# 10 The Thai Scientific Community: Reforms in the NIC of Time?

**Charles H. Davis, Jacques Gaillard** and
**Thomas Owen Eisemon**

Thailand, which means 'the Land of the Free', has maintained its political independence since the founding of the first Thai-speaking states eight centuries ago by resisting incursions from neighbouring states and, more recently, by fending off the Western imperial powers that laid claim to surrounding regions. In the post-War period, Thailand profited from its geopolitical situation, and its natural and cultural endowments to foster dizzying development, propelled by the highest national growth rates in the world in the late 1980s. This development has brought significant prosperity to many Thais and has raised the standards of living of a great many others, but at the cost of severe regional disparities, Bangkok's staggering congestion, and a variety of other disquieting social and environmental ills (Komin, 1989).

Cultural borrowers par excellence (Watson, 1989), the Thais have historically shown remarkable gifts for picking and choosing among various foreign institutional models, and adjusting and adapting them to suit their own purposes. The history of educational and scientific institutions in Thailand in the past century is one of a succession of foreign models—originally European, and more recently North American and Asian—that have been transplanted, retrofitted, infused with indigenous elements and experimented with.

However, new challenges to Thailand are raised by the rapid industrialization of the Pacific Rim and more generally by the global race to maintain economic competitiveness. Thailand aspires to become a Newly Industrializing Country (NIC) and much scholarly debate is taking place concerning whether or not Thailand is on the right track. Industrialization in the late twentieth century and success in global markets are underpinned by the capacity of a society to mobilize S&T for economic and social purposes. Although the growth rates, the patterns of investment, export and consumption, and the Thai cultural outlook all suggest that the country is poised to take its place among the world's developed economies, observers of the Thai system of industrial innovation are voicing alarm. Growth has come so quickly and so easily, they say, that the whole edifice of modern industrial Thailand is built upon a too-shallow foundation of scientific and technical skills. Thai S&T policy makers consider that extraordinary measures must be taken in the coming years to find ways to broaden and deepen the country's scientific and technical bases in the economic sector.

The problem of the sustainability of Thailand's industrial development is compounded by the lingering difficulty experienced by the Thai research community in reproducing itself (Gaillard, 1990). Despite the impressive development of the Thai scientific community during the 1960s and 1970s, Thailand is still unable to endogenously produce the cadre of high level scientific manpower that it needs in its research system. As in most developing countries, private sector R&D activities are very limited and mainstream scientific outputs are concentrated in the oldest metropolitan universities (Yuthavong, 1986). While Thailand is a regional leader in the quality and quantity of tertiary education, it lags in terms of secondary education. Furthermore, demand for technically skilled human resources has outstripped the ability of the education system to meet it and huge bottlenecks have developed in the supply of engineers. These bottlenecks are hindering Thailand's capacity to move up the technology ladder.

Since the late 1970s, Thailand has made relatively consistent and serious efforts to design and implement policies for S&T. Many studies of the Thai innovation system have been undertaken in recent years, often with the support of bilateral and multilateral donor agencies who are keenly interested in taking the scientific and technical pulse of this strategic country. As a result, Thai policy makers and researchers have a relatively good fix on the problems of scientific and technical development in Thailand. Many of Thailand's problems are those of a less developed country; these include problems of public health, poverty, regional disparity and environmental degradation. However, Thailand differs from most developing countries in one key respect. While many less developed countries are attempting to use S&T to move their national economies into a growth dynamic to generate income, this is not the problem in Thailand. The problem is that rapid economic growth has been driven by factors that are only marginally related to Thailand's scientific and technical capabilities. Consequently, there has been relatively little reinvestment of private wealth into the Thai S&T system except in the form of purchased capital equipment which is usually foreign. It is only in the recent past that the manufacturing sector has begun to express a demand for locally produced inputs, mainly in the form of technical personnel and also infrequently for technical support services.

Thailand is eager to join the ranks of the four Asian Tigers (Korea, Hong Kong, Taiwan and Singapore). However, the dynamics of industrialization in these first generation Pacific Rim late industrializers were undoubtedly very different from those that can be anticipated in Thailand (see Lall, 1990). Presently a plausible candidate to be the next Asian Tiger, Thailand must worry that the window of opportunity created by the global economic order in the past four decades (which have been relatively good to Thailand) will close before Thailand's innovation system is vigorous enough to drive the economy's growth. Vietnam, in particular, with its highly skilled work force and vast agricultural potential is viewed as a likely contender for Thailand's present economic niche. All agree the time for Thailand to move up the technology ladder has come. Although some observers advocate that Thailand should attempt to move into certain relatively mature heavy industries such as chemicals and automobiles, others argue that Thailand explore new models of industrialization based on biotechnologies (see for example Ichikawa et al., 1991). Whatever the strategy, to be effective it must put in place an array of institutions and policies to broaden and deepen Thailand's indigenous national technological capabilities.

It would be misleading to pretend to find consistently simple and direct relationships between endogenous scientific capacities, and processes of economic and social change. Any country able to exploit its own scientific capacity has developed an indigenous innovation system, which consists largely of actors outside the research system. Technology innovation systems are more complex than scientific communities (Clark, 1987). Most technology innovation systems include disparate actors of heterogeneous status: large, small, foreign and domestic firms; public and private laboratories; research, education and training institutions; financial bodies; and planning, policy making or programme agencies from each governmental level.

An in-depth examination of the emergence, structuring and social linkages of the Thai scientific community is not possible here. We limit ourselves to a sketch of the factors that are transforming the Thai scientific community, focusing on the emergence and differentiation of the higher education system, and the goals and institutions of Thai S&T policy.

## The Economic and Social Context of Investments in Science in Thailand

Thailand's interest in S&T is a response to the critical problem of sustaining the development of an economy in which growth in the past three decades has become concentrated in massive exports of low-wage manufactured goods. The Thai manufacturing sector grew at an average rate of 8.3 per cent in the period 1975–1985; in 1987, 1988 and 1989 the annual increases were 13.3 per cent, 16.8 per cent and 17 per cent respectively (*Bangkok Post*, 1990). Exported industrial goods include textiles, canned foods, assembled automotive vehicles, assembled electronics devices, ceramics, and some rubber and plastic products. In 1987, the top ten Thai manufactured exports in terms of revealed comparative advantage were tin, undergarments, leather, gold and silver jewellery, women's outerwear, precious and semi-precious stones, wood, men's outerwear, textiles and knitted undergarments (Dahlman et al., 1990; Appendix Table 2.1). The growth of the Thai manufacturing sector is attributable mainly to foreign direct investments, low-wage trainable labour, high rates of domestic protection, a stable macro-economic policy, a realistic exchange rate policy, export incentives and access to large markets in industrialized regions. The share of manufactured production in resource-based industries is decreasing and is increasing in labour-intensive industries. In science-based, scale-intensive or differentiated industries, no change in relative share has taken place (ibid.). Resource- and labour-intensive products present 75 per cent of Thailand's exports.

Agriculture still provided employment to about 67 per cent of the labour force, but it generated only 16 per cent of the GDP in 1988, declining from 27 per cent in 1975 (TDRI, 1990a: Tables 3 and 11). However, the value of agricultural goods and services tripled during this period, increasing by 22 per cent between 1987 and 1988. Agriculture's share of total exports dropped from almost half (46 per cent) of the exports in 1982 to a quarter (26 per cent) in 1990. Rice and rubber are still among the country's most important commodity exports. The value of these traditional exports still exceeds that of textile products. Export earnings for rice and rubber taken together are declining, although the decline is not as dramatic as for maize exports, whose value has fallen by half since 1985 (TDRI, 1990b: Table 6). The decline in the value of commodity agriculture exports reflects increased competition from other agricultural producers in the Asian region, poor prices and difficulties in securing access to markets in Europe and Japan.

The Thai model of economic development has had a particular kind of impact on national scientific and technological capacities. Thailand's industrial base remains very shallow and dependent on transfers of foreign investment and foreign technical inputs of all kinds. Only 0.17 per cent of GNP was spent on R&D from 1975 to 1987 (TDRI, 1989c), GERD/GNP ratios actually declined in the 1980s when the economy expanded rapidly and R&D expenditures failed to keep pace.[1] Most of Thai R&D is publicly financed and conducted in the public sector. Consequently, 'adaptive and innovative capabilities mainly reside in universities and government laboratories while operative capabilities, to the extent that they exist, reside in producing firms' (TDRI, 1989a: 2). Thailand's private sector conducts little R&D. Many studies of Thai technological capacities have been carried out by the Thailand Development Research Institute (TDRI), the Ministry of Science, Technology and Energy (MOSTE) and by foreign donors. In the aggregate, these studies reached similar conclusions: most firms in the modern sector have adequate ability to operate production technology but they 'are weak in searching for, acquiring, and adapting foreign technology. They are even weaker in developing their own technology' (Dahlman et al., 1990: 53).

In spite of these potentially serious structural shortcomings, Thailand's economic and social success is obvious to other less developed countries. This is because 'the Thais have demonstrated that it is possible to succeed without massive external assistance or the discovery of oil riches' (Nelson, 1991: 3).

## The Development of Science and Higher Education in Thailand: Brief Historical Background[2]

The Thai nation originated in the south of China. The invasions of the Mongol armies of Kublai Khan in the thirteenth century created migratory movements that led to cataclysmic changes in South-east Asia. Thai-speaking groups fled south, forming innumerable principalities in the central and northern parts of the region, chief among them the Sukothai Kingdom in what is now central Thailand. In the course of the following two centuries a major Thai-speaking regional empire emerged, the Kingdom of Ayudhya, supplanting the older Khmer Pagan empires (Wyatt, 1984). The Thai language was formalized and the Thai alphabet created.

Although Thai culture remains marked by its origins in China, Thailand adopted a Brahmanic system of justice and Therevada Buddhism as its state religion. Ayudhya secured itself against persistent conflict with the Burmese state and became an important international commercial centre, its ships trading from Korea to Persia. It was thus that by the sixteenth century the Kingdom of Ayudhya entertained diplomatic and commercial relations with foreign powers, including several European states—treaties were signed with Portugal in 1516 and Spain in 1598, and ambassadors were posted in Holland and England in the early seventeenth century. The reign of King Narai (1656–1688), under the influence of the Greek adventurer-turned-royal adviser Constantin Phaulkon, was marked by the development of closer relations with France and the exchange of ambassadors with Louis XIV. Through contact with European traders, missionaries and governments, a number of Western medical, commercial and military sciences and technologies were introduced, including a writing machine brought by a missionary (MOSTE, 1987a). But the Western powers' commercial intrigues and the religious activities of their missionaries led to a nationalist reaction at the death of King Narai, and relations with the West declined. When missionary activity was permitted again in the early nineteenth century, it was strictly regulated (Watson, 1989). From missionaries and traders Thais acquired skills in watchmaking, shipbuilding, mechanical engineering, physics and chemistry (MOSTE, 1987b).

The history of modern science in Thailand began in earnest with the arrival to the throne of King Mongkut (1851), recognized as the father of Thai science (*Thai Life*, 1985). King Mongkut was the fourth of the Chakri dynasty, established in 1782 with Bangkok as its capital. In the context of regional geopolitics dominated by French and British imperial rivalries, King Mongkut and his successor King Chulalongkorn (1868–1910) introduced important administrative, economic and social changes to Thailand while maintaining the country's independence (Muscat, 1966). Both recognized that their country could not sustain independence in the face of European imperialism without mastering and adapting the knowledge, the institutional models and the technologies generated by the West. A policy of modernization resulted during Chulalongkorn's reign; slavery and feudalism were abolished; modern public administration was established; railroads, telegraphs, telephones, electrical grids and urban water systems were constructed; and large-scale irrigation works were undertaken.

King Chulalongkorn was the first Thai monarch to travel to neighbouring countries as well as to Europe, which he visited twice. In 1890 he sent the first Thais, members of the royal family, to Europe (mainly to England) for education. Chulalongkorn's son Vajiravudh, who studied medicine at Oxford in England, continued the reforms of his father and grandfather. He founded Chulalongkorn University, the first Thai university, in 1916 in memory of his father.

## The Birth of the Thai Higher Education System: 1917–1943

Education in Thailand was at one time in the province of religion and was organized in close relation to monastic life. The educated elite was limited to men who served at the royal court and in monasteries. Very few women had access to education. The establishment of the civil service at the beginning of the century created new needs for educated personnel. These needs were at first filled by members of religious orders. Following the establishment of the Ministry of Education and the gradual development of the public school system, education moved away from the traditional *wat* ('temple') school. Elementary education was made mandatory by royal decree in 1921. In the decades following the promulgation of this decree, the education system had to confront numerous difficulties, the principal one being the scarcity of qualified teachers. To improve the level of instruction, numerous teacher training schools were opened (OPM, 1984).

It was also during the reign of King Chulalongkorn that the idea of establishing modern institutions of higher education emerged. The principle followed was that of establishing specialist institutions to provide civil servants to specific government departments, like the French Grandes Ecoles (Watson, 1991). Paetyakorn Medical School (1889), a law school (1897) and the Royal Pages School for future government administrators (1902) had already been established when King Vajiravudh, who had been exposed to European educational thinking during his study in England, proclaimed the Royal Pages School to become the Civil Service College in 1910. This school, intended for future members of the upper civil service, was to offer training in administration, foreign relations, agriculture, medicine, law, commerce and education. The Civil Service College was upgraded to university status in 1917. Paetyakorn Medical School and the Engineering School of Hor Wang, established in 1913, were attached to Chulalongkorn University, which at that time had four faculties: medicine, political science, engineering, and arts and science. A three-year programme of study led to a diploma. An agricultural training school was also established. Between 1923 and 1934, Chulalongkorn University received active support from the Rockefeller Foundation for the reform of medical education, the objective being to deliver a recognized doctor with a medical degree. The first Chulalongkorn University MD degrees were granted in 1930. In 1935, the first Chulalongkorn University Act was promulgated, establishing diplomas in medicine, arts, science and engineering, and the first Bachelor's of Science degrees were awarded in 1935, followed a few years later by the first Master's degrees.

Although no foreign advice was sought, the model of the Thai university system at this point was clearly European, with closed access, teaching organized by faculties, instructional programmes of specific lengths and government controlled (Watson, 1989). The results were that:

> as new universities were opened during the next forty years, they became associated with specific government ministries. As a result they were seen as 'finishing schools' or as 'professional training schools for government' rather than as communities of scholars engaged in research and the pursuit of truth. Moreover, all the new schools were situated in and around Bangkok, the capital. The effects of this . . . were to lead to an excessive dominance of key decision-making departments and of economic concentration in the capital, leaving much of the rest of the country scarcely affected until the 1960s (Watson, 1991: 71–72).

This model prevailed until the 1960s. Five specialized institutions, all of which eventually became universities, were opened on this model between 1933 and 1943. In 1933, the second Thai university, the University of Moral and Political Science, was created. Renamed Thammasat University in 1952, this university serviced the Ministry of Public Justice and the Department of Public Administration. A third university, which became Mahidol University in 1969, was created in 1942 from Chulalongkorn University's Faculty of Medicine and Departments of Pharmacy, Dentistry and Veterinary Sciences. The foundations of Thailand's well-known capabilities in bio-medical sciences were developed at Mahidol University, which serviced the Ministry of Public Health. Two other specialist institutes in agriculture and forestry provided training for the Ministry of Agriculture. They were merged in 1943 to establish the predecessor of Kasetsart University, Thailand's first agricultural university.

## The Expansion of Higher Education in Thailand: 1943–1992

The 1960s saw dramatic changes in Thailand's system of higher education. Rapid population growth and the development of elementary and secondary schooling created strong demands for higher education. Furthermore, concerns about the production of human resources for economic development provided a rationale for expanding access to higher education. Finally, the turbulence in neighbouring countries in the 1960s and 1970s strengthened the rationale for creating educational opportunities outside of Bangkok. In accordance with the government's wish to attenuate regional disparities and decentralize the educational system, a university was established in each of the three main less developed regions of the country. Thus, Chiang Mai University in the north was the first university to be established outside the national capital. Chiang Mai University was followed in 1965 by Khon Kaen University for the north-eastern region, and in 1968 by the Prince of Songkhla University for the southern region. These institutions were and are intended to be agents of development and modernization.

The regional universities were established on the same model as the previous generation of Bangkok universities, with closed access and rigorous selection procedures that favoured students of higher socio-economic status from Bangkok. Because only a few regional students could compete for places in regional universities, a quota system was established to provide access for the top 25 to 40 per cent of school-leavers in the region.

The creation of the regional universities and the recourse to quotas represent the first departure from the closed access model of higher education that had prevailed in Thailand. Watson (1989, 1991) identifies three other responses to the inadequacies of the early model: system diversification at the tertiary level, creation of open access institutions and privatization.

Diversification took place through the establishment of new, specialized public institutions. The National Institute of Development Administration (NIDA) was created in 1966 to provide postgraduate training in public and business administration, statistics, development economics and the English language. The Asian Institute of Technology (AIT), an international engineering and management school, was established in 1967. AIT and Chulalongkorn University's Sasin Business School, which is affiliated with the Wharton School, provide two of the rare international environments in higher education in Thailand. A Thai technical university, the King Mongkut Institute of Technology, was established in 1971 through the amalgamation and ugrading of several small Bangkok-area technical institutes. A similar procedure created Srinakharinvirot University in 1974 from existing colleges of education.

By 1970, only 30 per cent of eligible candidates could be accommodated in Thai institutions of higher learning (Watson, 1991). To satisfy the burgeoning demand for higher education, two open universities were created. Ramkamhaeng University, established in 1971, provides Sorbonne-style mass higher education in social science disciplines to any secondary school graduate with no entrance exams. By 1980, 546,000 students were enrolled at this university, many on a part-time basis, taking over a 1,000 courses. Ramkamhaeng University may be the largest university in the world. The second open university, Sukothai Thammathirat Open University (STOU), was created on the model of the British Open University. In contrast to Ramkamhaeng University, STOU uses distance education techniques to offer courses in the social sciences, business disciplines and other applied fields. In 1983, 110,000 students were enrolled at STOU, which caters mainly to working adults.

In 1987, there were fourteen 'closed enrolment' public institutions of higher education in Thailand, enrolling 96,500 undergraduates and 19,300 graduates (MUA, 1988: Table 7). Between 1983 to 1987, the massive enrolments in the open universities declined from 657,000 to 522,000 (ibid.: Table 7). This is attributable to the rise of private universities in Thailand. The Private Colleges Act, passed in 1969, recognized six private, tertiary, degree giving institutions. In 1988, there were twenty-five private universities and colleges, with a total enrolment of 52,700 students at the Bachelor's level (a doubling since 1980), 700 at the Master's level and 6,800 at the Associate level (ibid.: Table 18). Nine private institutions (Bangkok University, Assumption Business Administration College, Dhurakijpundit University, Payap University, Institute of Social Technology, Rangsit University, Siam Technics University, Sripatum University and the University of the Thai Chamber of Commerce) account for 93 per cent of the total student enrolment in private institutes. Many of the private institutions are very small; sometimes they have a religious affiliation and they usually offer courses in business, informatics and low-cost health disciplines.

Thus, at the end of the 1980s, about 20 per cent of Thai university students were in elite, government-supported, 'closed enrolment' universities. Another 70 per cent were in low-cost, open enrolment, public universities. And about 12 per cent were in high-cost, relatively selective, private universities. In terms of full-time equivalents, however, the relative shares are 39 per cent in the closed universities, 36 per cent in the open universities and 24 per cent in the private universities (Myers, 1991). Total enrolments in Thai higher education have stayed nearly constant over the past decade.

Overall, the greatest expansion in production of human resources has come in the number of students in the social sciences and humanities (including the arts, commerce, education and law). Agronomy attracts relatively few students. The fact that the most important and the oldest of the Thai universities specializing in agricultural sciences is situated in the outskirts of Bangkok is surely a factor in its ability to recruit students, many of whom come to Kasetsart University to study business administration, engineering, electronics and other fields that are relatively far removed from agriculture (USAID, 1988). Nearly half of Kasetsart's students are from the metropolitan region and have only limited interest in agriculture. Among those that do, few intend to work in professions directly related to agriculture after having obtained a degree. Interest in scientific professions (chemistry, biology, physics) declined in the latter half of the 1970s and has remained low (Manunapichu, 1981), although it picked up again in the mid-1980s. One of the main reasons for low interest is that science graduates have not easily found work. Most jobs for science graduates are in the teaching field, with few opportunities for promotion or for generating additional income to supplement inadequate salaries. This is not the case for graduates in the business, law, informatics, and more recently, engineering fields, where job openings have been relatively abundant in the public and private sectors. These are fields in which private institutions of higher education have positioned themselves. The demand for engineers is leading a number of Thai private universities to offer instruction in this area.[3]

In 1986, less than 10 per cent of the students in Thai universities and colleges (about 57,000 out of a total of 678,000) were studying scientific and technical subjects (MUA, 1988).[4] Production of Master's and doctoral students in scientific and technical fields was very low until recently (many postgraduate programmes were established in the 1980s) and remains concentrated in the medical and health sciences. In 1986, 218 doctorates or equivalent degrees were awarded, 188 of them in the medical and health sciences (ibid.: Table 11). The most common qualification of the academic staff at Thai universities is a Master's degree; the highest concentrations of doctorates are to be found at Chulalongkorn, Kasetsart and Mahidol Universities.

The policy of the Thai government has been to limit the growth of financial support to public universities to about 2 per cent per annum. One of the objectives of this policy, in addition to reducing the growth of the government's financial obligations to universities, is apparently to increase the relevance of the universities' work with respect to national development needs. The public universities are expected to generate the supplementary or alternative income that they need. At the same time, however, the university system has remained part of the public sector, constraining universities' latitude with respect to tuition fees and salaries.

In 1992, legislation was introduced to 'privatize' the public universities. The nomenclature is misleading, because under the new legislation the universities would still remain public institutions, eligible for public funds, but would acquire greater autonomy with respect to their own curricula and financial decisions, including tuition fees, tenure, salaries and involvement in income-generating activities. This could be another watershed in the history of Thai scientific institutions. Notes one observer, 'the relatively comfortable state of Thai science may be rocked to its core in the not-too-distant future if some universities decide to take up a proposal now being considered and leave the secure confines of the civil service to become quasi-independent' (Fahn, 1991: F3). The proposal has divided the Thai scientific community into several issue segments. One dimension of opinion believes that they can profit from market demand and the other believes that they cannot. In general, university personnel in the applied social and natural sciences, and engineering fields favour greater freedom for universities to offer competitive salaries because they are the ones in demand. Personnel in the basic social and natural sciences, and humanities are less optimistic about beneficial effects to universities from exiting the civil service. Employment security is another area of concern. Even though salaries are not high, positions are secure and promotion is almost automatic. However, some see employment security as an important cause of the lack of competitiveness of Thai science. A 'publish or perish' ethos is being advocated to make it obligatory for university professors to maintain currency. In highly demanded technical fields, universities are seen to need to compete with the private sector and keep productive researchers on campus. Unless universities can maintain technical currency for teaching purposes, Thailand will have to send another generation of students abroad to fill the positions which will fall vacant when the present generation begins to retire at the end of the decade. A final area of concern involves the capability of the public university system to survive in a quasi-independent situation. Some consider that 'many universities would fail' but that the system as a whole would be improved (ibid.: F3).

Although several public universities have prepared plans for receiving greater administrative autonomy from the government, the overall framework of 'privatization' has not been clarified. In the background of the debate over the advantages and disadvantages of privatization of public universities in Thailand is a set of assumptions about how well each institution could increase its income from students and clients compared to competitors, the effects of this redistribution of income within the institution and the degree to which government assistance would cover other operations. However, as Thai universities jockey to position themselves in lucrative fields of human resource production, the research and technical service functions of higher education have moved into the background. The implications for graduate education and research need to be carefully considered. As one observer puts it,

> . . . the picture at the moment is not very encouraging. Faculty in key fields are being hired away by the private sector and to a lesser extent by new universities and new programs in these fields at existing universities. There is thus a real threat to the nation's ability to train the next

generation of faculty and the highly skilled manpower increasingly needed in industry and in formal sector service firms (Myers, 1991: 12)

The new system will probably be more responsive to short-term social needs. After all, it took more than seven years for Thai universities to respond to the shortages in technical manpower observed in the mid-1980s (Sripaipan and Brimble, 1991). But there is the danger that 'privatization' is viewed as a panacea for all the problems of Thailand's economic and technological development. In particular, 'the case for S&T training programs which often require large expenditures on equipment and supplies may be difficult to raise under conditions of financial autonomy' (ibid.: 14). Furthermore, the greatest scope for increased income for universities lies in increases in tuition fees, raising issues of equitable access to higher education.

## Thai S&T Infrastructure and the Emergence of S&T Policy Organizations

Two key problems have emerged in the Thai innovation system in the past decade. One is the difficulty experienced by the educational system in delivering human resources with appropriate skills in a timely manner. Unfavourable quantitative and qualitative characteristics of the labour force are viewed as key constraints to science-based technological innovation in the private sector; there are 'critical S&T manpower shortages', especially at the university degree level. The 'supply of human resources . . . does not match demand in the labour market' and 'new projects . . . require a high level of scientific and technological competence' that many firms do not possess (NESDB, 1986: 155–56). A multi-objective strategy for the improvement of human capital is required, including the reinforcement of graduate teaching and research, and vocational training (Dahlman et al., 1990; Sripaipan and Brimble, 1992).

The second problem in the Thai innovation system is that although demand for technically qualified human resources is strong within the Thai industrial sector, demand for R&D and externally-procured technical services is weak. Thailand's national industrial structure is considered not to lend itself to private investments in R&D and, consequently, technological innovation. There are believed to be too many small, family-owned firms that cannot afford to invest in R&D, or there may be too many large foreign firms and joint ventures which rely on the R&D capability of the parent company. These particular patterns of entrepreneurship are said to discourage long-term investments in product innovations and improvements in the manufacturing or distribution process (see TDRI, 1994; Brimble and Sripaipan, 1994).

Studies usually propose various policy remedies to trigger a process of technological accumulation in Thailand so that the country can break out of its current technological trajectory and provoke 'changes in the Thai economic structure away from agriculture toward industry' (NESDB, 1986: 152–55). Two principal groups of constraints to technological development are identified. For many Thai S&T planners, the main policy problem is to raise private sector R&D expenditures (Kritayakirana and Srichandr, 1990). Overall, industry in Thailand does not invest in R&D. Only about 14 per cent of R&D expenditures was financed by productive enterprises in 1985 (Lall, 1990). A 1982 survey of Thai firms showed that research budgets represented a meagre 0.01 per cent of sales revenue (Yuthavong and Sutabutr, 1983), a figure that is well below private sector spending for technology development in Asian NICs. Firms judged to have some capacity for technological innovation had on the average fewer than two staff assigned to this work, most of whom did not possess any university level scientific or technical training. Although lacking significant research capacity themselves, the firms were not using the resources of universities and government scientific institutions; only 2 per cent of research expenditure was contracted out of these institutions or their staff.

The policy emphasis is therefore on identifying and removing disincentives to investments in R&D in a fast-growth, export-led economy in which most major production facilities are branch plants of foreign firms. Analysts believe that in this sort of economy, fast growth sharply reduces the need to raise production efficiency. High tariff protection has resulted in low domestic levels of competition and certain fiscal disincentives such as import taxes on capital equipment, income taxes on foreign consultants and absence of positive fiscal incentives such as tax credits for R&D are held responsible for hampering the deployment of R&D activities in the private sector (TDRI, 1990b). The system of financial incentives to stimulate industrial innovation, such as grants and R&D tax write-offs, needs strengthening as well (TDRI, 1990a and b, 1993).

Rapid growth of assembly operations for export of manufactured goods has led to a shortage of engineers and technical personnel which 'is posing the most serious bottleneck for the further industrial and economic development of Thailand' (TDRI, 1990b: 50). Some demand also appears to be developing for technical services and technology management skills. These trends will put pressure on Thai manufacturing firms to upgrade their technological capabilities.

The second group of constraints has to do with the inadequacies of the Thai S&T infrastructure (TDRI, 1993). One important shortcoming is the weak technical service sector to provide S&T consultancy, information, standards, calibration and testing, prototyping, etc. Few free-standing organizations exist to service sectoral technical problems. Existing S&T information centres 'cannot describe either the R&D conducted in this country, or the technical and consultancy resources which are available in universities' (TDRI, 1990b: 50; see also TDRI, 1989b).

These are the conclusions that Thai policy makers have arrived at after a decade of serious S&T policy efforts, including the development of S&T analysis skills in such institutions as TDRI. In the following sections we examine more closely the emergence of key Thai S&T policy strategies and institutions.

## S&T Strategies in the National Economic and Social Development Plans

Thailand's economy developed on the basis of extensive agriculture in response to its endowments of large areas of cultivable land and few densely populated areas. Rice and rubber exports provided linkages to the international economy. Minor manufacturing activity was controlled by foreigners. The 1932 military coup created a constitutional monarchy and also a nationalist policy of industrialization. The strategy adopted was based on import-substitution via state-owned enterprises in rice milling, sugar refining, smelting, cement and rubber products. After 1958, the policy changed to one of promotion of private investment through adequate regulations, and promotion of appropriate infrastructure and manpower. Investment promotion targeted the consumer goods industry, which was highly protected.[5]

Since 1961, the Thai government has issued seven national development plans. S&T is given only superficial treatment in the first four, and although the Fifth Plan (1982–1986) had a chapter on S&T, technological goals and strategies were not clear due to lack of information and experience (Dahlman et al., 1990: Annex 2). It is instructive to examine the ways in which preoccupations about industrial innovation have emerged.

The First Plan (1961–1966) reiterated the strategy of promoting private investment in industries using local raw materials or substituting for imports. The role of the state was to develop infrastructure in transportation, power and communications. Public research and technical assistance was promised in agriculture, mining and public health. The Second Plan (1967–1971) added to the private investment-promotion strategy an emphasis on employment generation through the support of cottage industries and joint ventures with foreign firms. The Plan included projects for research and technical support in standardization, agriculture, public health and agro-industry. The Second Plan maintained the orientation of the first, while also insisting on social development. The idea that human resources would be a determining factor in the successful application of the Plan was largely accepted, and consequently a national programme for the development of professional education was implemented.

By the time of the Third Plan (1972–1976), the difficulties of the import-substitution strategy had become apparent, and a strategy of export-promotion was adopted to correct balance of payment problems with duty exemptions, tax breaks and industrial estates. The Thailand Institute of Scientific and Technological Research (TISTR) was given the task of conducting research on materials and product development (MOSTE, 1988). The Third Plan emphasized the need to increase production while reducing the growing gap in social services between the metropolitan area and the regions. The Third Plan also emphasized the necessity of developing adequate supplies of scientific and technical personnel. A Technology and Environmental Planning Division was established in 1975 in the Office of the National Economic and Social Development Board (NESDB) in order to formulate a national S&T development plan and a national environmental plan as integral parts of the national development plan.

The Fourth Plan (1977–1981) strengthened the investment-promotion mechanisms deployed by the government (subsidies, tax breaks, guarantees, etc.), but continued to provide protection for import-substituting industries. In this Plan, the government acknowledged the significance of S&T, called on the increased use of S&T for industrial productivity and announced that national S&T organizations would be upgraded. It was during the Fourth Plan that MOSTE was established in 1979 with overall responsibility for planning, coordinating and promoting S&T within the government (UNESCO, 1985).

The Fifth Plan (1982–1986) recognized the costs incurred by encouraging highly protected import-substituting investments: too many inefficient, uncompetitive industries with weak backward linkages concentrated in the capital. The Plan emphasized industrial restructuring, regional development through small-scale industry, further export promotion, and increased efficiency, productivity and quality in existing industries. This Plan included an explicit S&T chapter which called for the upgrading of S&T institutions, extensive technology dissemination, more vigorous use of technology in firms and enhanced international cooperation (MOSTE, 1988).

Thailand's Sixth Plan (1987–1991) continued the emphasis on export promotion, productivity, efficiency and quality. It stressed the importance of investments in S&T: 'serious and continual development . . .coupled with good management and services are vital if Thailand is to increase her standing in the intensely competitive world markets which she faces today, and raise the standard of living of her people' (NESDB, 1986: 150). It identified a number of problems in the Thai S&T system, notably under-investment in S&T, excessive payments for foreign technology and weak production of human resources. Three factors causing these problems were identified:

> lack of a policy and master plan on science and technology, . . . lack of an effective central coordinating agency in science and technology,

[and] lack of interest among private users of technology in the development of science and technology as a means of increasing production efficiency (ibid.: 157–58).

The Seventh Plan (1992–1997) identifies three successful outcomes of past S&T policy efforts. First, a policy environment has been created in which S&T is taken seriously. Second, dedicated S&T promotion organizations have been established in the public sector in three key areas: biotechnology, micro-electronics and materials, and a variety of instruments, mechanisms and inducements are in place to encourage R&D and innovation in the private sector. Third, initiatives to produce high level S&T manpower are showing results and extensive scholarship programmes for overseas study are in place. It identifies as key problems the limited application of technology to increase productivity, limited capacity to acquire and transfer technology, inadequacy of the quantity and quality of S&T manpower, and weaknesses in R&D facilities and support facilities. The Seventh Plan is novel in three respects. First, unlike previous plans, it proposes several quantitative targets for S&T development regarding manpower training and public investments (the GERD/GDP ratio is to rise to 0.75 per cent). Second, it begins to formulate a sectoral approach to technology development. Third, it expands the range of proposed innovation policy instruments and incentives compared to previous plans (NESDB, 1991).

## Thai S&T Policy Organizations and Delivery Mechanisms: From Research Coordination to Enterprise and Technology Development

Thailand's S&T policy establishment emerged in three waves. In the first, the foundations of a national research and technology support infrastructure were established. One institution—the National Research Council (NRC)—established in 1956, was given nominal responsibility for funding university research, coordinating the overall research programmes of public and private actors and advising the government on research priorities. In the second wave, beginning in the mid-1970s, dedicated S&T policy functions were developed within the government. An S&T policy ministry (MOSTE) was established in 1979, and the NRC and other scientific and technical institutions were placed under its auspices. Agencies responsible for economic planning (NESDB), investment (the Board of Investment), and industry policy and extension (the Ministry of Industry) came to address S&T policy issues, and S&T policy was integrated into the more general framework of government policy. Specialized programmes and institutions to promote key technologies were created. By the end of the 1980s, the country's S&T deficiencies were relatively well-known and in the course of the Sixth Plan experience had been gained in developing and applying a range of policy instruments to remedy them. In the third wave of S&T policy development beginning in 1991, a new S&T support organization—the National Science and Technology Development Agency (NSTDA)—was created with a combination of operational and policy responsibilities to act as a '"driving force" for rapid S&T development' (NSTDA, 1991: 10), and ways were sought to make the higher education sector more responsive to Thailand's human resource needs.

The major departments under MOSTE until 1991 were the Office for Science, Technology and Energy Policy and Planning (a central policy analysis shop), the Technology Transfer Centre (which is concerned with terms of acquisition of technology), the Department of Science Services (offers testing and information services to industry), NRC, TISTR (the largest public research agency in Thailand with responsibility for applied research and technology support), the Science and Technology Development Board (STDB), and three specialized research centres to promote R&D in key areas of technology (biotechnology, advanced materials, and electronics and computer technology).

The STDB was the primary vehicle through which Thailand financed strategic R&D in advanced technologies. It was established in 1985. In 1991 its primary strategic research functions were rolled into the new NSTDA. STDB was established to administer a USAID programme of support for S&T. It had four elements: enhance interaction between users and producers of scientific and technological knowledge; promote policy review and dialogue; promote research, development and engineering (RD&E) in biotechnology, materials science and electronics; and supply industrial development support in the form of standards testing and quality control, technical information, diagnostics and technology assessment (Dahlman et al., 1990: Annex 2).

STDB was intended to fund designated RD&E, competitive RD&E, company-directed RD&E and RD&E support activities such as scholarships in the three priority areas of technology mentioned earlier. STDB received US $49.4 million for the period 1985–1994. US $35.4 million was contributed by USAID, US $19.6 million was a soft loan and the remainder a grant. The Thai public and private sectors contributed US $14 million (USAID, 1992). STDB was intended to offer 'grants and low-interest loans to the private sector to prompt it to develop its RD&E capabilities and enable the private sector to apply the R&D of local institutions and organizations to commercial and industrial uses' (*Bangkok Post*, 1991: 18). However, of the approximately US $7 million it disbursed between 1986 and 1988, about 90 per cent was used to support research universities and public laboratories; only two company-directed projects were supported (Dahlman et al.,1990: Annex 5). Between 1987 and 1990, STDB supported forty-two projects in biotechnology at a cost of US $7.1 million (Davis et al., 1993a).

In the 1980s, Thailand was able to combine a number of other sources of funding to support research in strategic technologies. In biotechnology, for example, the National Centre for Genetic Engineering and Biotechnology (NCGEB), one of the specialized technology centres under MOSTE, funded eighty R&D projects in biotechnology worth about US $4.4 million. Three other important sources of biotechnology R&D support in Thailand were available in a bilateral assistance framework with the United States. The Agricultural Technology Transfer Programme (ATT), a USAID programme supporting R&D projects conducted by the Ministry of Agriculture and Cooperatives of Thailand, funded US $8 million of biotechnology research in Thailand between 1985 and 1990. The US–Israel Cooperative Development Research Programme (UICDR), a USAID funded programme supporting joint bilateral R&D projects between Israeli scientists and those from developing countries, spent US $1.5 million in Thailand between 1985 and 1990. The Programme in Science and Technology Cooperation (PSTC), another USAID programme that funds innovative research in developing countries on a competitive basis, supported US $6.5 million of biotechnology research in Thailand between 1983 and 1990 (Davis et al., 1993a). The number of Thais winning PSTC grants is impressive: by 1990, Thai scientists had won fifty-three grants, more than twice the total awarded to any other country (USAID, 1992). Thailand is also the leading developing country recipient of UICDR awards (USAID, personal communication).[6]

In sum, Thailand's policy and delivery system for supporting RD&E, training and technical services in advanced scientific technologies evolved in the 1980s to a certain degree, within the framework of bilateral cooperation with the United States.[7] This arrangement was characterized by sharply focused investments in strategic R&D, primarily in Thai universities.

The situation in the 1990s promises to be very different. In the first place, the implicit strategy of driving industrial innovation through investments in university-based strategic research has been only a qualified success. In the second place, Thailand's public RD&E system is being transformed through the changes in the university system (discussed earlier), and also through the new missions and functions that NSTDA is bringing to the system. In the third place, the roles of international collaborators are likely to be very different in the coming decade. To conclude this article, we briefly discuss each of these issues.

The effects and, especially, pay-offs of concentrating public S&T investments in strategic university-based research have been mixed.[8] On the positive side, research projects often produced prototypes or processes and permitted numerous laboratories to be equipped with up-to-date equipment. The research provided training for many Master's students. Researchers often presented papers in local conferences or, less frequently, published in international journals. They also often became deeply involved in extension work and in providing technical support to users. Those researchers fortunate enough to obtain grants rarely wasted the sources. A number of researchers gained industrial credibility and developed personal linkages with industrial users. The donor, the United States, received a number of tangible and intangible benefits (ISTI, 1989).

On the down side, successful commercialization of products or processes did not take place as extensively as anticipated. Few cases of spin-off firms were reported; in most cases of successful utilization, the technology was captured and assimilated as an incremental innovation by an already-existing firm.[9] Senior researchers became so involved in managing scale-up, plant propagation or demonstration efforts that they were unable to pursue scientific research. In some cases, universities were offering subsidized technical services that undercut private service providers. The shortage of post-doctoral researchers made it unlikely that frontier research could take place. Two other factors steered the effort towards selection of easily harvestable areas of applied science. One was the STDB selection committee's emphasis on projects appearing to offer relatively quick applicability. The other was the demographics of the Thai scientific community: few universities had hired younger scientists and competition for scarce research money favoured senior scientists. As a result, investments flowed more easily towards mature technologies like tissue culture than towards sciences upon which next-generation technologies might emerge, such as molecular biology. In other words, seven years of strategic research investments did not adequately prepare the Thai scientific community to work in emerging areas of generic scientific technology. These investments have yet to take place.

NSTDA's strategy and structure appear designed to overcome three problems. The first has to do with creating a critical mass in priority areas of S&T. NSTDA anticipates having over 300 scientists working in three national research centres in generic technology by 1996. The second problem is the lack of integration of innovation support instruments. NSTDA combines a number of instruments to permit a systematic approach to industrial innovation, particularly downstream from research. In addition to the three centres, NSTDA will manage a centre for technical information, a programme for RD&E support in the private sector, a science park, an investment fund for commercialization of S&T, a fund for supporting RD&E in public sector institutions, and a fellowship programme for overseas and domestic studies. NSTDA's objective is to develop technology-based businesses in Thailand. NSTDA anticipates a budget of 3.5 billion Baht (about US $140 million) for 1996. The third problem that NSTDA addresses is that of the rigidity and lack of incentives in the public sector. NSTDA has been created outside the civil service and the state enterprise sectors. It is free to set its own rules with respect to employment and remuneration; to obtain funds from any sources; to borrow, lend and invest; to recover costs and retain income; and to independently enter into agreements. In other words, NSTDA is an enterprise and technology development agency, a research funding agency and a dedicated research agency.

The concentration of these functions in one public agency did not reassure all observers. Those familiar with the record of intramural R&D in public laboratories such as TISTR were apprehensive that the three new centres might follow suit. While Thai proponents of NSTDA pointed to the successful use of institutions such as the Korean Institute for Science and Technology (KIST) to incubate capacity in advanced technologies, representatives of American donors were reluctant to invest in the development of public sector intramural R&D capability in Thailand.

## Conclusions

Rapid economic growth is placing severe strains on Thailand's S&T infrastructure, which is mainly in the public sector. Thai universities and research institutes were widely viewed in the past decade as public goods, from which benefits could be taken but which required little cultivation. The private sector is far more attractive than the public sector to those with scientific or technical skills in demand—mainly applied sciences, engineering, informatics and business disciplines. Basic sciences are languishing and university research careers for young scientists are not secure. Furthermore, no one is looking after next-generation technologies except a handful of visionaries in the Thai S&T policy establishment.

The Thai scientific community is a necessary but not sufficient element in the process of industrial development. Its role is likely to become increasingly diversified in coming years, as it is called upon to provide training, policy guidance, service to a variety of constituencies and evidence of excellence in the production of science.

Thailand's strategy of creating a strong core of public technology institutions while inducing the university system to respond forcefully to market demands for human resources bears some resemblance to Korea's. Two key differences are worth pointing out, however. In the first place, Thailand does not enjoy the consistently high-quality international networks among scientists and engineers that Korea enjoys. There are few Thai expatriate scientists to bring home and Thailand's scientific community is not highly internationalized. In the second place, Thailand's industrial structure is much less integrated than Korea's. The limits to technology spillovers from foreign direct investment are becoming visible, and mounting a very vigorous technological modernization effort does not appear to be one of the principal objectives of Thai S&T policy in the immediate future. As intra-Asian trade and Japanese investment increase, Thailand's technology strategy will have to come to grips with the threats and opportunities of being a late industrializer in an already large 'flock of flying geese'.[10]

## Notes

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1. In comparison, Singapore increased its Gross Expenditures on R&D/Gross National Product ratio (GERD/GNP ratio) from about 0.2 per cent in the late 1970s to about 1 per cent a decade later. Taiwan and South Korea increased their R&D spending from a level similar to that of Thailand's to about 2 per cent in the late 1980s.
2. This section draws on Gaillard (1990).
3. On the proliferation of engineering degree programmes in Thai universities, and the problems in funding and staffing them see Meyers (1991: 9–10).
4. Mathematics and computer science, medical and health sciences, engineering, agriculture, forestry, fisheries or basic science.
5. This section and the next draw on Dahlman et al. (1990: Annex 1).
6. Thai scientists have also been remarkably successful at winning awards from other international sources of competitive research funding. Between 1974 and 1991, about eighty Thai scientists received research grants from the International Foundation for Science (IFS), placing Thailand in the top four recipient developing countries in the IFS programme. It is also the leading Asian recipient of funds from the European Community's Science and Technology for Development (STD) Programme.
7. Thai scientists have been largely trained in the United States, but also in Japan and in a number of European countries, especially France, Germany and the United Kingdom. This diversified training strategy has no doubt facilitated the ability of Thai scientists to maintain a range of international contacts and collaborative relationships, even though the United States is the main donor. The success of Thai scientists in the European STD Programme is quite revealing of their capacity to develop collaborative linkages with European scientific institutions. For a thorough discussion of Thailand–US bilateral cooperation, see Muscat, 1990.
8. The following is based on Davis et al., 1993a, 1993b; TDRI, 1992.
9. In other words, investment in strategic research in Thai universities did not produce a swarm of new technology-based firms.
10. On the 'flock of flying geese' model of Asian regional industrialization see Ozawa (1991).

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