2. To protect Thai property rights	Providing services in PR related matters to the private sector	1. To give advice, consultations on the process of PR application and PR commercialization 2. To help coordinate in searching for PR information 3. To give specialist advice and consultations on legal-related matters 4. To provide training in and seminars on PR-related issues	During 1999-2005, the services provided to the private sector were follows: - PR: 46 cases; - Licenses: 55 cases; - Trademarks and other services: 31 cases
2.	Cooperation on implementation in the areas of innovation and intellectual property	- NSTDA - NIA - Department of Business Development - Export Promotion Department - Intellectual Property	1. To coordinate cooperation among government agencies involved in innovation creation, IP protection and IP commercialization; 2. To provide services in the	A MOU has been signed by the five government agencies to demonstrate their commitment to working together.	Setting up a framework of cooperation in six areas: 1. Innovation creation and IP 2. PR protection 3. PR commercialization 4. PR enforcement 5. HRD in innovation and IP	

No.	Schemes	Organizations	Objectives	Details of the Scheme	Supporting Measures	Outcomes
		Department	areas of innovation, IP, and Thai-business promotion; 3. To cooperate on setting up measures/procedures/ mechanisms for start-up for innovation creation, IP protection and IP commercialization; 4. To sign a MOU that allows the flow of information and the creation of openness among the agencies.		6. Thai-business promotion	

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