TDRI Quarterly Review
Published in *TDRI Quarterly Review*
Vol. 6 No. 4 December 1991, pp. 3-10
Editor: Anne Johnson

Technology Upgrading in Thailand: A Strategic Perspective*

Chatri Sripaipan

BACKGROUND

The importance of scientific research has been officially recognized since the Constitution of the Royal Thai Kingdom, B.E. 2492 (1949). Article 65 states that "the government should support research in the fields of liberal arts and sciences." Later, in 1956, the government passed the National Research Council Act with the view that the country's progress had to be based on scientific research so that development could be sustained. The establishment of the National Research Council of Thailand (NRCT) can, therefore, be seen as the starting point of encouraging research and development (R&D) to systematically increase the nation's scientific and technological capability.

In 1963, the National Applied Science Research Institute (NASRI) was established to take charge of implementing research in applied science, and to promote the national use of natural resources to develop industry. In 1979, the Ministry of Science, Technology and Energy (MOSTE) was established to take the central role in planning science, technology and energy and setting national policy. A number of science and technology (S&T) organizations, originally under the Ministry of Industry and the Office of the Prime Minister were incorporated into MOSTE. They are: the Department of Science Services, NRCT, Office of the National Environmental Board, Office of the Atomic Energy for Peace, National Energy Administration, and Thailand Institute of Scientific and Technological Research (TISTR)—previously called the National Applied Science Research Institute (Charuay et al. 1991a). However, a number of S&T activities remain with other ministries. Research in agriculture is mainly conducted in the Ministry of Agriculture and Cooperatives, which consumes over 40 percent of the government's research budget. The Ministries of Education and University Affairs—two large R&D performers—spend about another half of the country's R&D budget. The Ministry of Industry is responsible for industrial standards and provides technical assistance to small- and medium-sized industries.

After the establishment of MOSTE, the next Five-Year National Economic and Social Development Plan 1982-86 (NESDB 1982), was the first development plan where S&T issues were explicitly addressed. Issues addressed in the Plan were: the limited use of S&T to increase production efficiency, the protracted time taken to modify or improve imported technology, and the slow pace of technological development. Proposed measures were as follows:

- Promote the survey of basic data essential to technological development
- Promote the transfer of foreign technology
- Increase the country's S&T research and development capability
- Mobilize manpower for S&T development

Achievement of these goals was, in that period, rather limited. More visible results were a number of signed agreements for S&T cooperation with foreign countries. The most significant agreement was the Science and Technology for Development Project which had a total fund of US$49 million, spread over seven years, and with assistance provided from the U.S.

Another achievement was the establishment of the National Center for Genetic Engineering and Biotechnology (NCGEB) at MOSTE as a funding agency for a network of research laboratories in universities, and TISTR in the same discipline.

The Sixth Plan 1987-91 (NESDB 1987) also contained a Science and Technology Development Plan. The Plan identified two key issues: that cooperation between S&T units of all government agencies and the private sector was the key to successful development, and that effective linkage between developers and users of S&T was required to meet the needs of the private sector. Four main policies were drawn up under this plan:

- To set up an effective S&T management system and to develop S&T infrastructure
- To increase the efficiency of S&T activities
- To develop S&T manpower
- To increase production efficiency

During the Sixth Plan, the Office of the Science and Technology Development Board (STDB) was established to manage the Science and Technology for Development Project. MOSTE also established two more National Centers: the National Center for Metals and Materials Technology, and the National Electronics and Computer Technology Center. This makes a total of three National Centers at MOSTE, corresponding to STDB's three areas of emphasis—biotechnology, materials, and electronics. These three areas continue to be MOSTE priorities.

One of the most important milestones in promoting S&T in Thailand will be, once passed, the enactment of a law for the Development of Science and Technology. This law will establish STDB as a juristic entity to administer a "Science and Technology Development Fund" from the government and other sources, including international agencies. The law will also establish the three National Centers as specialized research institutes to carry out R&D, both in-house and through contracts from industry. In November 1991, the draft law was passed in the National Legislative Assembly.

RESEARCH AND DEVELOPMENT

R&D Expenditure

Both the Fifth and the Sixth Plans set a target for R&D budgets of 0.5 percent of gross national product (GNP), or roughly 2 percent of the government's budget. This compares to the actual R&D expenditure from 1983-87 of only 2,272 million baht per year, or an average of 0.22 percent of GNP. Data on R&D expenditure for 1987 is from surveys—the first time such surveys were conducted—whereas those for previous years are budget allocations. In any case, R&D budget is very low— much lower than that of the developed countries, which ranges from 2.5 to 3.0 percent of GNP, and of newly industrialized countries which ranges from 1.0 to 2.0 percent of GNP. Other features are that the R&D expenditure by both state enterprises and private firms in Thailand is very low, being only 277.24 and 181.56 million baht, or 10.41 and 6.81 percent respectively, in 1987. To make matters worse, the state enterprise category includes TISTR—the only major research institute in the country with an annual budget of about 200 million baht. Therefore, the R&D expenditure by all other state enterprises is very low indeed.

R&D Funding

For individual researchers, there are a number of research funding sources. A university lecturer may apply for a research grant from his or her university in the order of several tens of thousands of baht per project. For larger projects, researchers have to seek outside funding. NRCT is a possible source, but grants are limited and the coverage is wide. In 1990, NRCT funded 120 projects, with a total of 21.75 million baht. The three National Centers can provide about one million baht, while STDB sets a limit of six million baht per project. In addition to these sources, there are a number of foreign sources. In 1987, foreign sources accounted for 14.55 percent of R&D funds, or 387.60 million baht.

As clearly demonstrated by the large number of researchers and the interest shown by foreign funding sources, researchers in the area of biotechnology have been able to attract a much larger level of support than those in material technology or electronics and computers. Over the past five years, total funding for research projects in the area of biotechnology amounted to 709 million baht, as compared to 272 and 187 million baht for materials and electronics respectively.

R&D Results

R&D results usually come as reports and articles published in journals or presented at academic conferences. Thailand's research community publishes around 300 articles a year in international journals covered by the Science Citation Index (see Table 1). Of these, health science articles account for 130 articles a year, followed by biological science and physical science at about 50 articles each. Twenty to 40 articles each on natural resources and environmental science, agriculture, and engineering and technology are also published each year. Although the number of articles published internationally by field may roughly reflect scientific strength, it should also be noted that about one third of these articles are written by foreign scientists in joint research efforts. Thus, one interpretation could be that foreign interests and funding also affect the number of published articles in a particular field. The number of research articles published in international journals, however, does not represent the research strength of the whole country, because of the small number of researchers involved (Charuay et al. 1991a). A more comprehensive evaluation would include local journals and papers presented at conferences.

In developed countries, the number of patents registered can be used as a measure of technological capability in a particular field. However, in developing countries such as Thailand, which have very few commercially viable research results, this number is meaningless as an indicator. Since the enactment of the Patent Act of 1979, 1,827 patents had been issued up until June 1990. Of these, 1,304 were for industrial designs, some of which involved rather low technology. Up to August 1990, 526 patents for engineering and chemical inventions were issued; 456 belong to foreign nationals, 63 to Thais, and seven unspecified. It is, therefore, clear that the Thai patent system is more frequently used by foreigners than Thai nationals.

It should be noted that only a few of the inventions funded by STDB and the three National Centers have resulted in commercially-viable products. More, however, are expected to come out within the next five years.

R&D in the Private Sector

R&D in the private sector is much less than that of the public sector. In 1987, the total amount of public-sector expenditure on R&D accounted for 181.6 million, or 6.8 percent of total R&D expenditure. A previous survey (Harit et al. 1983) suggests that Thai companies only invest 0.1 percent of sales income on R&D. This low expenditure explains the reported weakness of innovative capacity in Thai companies. A major study (Kopr et al. 1989) revealed that Thai industry is quite good at "operating" technology as well as "adapting" technology, but is remarkably incapable of "innovation" or of creating new technology.

A study on R&D in the private sector (Chatri et al. 1990) found that a majority of Thai companies concentrate on "operating" or utilizing existing technology. This does not mean that their operations are outdated or primitive. In fact, some have state-of-the-art technology and operate ultra modern plants; some are quite large, and some are subsidiaries of leading multinationals. The only drawback is that these companies have not felt the need to undertake development work locally. A smaller number of companies have undertaken their own "adaptation" and development of existing technology—usually driven to do so by the nature of the local environment or market needs. For example, in adapting to the local operating environment, a foreign joint venture in aquaculture modified Taiwanese hatchery equipment to produce low-cost feed formulas using locally-available raw materials. Other companies have been led to technology development by market needs. Two multinationals producing consumer goods have continuing programs to modify products, such as soap, detergents and foods, to suit local preferences. Predictably, instances of inventing new technology are extremely rare. Only a few large companies can afford them. Recent research advances in such companies are, for example, the production of special, high-grade refractories and also a new formula for shrimp feed which has a better growth efficiency ratio than equivalent products manufactured in Taiwan and Indonesia.

Some of the reasons why private companies do not conduct more R&D infrastructural activities are:

- Due to Thailand's rapid economic growth, firms are escalating production capacity to meet growing demand. Therefore, they dc not feel the pressure for innovation or differentiation of products.
- Government policies limit the number of companies entering the different sectors, lessening the competitive pressure required to stimulate R&D activity.
- Import tax on R&D equipment and precision instruments remains prohibitively expensive for small- and medium-sized companies.
- The taxes on royalties and license fees increase costs of foreign technology.
- There is a need to improve the availability of technical consultancy services and information on S&T activities in the public sector.
- There is a clear shortage of technical manpower to satisfy the present demand for production engineers and technicians who can use and absorb imported technology. Although there is no obvious shortage of manpower for technology generation, this is due to too little activity in R&D rather than to an oversupply of R&D personnel.
- Companies finance technology acquisition either by using internal resources or by raising loans from commercial banks as part of overall business development plans. Some financial assistance to small- and medium-sized companies does exist, but its impact has yet to be felt.

Assistance to the Private Sector

The Board of Investment (BOI) provides incentives to R&D projects through exempting import tax on machinery and corporate tax, irrespective of the location of a project. So far, 15 projects have been given incentive privileges, with a total investment of 996 million baht (A. Auansakul 1991).

At present, there are three sources of soft loans with low interest rates for private-sector R&D activities: MOSTE, STDB and the Bank of Thailand (BOT). In addition, STDB also operates a grant fund which requires a matching sum from the company. It should be noted that MOSTE's loan fund has the longest history, i.e., three years, and has been the most heavily used, with 10 projects approved totaling 75.3 million baht. STDB's activities have markedly improved since March 1990 from only two to seven loan projects and four grant projects. BOT's fund is least utilized since it is restricted to R&D projects promoted by BOI.

S&T Manpower

In 1990, Thailand had an estimated 36,700 scientists, 49,934 engineers, and 33,847 agriculturists with Bachelor's degrees or higher levels of education. Below Bachelor's degrees, there were 1,494, 706,317 and 115,256 people educated in science, engineering and agriculture respectively. This amounts to a total of 120,481 people, or 12.8 percent, with Bachelor's degrees and 823,067 people, or 87.2 percent, educated below this level. In 1990, Thailand had a total number of 943,548 S&T personnel, or 2.9 percent of the country's labor force. The country therefore had 15 scientists and engineers per 10,000 citizens (Charuay et al. 1990). This is very low compared to Korea, with 122 scientists and engineers per 10,000 citizens (Charuay 1991b).

In the past few years, due to the economic boom, Thailand has been experiencing severe S&T manpower shortages. In 1989, 2,745 scientists and 3,619 engineers graduated, but the demand forecasts in 1992 were for 2,532 and 5,136 persons respectively (Charuay et al. 1990). This is despite recent efforts by the Ministry of University Affairs to increase the number of engineers in those fields with severe shortages, i.e., mechanical, electrical, industrial, and chemical engineering. It is expected that this shortage will persist throughout the Seventh Plan (1992-96). This shortage has already resulted in an alarming rate of technically-qualified people transferring from the public sector to the private sector, where salaries are much higher. In the private sector, there are complaints about recruiting difficulties, high salary demands and a high turnover rate.

In 1987, Thailand had a total 8,493 researchers or the full-time equivalent (FTE) of 5,539 persons.

Universities had the highest number of researchers at 4,898, but the number of FTEs was only 2,518—slightly higher than the 2,416 government FTEs. State enterprises, private firms and non-profit private organizations have much fewer researchers at 527, 145 and 21 respectively. As for the number of researchers in the different academic disciplines, medical science has the highest number at 8,261. Ninety percent of these are physicians who are classified as having Master's degrees. Social science and humanities come second at 2,229, and engineering last at 1,176. To make an international comparison, the number of research scientists and engineers (RSE) in Thailand totals 2,846 persons, or one person per 10,000 workers. This is much lower than in other countries, for example, 32 RSE in Taiwan, 44 in Sweden, and 79 in Japan (Table 2).

Science and Technology Services

Science and technology services are support services. They encompass metrological industrial standards, calibration services, testing services, information services, technical consultancy services and other supportive infrastructural services.

The Ministry of Commerce is empowered by the Weights and Measures Act 1923 to maintain primary standards, and as the licensing and certifying authority for weighing machines and linear and volumetric measuring instruments. In 1985, the Cabinet assigned the Department of Scientific Services to maintain mechanical primary standards and TISTR to maintain electrical primary standards. The Thai Industrial Standards Institute (TISI) is responsible for the preparation and publication of Thai industrial documentation on standards. Most of the calibration services are carried out by the Thai public sector, with the exception of the Technological Promotion Association (Thai-Japan), a private organization. Product testing services are carried out by 30 authorized laboratories in the public sector. To cope with an ever-increasing work load, a further seven testing laboratories in the private sector have now been authorized.

Apart from major libraries in universities, a number of organizations provide specialized information services. For example, the Scientific and Technological Information Division, Department of Science Services, offers patents and industrial standards services; the Technology Information Center, Technological Promotion Association (Thai-Japan), provides practical technical information, such as trade catalogs; and the Technical Information Access Center of STDB supplies on-line information search services from a number of foreign databases. There is still a pressing demand for information not only from foreign sources, but also for information on domestic S&T activities. Manufacturers wishing to export also complain of the lack of internationally-certified local testing facilities to eliminate the need for testing products abroad.

TECHNOLOGY STRATEGY FOR THAILAND: THE SEVENTH PLAN

The Seventh Plan will include a chapter on Science and Technology Development (NESDB 1991), summarized as follows:

There have been three main achievements in the development of S&T to date. First, the creation of awareness of the role of S&T among the Thai populace and top government administrators, both becoming more supportive of S&T promotion.

Second, there are now more R&D activities in the public and private sectors. The government has established STDB and three National Centers to fund R&D. The private sector provides low-interest soft loans and grants for R&D via a number of agencies, and also fiscal incentives for R&D projects promoted by BOI.

Third, each year, about 1,200 scholarships are being granted for advanced degrees in S&T in the industrialized countries.The targets set include:

- To use industrial technology and agricultural technology to increase productivity at a rate of 2.6 percent a year in the industrial sector and 1.8 percent a year in the agricultural sector, and to support

expansion at 9.5 and 3.4 percent a year respectively.
- To increase the number of S&T personnel in the following categories: engineers from 9.8 to 14.9 persons per 10,000 of the population, scientists from 7.2 to 10.2, agriculturists from 6.7 to 10.5, technicians from 141.5 to 221.5, and researchers (FTE research scientists and engineers) from 1.4 to 2.5.
- To increase R&D expenditure to 0.75 percent of GNP by 1996. This will comprise 0.5 percent of GNP from the government and the remaining 0.25 from the private sector.

Strategies to achieve the above targets are:

- Encourage the private sector to use more technology through creating a competitive atmosphere by providing fiscal incentives, disseminating technology to industries and government regulations to support the development of specific technology for targeted industries. It is interesting to note that this is the first time a Five-Year Development Plan targets specific industries by sector. They are: metalworking and machinery, electronics, textile, food, plastics, gems and jewelry, and iron and steel.
- Promote the use of modern technology and management to increase productivity, reduce costs by stabilizing the price of farm produce, promote farmers' organizations, improve extension services, and increase the role of the private sector in technology transfer. Specific measures have been drawn up for agriculture, livestock, and fisheries.
- Increase the efficiency of technology acquisition and transfer to strengthen bargaining power, promote the diffusion of imported technology, upgrade the technological capability of state enterprises, and monitor technology transfer programs for large projects.
- Develop S&T manpower by increasing the number of scientists, engineers, mathematicians, technicians and skilled labor in areas of high demand, raising the number of university teachers and researchers, stressing the urgency for training, and improving the working environment for academic staff.
- Organize the R&D system to support industrial development by concentrating R&D activities on the selection, adaptation and improvement of imported technology, re-orienting public R&D institutes to solve industrial technical problems, supporting educational institutes in research and to serve as S&T information centers, increasing the role of private-sector R&D through fiscal and financial incentives, developing the domestic market and intellectual property protection, and encouraging careers in R&D.
- Improve the S&T infrastructure by developing metrological and industrial standards and product testing systems, improving the S&T information system, increasing the capability of engineering consultancy services and creating greater awareness of S&T.

STRATEGIES FOR SECTORAL TECHNOLOGY

The Science and Technology Development Plan has to satisfy both the representatives of the various government departments concerned and through those of the private-sector. The Plan also has to encompass all aspects of S&T development. There is, however, a definite shift toward more private-sector participation in all the Plan's strategies. For R&D, a target of 0.25 percent of GNP for the private sector by the year 1996 was set. But only one of the six strategies in the Plan mentions R&D. Most of the strategies are on the utilization, acquisition, transfer and diffusion of technology, and on developing S&T manpower. Even then, R&D strategies concentrate on selecting, adapting and improving imported technology, rather than on domestic invention. Public-sector R&D institutions are to be re-oriented to solve industrial problems. The Plan does, however, have a more pragmatic approach than the previous plan to the present S&T situation.

Another significant feature of the Plan is that it has, for the first time, targeted industries by sector. Those targeted are crucial to Thailand's development over the next five years and tend to be industries already in existence, rather than potential ones. Key technologies and technology strategies for the seven industries targeted have been worked out. They are described below.

The Electronics Industry

Key technologies identified are computer-aided, software engineering, circuit design, process, production management, and mechanical technology. Strategies for development include promoting investment in manufacturing products with a higher level of technology than is presently used, promoting supporting industries, promoting product design, and developing targeted products, such as personal computers, small PABX, mobile telephones, facsimiles and application-specific integrated circuits.

The Metalworking and Machinery Industries

Key technologies are computer-aided, production management, and metalworking technology, such as casting, forging, machining, heat treatment, electroplating and stamping. Development strategies include promoting investment in the machine tools industry, promoting metalworking industries, promoting the development of the mold and die industry, and developing automotive parts, such as engines, transmissions, steering systems and suspension systems.

The Petrochemical and Plastics Industry

The emphasis is on the downstream plastic products industry. Key technologies identified are compounding, molding for plastic products, and production management technology. Development strategies include improving the properties of plastics from commodity plastics to intermediate and engineering plastics, and establishing a design center to provide products and mold and die design.

The Textile Industry

Key technologies identified are the efficient use of modern machinery, production management, and textile chemicals technology. Development strategies include subcontracting the manufacture of world-famous brand-name garments, promoting investment in the dyeing industry, and promoting the switch to modern machinery.

The Food Industry

Key technologies are sterilization and production management, packaging, and waste management technology. Development strategies include planting fruits and vegetables to uniform standards, using modern machinery, and incentives for waste-utilization technology.

The Gems and Jewelry Industry

Key technologies are computer-aided technology, and precious metal metallurgy. Development strategies include establishing gem standards, R&D in alloying precious metal, and tariff rate reduction for R&D equipment.

The Iron and Steel Industry

Key technologies are ladle technology and steel alloying. Development strategies include increasing the efficiency of furnaces, and acquiring alloyed steel-casting technology.

Almost all of the above key industries have computer-aided technology[1] and better production management[2] targeted as key technologies. These types of technology are called "generic." Though metalworking has not been explicitly identified as a key technology in some of the industries, it is nevertheless a common fact that all industries to varying degrees require production machinery or manufacture products which constitute metal parts. Metalworking is consequently also classified as generic technology.

Other types of technology do not bear directly on manufacturing processes or product quality, but on production costs and environment. These are classified as "auxiliary" technology and include energy conservation, which significantly affects the motor vehicle, metalworking and machining, textile, and food industries, and also waste management technology, vital to the food and textile industries.

STRATEGY FOR TECHNOLOGY ACQUISITION

Thailand's two most popular modes of technology acquisition are capital goods import and foreign investment. In 1990, these totaled 362,008 and 74,818 million baht respectively. Foreign investment brings in product management and process technology, but no design nor product-specific technology. Machinery is imported with minimal instructions on operational procedures given by suppliers resulting in inefficiently operated and inadequately maintained equipment.

Compared to the above import figures, the payments for technology through contractual arrangements on royalties, trademarks, technical fees and management fees, totaling 5,334 million baht in 1989, is simply too little. This is equivalent to an expenditure of a mere 1.1 percent of capital goods imports for purchasing technology and of 0.7 for purchasing technical assistance. This means that Thai manufacturers have not been using licensing or consultancies for technology acquisition.

Although it is certain that R&D activities will increase, judging from the performance of public R&D institutions on commercializing technological products and the levels of R&D activity in the private sector (Chatri et al. 1990), it is unlikely that R&D will become the main mode of technology acquisition for Thai industry within the next few years. Mergers and acquisitions of foreign companies for technology are unlikely to be prevalent, despite some cases of acquisition for access to markets. Therefore, it is suggested that subcontracting be used as a strategy for technology acquisition in the Seventh Plan. The high level of foreign investment presents favorable conditions to develop mutually beneficial projects. This strategy fits well with those for the development of the electronics, metalworking and plastic industries already described. Thailand, however, must not be satisfied with solely producing parts and components to order. New product management and process technology should be mastered and attempts should be made to learn both product-specific technology and design technology. This will enable Thailand not only to attain higher quality products at lower costs, but also to adopt products according to market demand or to use new raw materials to manufacture more complex products with higher value-added. These types of technological activities lead to better use of existing technology and ultimately to technology creation through R&D. A number of government policies beyond the scope of this paper are required to facilitate the formation of a competitive subcontracting network (see for example Dahlman and Brimble 1990, Rachain et al. 1991, Mingsarn et al. 1991).

Another strategy used by some governments of newly industrialized economies (NIEs) is the purchase of technology by government agencies. The technology is then transferred to private domestic manufacturers. This method is mainly used to purchase advanced technology, requiring investments beyond the means of the private sector, critical to the development of a large number of related industries. The Thai government should encourage the development of this method if it wants to support technology acquisition.

CONCLUDING REMARKS

Although the Thai economy is growing at a rapid pace, there are still major weaknesses in the country's technological capability which will make this growth unsustainable in the long run. These weaknesses cannot be remedied over night, but strategies must be worked out now to deal with them.

Despite a number of programs to boost R&D in both the public and private sectors, it will take time for these efforts to bear fruit. If sound technology strategies are pursued, the technological capability of the country could be substantially improved by the end of the Seventh Plan.

The present shortage of S&T manpower, if allowed to continue, will certainly have detrimental effects on investment and industry, and possibly on the development of the country as a whole. In the short term, there is no choice but to import needed personnel and launch massive training programs. In the medium term, unless hiring conditions are substantially improved, the ability of educational institutions to increase enrollment will be limited by the availability of teachers. In the long term, there will be more options and less excuse not to work out viable solutions.

Needless to say, effective implementation is more important than immaculate strategic plans. The NESDB Plan only serves as a guideline for ministries themselves to draw up yearly plans. It is up to the ministries to make the plans work. NESDB should, however, closely monitor these plans to ensure conformity. On the other hand, long-term sectoral plans (beyond 10 years) will have to be developed to guide us into the type of society we want to live in.

REFERENCES

A. Auansakul. 1991. *From Research to Market: Success in RD&E Investment in the Thai Private Sector.* The Office of the Science and Technology Development Board, Chon Buri, Thailand, September.

Booncherd Sopon et al. 1990. *National Study of Research and Development (R&D) Expenditure and Manpower in 1987*. Office of the NRCT, July 1990, Table 2.4, p.23.

Charuay Boonyubol et al. 1990. *The Demand Forecast and Direction of S&T Manpower Development.* Bangkok: Chula Unisearch, Chulalongkorn University.

__________ et al. 1991a. *The Management of the R&D System to Support Industrial Development*. Bangkok: Thailand Development Research Institute.

__________. 1991b. *Human Resources Development in the Era of Rapid Technological Change.* The Office of the Science and Technology Development Board, Chon Buri Thailand, September.

Chatri Sripaipan et al. 1990. *Enhancing Private-Sector Research and Development in Thailand*. Bangkok: Thailand Development Research Institute.

Dahlman, C. J., and P. Brimble. 1990. *Technology Strategy and Policy for Industrial Competitiveness: A Case Study of Thailand*. Industrial Series Paper No. 24, April. The World Bank.

Harit Sutabutr et al. 1983. *Survey of Science and Technology Manpower and Research and Development: R&D in the Private Sector in Thailand*. Bangkok: Ministry of Science, Technology and Energy and the Science Committee of the Thailand National Commission for UNESCO.

Kopr Kritayakirana et al. 1989. *The Development of Thailand's Technological Capability in Industry*. Six volumes, Bangkok: Thailand Development Research Institute.

Mingsarn Santikarn Kaosa-ard et al. 1991. *The Barriers to and Strategies for Technology Acquisition*. Bangkok: Thailand Development Research Institute.

National Economic and Social Development Board (NESDB). 1982. *The Fifth National Economic and Social Development Plan (1982-86).* Bangkok: NESDB.

__________. 1987. *The Sixth National Economic and Social Development Plan (1987-91)*. Bangkok: NESDB.

__________. 1991. *Science and Technology Development Plan in the Seventh Development Plan 1992-1996* (draft). Subcommittee on Science and Technology Planning, NESDB, June.

Rachain Chintayarangsarn et al. 1991. *The Identification of Key Technologies for Industrial Development*. Bangkok: Thailand Development Research Institute.

Wit Satyarakwit and T. Pongsaksri. 1991. *Scientific and Technological Services in Thailand*. The Office of the Science and Technology Development Board, Chon Buri, Thailand, September.