The Barriers to and Strategies for Technology Acquisition

Final Report

The Barriers to and Strategies for Technology Acquisition

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The Research Team

EXECUTIVE SUMMARY

The two major channels for aquiring technology are: through imports of foreign technology and through local research and development (R&D). The latter channel comprises two possible means i.e., public and private R&D.

At present, Thailand's most important means of technology acquisition is through imports of capital equipment from international markets. The next most important channel is through technical assistance from material suppliers. Contractual arrangements with foreign companies for technology acquisition is mainly used only by large enterprises. Other channels, especially direct foreign investment and joint-ventures, have had an increased role only in recent years. Subcontracting, on the other hand, has not been a significant in technology acquisition because many local enterprises do not possess adequate technical and managerial capability. Foreign firms are willing to subcontract to local firms if only they have a sufficient science and technology (S&T) capability.

Private R&D activities are yet to play a significant role in Thailand because import of foreign technology is commercially more effective in the short-term. Most foreign joint-ventures rely on the R&D of their parent companies. R&D by the Thai private sector induced by the Patent Act, is almost negligible. From 1979 to 1990, 526 patents were granted, of which 63 belonged to Thai nationals. No inventions came from local enterprises and only 10 patents have been transferred from individual Thai inventors to local firms.

Most of the local inventors rely on personal funds for R&D and therefore local inventions are relatively low cost investments. Local inventors usually work alone without a team of complementary scientists and engineers. Most of the inventors do not have an education higher than a fi: degree.

The first obstacle to the commercializing of local inventions is the lack of S&T infrastructure which links laboratories and industries. Second, most of the local inventions are merely concepts. Inventors do not have sufficient funds to build prototypes. Finally, dissemination of information on registered patents has not been attempted either by the government or by the inventors.

Similarly the obstacles to technology acquisition and development in Thai industries are manifold, The first obstacle is inadequate S&T infrastructure, which includes lack of an organization for long-term investment in R&D, an insufficient pool of people with the necessary skills and industrial experience, and weak supporting industries. The second is the high costs of acquiring technology. These costs include high import duty on testing and manufacturing equipment, the high costs of non-hardware technology, and high interest rates. Third, the several constraints resulting from government measures and policies, including the following:

- the higher taxes on parts and components than on completely-knocked down (CKD) kits, which discourages firms from using local design and thereby accumulating local skills;
- the harmonized tariff system has not been effectively carried out, leading to higher taxes than there otherwise would have been for some manufacturing-related equipment;
- there are import tariffs protecting some producers with relatively low technology potential, thus unnecessarily raising the cost of production to user industries;
- the capacity regulation (especially in industries where economy of scale is not a major factor) which tend to slow down imports of technology.

1. STRATEGIES AND MECHANISMS FOR GENERAL INDUSTRIES.

Strategies	Measures
1. Improve the present organizational system and basic infrastructure to develop industrial technology.	1.1 Establish the National Committee for the Development of Industries and Technologies to allocate the National Fund for Industrial Technology Development for developing industrial technology in target industries. 1.2 The sources of the Fund could be from: - income tax from the beneficiary groups; and - trade tax. The allocation of the National Fund to subsectors shall be the responsibility of the Subcommittee for the Development of Industries and Technologies of the specific industrial branch. 1.3 Reform the current financial and recruitment regulations of government agencies which specialize in R&D and technology extension 1.4 Upgrade the technology of supporting industries by:

Strategies	Measures
	- accelerating the use of value added tax (VAT); - increasing low-interest loans for businesses in the supporting industries; - providing incentives for industrial estates with common facilities for small and medium scale supporting industries.
2. Promote marketing mechanisms and increase the effectiveness of technology transfer.	2.1 Abolish the capacity regulation. 2.2 Improve information systems regarding: - investment/machinery manpower by industry; - technology; and - local patents. 2.3 Announce in advance official plans for infrastructural or public investment, including technical specifications, to enable advanced preparation for investment by private enterprises.

Strategies	Measures
	2.4 Increase the BOI's role in linking vendors and contractors to promote subcontracting activities. 2.5 Increase the BOI's role in promoting effective transfer and diffusion of technology from promoted foreign firms. 2.6 Improve fiscal incentives and mechanisms by: - reducing import duty on parts and components to below the duty for CKD; - lowering import duties on spare parts to 5 percent; - lowering import duty on testing equipment and computer-aided manufacturing equipment to 5 percent; - revoking import duties on chemicals, machines and equipment for water treatment purpose; and - improving the effectiveness of the harmonized tariff scheme by providing more technical training to the staff of the Customs Department

Strategies	Measures
3. Provide incentives for both local and foreign enterprises to participate in technology extension activities.	3.1 Encourage the establishment of professional associations and forums to create additional channels for technology promotion e.g., by allowing the use of government premises for such forums in the initial phase. 3.2 Provide direct grants to NGOs and professional associations which participate in technology extension.
4. Increase the number and quality of Trained S&T people.	4.1 Increase skill in CAD/CAM and other modern equipment through the training effort of National Electronics and Computer Technology Center (NECTEC) for CAD and Metal-working and Machinery Industries Development Institute (MIDI) for CAM. 4.2 Organize a series of seminars and courses for the private sector, emphasizing production management, quality control, energy saving and waste-treatment technology.

Strategies	Measures
	4.3 Improve S&T education in both the formal and nonformal sectors by: - emphasizing engineering design at university level; - expanding the dual system of the Department of Vocational Education to increase the knowledge of production workers in basic subjects - increasing the length of practical training for university students; - promoting "factory-in-school" systems at technical colleges and "school-in-factory" systems for manufacturing industries. 4.4 Provide incentives through the BOI to both local and foreign private enterprises to establish institutes for S&T education at or above university level. The incentives may include: - Exemption from import duties on machinery and equipment used in educational institutes;

Strategies	Measures
	- Exemption from income tax for 8 years, - Import of necessary personnel from abroad. The BOI should also be allowed to provide these incentives to NGOs, professional associations, etc. 4.6 Establish a The National Technical Qualification System through the joint effort of MIDI and Engineering Institute of Thailand (EIT) to provide an opportunity for long-term career developments for technicians. Provide additional income to those public servants who have passed through this system.
5. Utilize ad-hoc measures to promote specific skills and target branches of technology.	The target groups could be selected from: (1) Producers of industrial products for government agencies; or (2) Producers of target products which require desirable skills and technology.

Strategies	Measures
	The promotion measures could include one or a combination of the following measures: - low-interest loans; - accelerated depreciation within three years; - income tax exemption from target products; - exemption form trade and business taxes on machinery; - technical assistance in R&D provision; - subsidies for technological acquisition e.g., reduction of withholding taxes on remitted royalties and know-how fees; and - government procurement as markets for target groups. These incentives are to be granted according to the need and significance of the target technology.

Additional strategies and mechanisms for target industries are presented as follows:

2. STRATEGIES AND MEASURES FOR TARGET INDUSTRIES

2.1 The Metal Working, Machinery, and Automotive Industries

(a) Targets

1. Developing process technology for higher manufacturing standards of all metal-working products. For instance, casted products to the standard of ISO 1083-76, machined products to repeatable accuracy of 10 microns; forged products to tensile strength of 60 kgf/mm^2

2. Accumulating and diffusing design technology and product-specific technology of parts and components for pickup trucks, machine tools, and agricultural machinery to build up design capability for metal parts, in particular for engine, transmission, axle, and steering parts.

(b) Strategies and measures

Apart from all the aforementioned general measures, it is recommended that The Metal Working and Machinery Industry Development Institute (MIDI) be appointed as the secretariat of the Subcommittee for the Metal Working, Machinery, and Automotive Industry and Technology Development.

Other recommended measures are as follows:

1. Assigning the MIDI to establish a testing and calibration center to support the manufacturing of metal-working parts for automotive and machinery parts and components.

2. Assigning the BOI to perform the role of match maker between local subcontractors and local and overseas principals to support the metal-working industry for automobiles and machinery.

3. Assigning the Ministry of Education and the Ministry of University Affairs to increase the number of vocational students and university graduates specializing in metal working.

4. Assigning the MIDI to perform as a leading training and service center in computer aided manufacturing, training and services; and cooperate with the NECTEC in computer-aided design training and services.

5. Assigning the MIDI to administer the following incentives to support manufacturers producing metal parts and components for engines, transmissions, steering and axle parts of pickup trucks, machine tools, and agricultural machinery:-

- soft loans;
- accelerated depreciation;
- tax exemption;
- technical and R&D support;
- government procurement.

2.2 The Electronics Industry

(a) Targets

1. Developing design technology and product-specific technology for the following target products personal computers, private automatic branch exchanges, facsimiles, cellular telephones, application-specific integrated circuit design, and industrial electronic control systems.

2. Developing process technology ranging from equipment assembly, subsystem assembly, and supporting parts and components for manufacturing computer, telecommunication, and office automation products.

(b) Strategies and measures

Apart from all the aforementioned general measures, it is recommended that the National Electronics and Computer Technology Center (NECTEC) be appointed as the secretariat of the Subcommittee for the Electronic Industry and Technology Development of the National Committee for Industrial and Technological Development.

Other recommended measures are as follows:

1. Assigning the Ministry of Finance to set up a free trade zone for electronic parts and components, other supporting parts and components, and raw materials for manufacturing those parts and components.

2. Assigning the NECTEC and the Science and Technology Development Board (STDB) to support universities/higher educational institutions to set up centers of excellence for target electronic fields.

3. Assigning the Ministry of Education to support both public and private vocational colleges to upgrade their curriculum to bachelor degree level in the fields of computers, telecommunications, and office automation.

4. Assigning the NECTEC to set up a center for product testing and equipment calibration in compliance with UL and FCC standards.

5. Assigning the Office of the Prime Minister to issue new purchasing regulations for all government bodies and state enterprises to buy computer, telecommunication, and office automation equipment from manufacturers who develop these products with or are endorsed by the NECTEC. Purchasing must be through bidding from at least two qualified bidders. And the purchasing quantity should be increased by 10 percent per annum, starting from the 1992 fiscal year.

6. Assigning the NECTEC to give the following incentives to manufacturers producing personal computers, private automatic branch exchanges, cellular telephones, facsimiles, application-specific integrated circuit, and industrial electronic control systems:

- soft loans;
- accelerated depreciation;
- tax exemption;
- technical and R&D support;
- government procurement.

2.3 The Textile Industry

(a) Targets

1. To upgrade textile chemistry technology, especially in textile dyeing and finishing,
2. To promote water treatment technology.

(b) Strategies and measures

The strategies and measures recommended earlier for general industries can also be used for the textile industry. Additional measures are recommended as follows:

1. The Department of Industrial Works should issue specific and measurable standards for waste water treatment.
2. Import duties on textile chemicals should be reduced.
3. Import duties on chemicals and machinery for waste water treatment should be abolished.
4. Increase training capacities in the following directions:

   - graduate and post graduate level for synthetic textile fibres and polymers;
   - textile chemistry curriculum at university level;
   - technical college training for other branches of textiles.

2.4 The Food Industry

(a) Targets

1. Create and develop basic S&T knowledge of local raw materials, especially the high value crops.
2. Promote R&D in post-harvest technology.
3. Develop and enhance industrial skill and experience in the food processing industry.
4. Promote waste management technology, especially in the economic utilization of waste materials.

(b) Strategies and measures

The strategies and measures recommended earlier for general industries can also be used for the food industry. The National Centre for Genetic Engineering and Biotechnology should be the secretariat for the Subcommittee for the Development of Industries and Technologies for the Food Sector. Additional measures are as follows:

1. Upgrade food processing technology. MIDI could select some target equipment for technical assistance.
2. Increase R&D funding through The National Centre for Genetic Engineering and Biotechnology and STDB for local research institutes and regional universities to conduct basic research on local raw materials.
3. Increase funding for R&D for waster treatment technology.

2.5 The Jewelry Industry

(a) Targets

1. Establish transaction standards to increase international credibility.
2. Transfer metallurgy technology for high value materials.
3. Promote the transfer of gemology to local industries.

(b) Strategies and measures

Additional measures are the establishment of:
- color standards for transactions
- standard lamps.

The standards should not be compulsory but should be promoted by the private sector.

2.6 Plastic Industry

(a) Targets

1. To upgrade plastic technology to achieve the accuracy level of 100 micron,
2. Promote diffusion of and local capability on computer-aided designs,
3. Increase local capability on engineering plastic.

(b) Strategies and measures

Measures specific to this industry are:

1. Incorporate courses on mold and die for Vocational Certificate Level and Higher Vocational Diploma Level;
2. Increase basic courses on plastic materials at university and technical college levels;
3. Provide courses on industrial designs for plastic materials in engineering faculties in tertiary institutes, emphasizing the linking of knowledge on product design, functions, tool design and production process;
4. Provide training courses on designs, engineering process of molds and dies, properties of plastic materials and materials for molds and dies by utilizing both local and foreign production experts and resource personnel from MIDI.

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CHAPTER 1: OBJECTIVES AND SCOPE OF THE STUDY

International structural change in both the financial and the real sector during the Sixth National Economic and Social Development Plan has stimulated rapid growth in Thailand enabling a particularly remarkable growth in the manufacturing sector.

High growth economy offers both additional opportunities and challenges especially to small and medium scale enterprises. There are opportunities for expansion, investment and upgrading existing technologies. Rising income may also divert demand from small and medium enterprises to relatively higher quality products produced by larger enterprises. Technology adoption decision becomes a crucial determinant of firm's ability to participate in the competitive market.

This report was prepared as background information for the formulation of the S&T strategies for the Seventh National Economic and Social Development Plan during which growth is expected to be sustained. The project is the second phase of an earlier study entitled the Identification of Key Technologies for Industrial Development which had selected six target industries. These are 1) Electronics, 2) Motor Vehicle, Metal-working and Machinery, 3) Petrochemical and Plastics, 4) Textiles, 5) Food, and 6) Gems and Jewelry. The tasks of this project are to study the obstacles in the process of technology acquisition and absorption at both policy and enterprise level with special emphasis on the small and medium enterprises.

1.1 OBJECTIVES

- Identify firm-level factors affecting entrepreneurs' decision on S&T adoption,
- Evaluate the current technology supply system in terms of both qualitative and quantitative adequacy,

- Analyze policies and other constraints limiting the adoption of S&T in the recommended key sectors,
- Identify the current process of information dissemination in matching demand and supply of technology,
- Recommend government priorities, responsive strategies, and mechanisms for enhancing S&T development in the key sectors.

1.2 CONCEPTUAL FRAMEWORK

1.2.1 Acquisition of Technology

The process of technology acquisition involves a string of activities such as technology search and sourcing, evaluation, negotiation for right to use the selected technology, machinery installation and so on. Technology acquisition is the initial step for technology accumulation and technology transfer from abroad. In advanced countries, technology acquisition is likely to be an internal process which relies mostly on research and development. In developing countries, technology acquisition relies more heavily on imports of technology than on local research and development.

Technology is embodied in various forms; in hardware such as machinery and equipment, in documents such as manuals, blueprints etc., in persons in the form of skills and experience and in management system and so on. The non-hardware types of technology is loosely called software technology in this report. Moreover technology is usually employed in a package i.e. machinery, documents, management and human resources must be use in appropriate combination to achieve maximum efficiency. In certain cases, the technology employed could be firm specific. Therefore there are many channels for acquisiting technology depending on the desired technology components, the structure of the technology market, competition in the product market, technological capability.

(a) Technology Acquisition

Technology acquisition can be grouped into three categories

(i) Acquisition of technology- cum-management e.g.
- foreign subsidiaries,
- joint ventures with foreign firms and
- merger and acquisition.

(ii) Acquisition of technology in a separate package from policy management

These include :
- contractual arrangements for technology transfer. The technologies under this categories are likely to be software technologies such as know-how, secret formulae, management technology, quality control (which is part of the trademark licensing) and so on ;
- turnkey arrangements,
- purchase or leasing of machinery,
- hiring of experts and consultant firms,
- technical assistance from suppliers,
- technical assistance through subcontracting.
(See details under 6.13 in chapter 6 of Project on The Identification of Key Technologies for Industrial Development)

In addition technology can be acquired through study tours, seminars and workshops, exhibitions, education and so on.

(iii) Acquisition Through Local Research and Development

This requires rigorous local R&D systems which could be through public institutes or private sector effort. Local development could rely on reverse engineering, analysis of rivals' products or on in-house innovation.

Generally, business enterprises may use several means at the same time. For instance a joint venture firm could have a technology licensing agreement with the mother company and at the same time is engaged in in-house R&D.

(b) Advantages and Disadvantages of Different Modes of Technology Acquisition

The choice of technology acquisition is not made solely by the purchasers but also by the owners of technology. The advantages and disadvantages outlined here will be from the point of view of the purchasers of technology.

(1) Technology-Cum-Management

Direct foreign investment in the form of 100% foreign owned subsidiaries is generally preferred by foreign investors but this is a less preferred channel in the eyes of the host countries because technology diffusion under this circumstance may not be sufficiently widespread. This mechanism is used in the case where the required technology is important and cannot be acquired by other means. Or the project need to be started as soon as possible. If such as a project involve, the exploitation of natural resources, the government usually hold a certain amount of equity share in the venture.

Joint ventures with foreign partners are the mechanism which can combine strengths between partners e.g. technology and international marketing network of the foreign partners and local marketing expertise of the local investors. However an earlier study (Santikarn, 1981) found that during the time of the survey which was in the seventies technology transfer between Japanese and local partners is quite limited as each party tended to focus their attention on their specialized function. Local entrepreneurs were happy to let the Japanese partner looked after production rather than trying to absorb the technology by themselves.

Merger and acquisition is a necessary means for obtaining firm-specific know-how or trade secrets. This method is more widespread in advanced countries. However it is possible only when the desired or the rival company is in financial difficulty.

The advantage of this channel of technology acquisition is that technology can be effectively utilized in a relatively short period of time. But there are several disadvantages. First technology may not be completely transferred to local workers. Secondly the cost of technology could be relatively high. In the case where there are only a few sellers in the market, the transnational corporations that own the required technology may set unreasonable transfer prices for technologies, imported inputs as well as interest rates.

(2) Acquisition of Technology Without Management

An earlier study of 14 case studies of industrial enterprises (Santikarn Kaosa-ard, 1987) indicated that it could not be said a priori which channel would be the most appropriate mechanism for acquisiting *industrial* technology without management. In a case study of a refractory plant, it is found that hiring retired engineer from an international agency was not a suitable method. As the firm grew, the engineer's knowledge remained limited to a small range of products. The firm subsequently had to enter into a technical assistance contract with an industrial firm in a developed countries to have continuous access to R&D output of the technology owner.

Turnkey arrangements are generally more appropriate for a going concern than for a newly established enterprise which lacks experienced personnel. Consultant firms on the other hand could be more effective in solving a particular problem than in running a factory. A case study of a paper producer revealed that hiring of a consultant firm to run a newly established factory became unsuccessful and a leading Japanese paper maker was contacted to help running the plant.

The problem of technology acquisition of the second category is that of high cost of both hard and software technology. These costs could be explicit or implicitly disguised in the form of higher fees, prices of accompanying inputs and equipment etc..

Technology which can be acquired through education is normally basic technology. Training, exhibitions, study tours are generally used to improve technical efficiency rather than to acquire technology. The conclusion from the study of 14 case studies cited earlier indicated that effective technology mastery was often found infirms where the local manager that had firm S&T basis and took initiative in absorbing the imported technology.

(3) Acquisition Through Local Development

This mechanism is more widespread and effective in advanced countries which have strong S&T foundation. The State need not engage directly in R&D activities but may set up incentive systems for the private sector to invest in R&D activities. The incentives include the intellectual property right system which provides temporary monopoly in the use of the technology. The State could also provide fiscal incentives to R&D activities.

In developing countries, private companies rarely engage in R&D activities because proven technology can be acquired more rapidly from enterprises in advanced countries. This could be less costly than attempting to develop technology in their own companies except that the required technology involves the use of local raw materials and plants.

1.2.2 Resources of, and Market Conditions Facing Entrepreneurs

It is widely believed that entrepreneurs who employed outdated technology have obstacles in acquiring technology. Such belief is a result of neglect of market conditions. An earlier study (Santikarn Kaosa-ard, 1984) suggested that firms may not employ superior technology if profits

accrued was lower than these from outdated technology. In villages where custom milling of rice was monopolized, owners of rice mills charged milling fees in kind i.e. by keeping the brokens and brans. Therefore they avoid using a more superior husking and polishing technology which produced less brokens as the improved technology would have reduced their income. This example clearly illustrated the fact that market condition can also affect technology adoption decision.

Another study on the ceramics industry in Lampang (Santikarn Kaosa-ard, 1989) also revealed that market characteristics affect technology decision. The Lampang industry produced mainly low-cost products for low-income customers in the Northeast and border markets with Loas, Myanmar and Cambodia. Their customers generally ordered small lots of the lowest qualities. Grade C products turned out to be much more fast moving than Grade A products. Moreover, these small enterprises do not have a marketing department. Customers usually come to the factory to collect the products. As a result these entrepreneurs used the simplest production and packaging technology. They did not need to change the existing technology unless they wanted to shift to a higher income market where consumers demand higher quality products. Another example is a producer of brass valves who could shift to the production of hard disk cases on subcontract with a transnational corporation as it had sufficient internal technological and marketing resources.

1.2.3 Obstacles in Technology Acquisition

If market conditions are not considered as obstacles to technology acquisition, the real obstacles can be summarized as follows:

(1) Type of Technology and The Structure of Technology Market

Monopoly in technology market is not expected to be a permanent obstacle as excess profits will attract new investors into the market. Monopolized technology is often very complicated and is beyond the current utilization capacity of the local industry at present.

If the technology is firm-specific, technology need to be acquired by merger and acquisition. However since the level of industries are relatively simple, the markets of these technologies are generally quite open and competitive.

(2) Obstacles from Government Policies, Measures and Organization

The government may intervene in the market in order to gain revenue or to protect infant industries etc.. Such interventions may affect the level of technological utilization and may become an obstacle to technology acquisition. These are:

- import duties which increase the cost of machinery,
- business taxes which discourage subcontracting activities,
- capacity restriction e.g. regulating expansion or entry of new firms, which reduces the level of competition and hence indirectly limit expansion of demand for technology,
- government machinery and procedures which may not be sufficiently responsive to rapid technological change and so on.

The details of government policies and measures which may the affect technology acquisition of the private sector has been summarized in Appendix 2. The impact of these measures are illustrated in Chapters 3-5.

(3) Obstacle from Lack of Information

Although the government policies, measures and all market signals may be right, optimum technology may not be utilized due to lack of information regarding the availability of technology. In this situation improving information system will correct technology adoption decision.

(4) Limitations of Entrepreneurial Resources

Experience, attitudes, formal education with scientific basis and skill profile and the potential to shift to upper quality market are important factors triggering the search for and the absorption of technology. The example provided under 1.2.2 illustrated the fact that if the owner of the firm was not an engineer, he would not be able to take advantage of the available opportunity. Measures which aim to increase entrepreneurial exposure, attitudes and skill, i.e. a company enhancement program are likely to improve firm level technology acquisition.

1.2.4 Target Technologies

The project on The Identification of Key Technologies for Industrial Development has selected targeted industries according to the following economic criteria:

- growth potential,
- international competitiveness,
- industrial linkages,

and evaluated these industries according to technological potential. The selected industries are 1) Electronics, 2) Motor Vehicle, Metal-working and Machinery, 3) Petrochemical and Plastics, 4) Textiles, 5) Food, and 6) Gems and Jewelry. The target technologies of these industries are presented in Table 1.1. The obstacles to the acquisition of these target technologies are also analysed in this report.

1.3 APPROACH AND SCOPE OF THE STUDY

On the basis of conceptual framework outlined above, 44 entrepreneurs in the target industries and 14 government officials were interviewed. The names of interviewees are listed in Appendix I. The interviews were supplemented by literature and statistical reviews.

The findings and the proposed government policies, measures and mechanisms from the interviews were presented to a small expert group meeting.

In addition, information regarding patents were collected at the Department of Commercial Registration and a questionnaire was sent to 57 local inventors.

In this report, the Electronics and Motor Vehicle, Metal Working and Machinery are given special attention because they are important supporting industries. The technology trend in most industries is such that computer controlled and computer related technology such as CNC machines, computer-aided designs (CAD) and computer aided manufacturing (CAM) will be increasingly used in most industries.

1.4 ORGANIZATION OF THE REPORT

The next chapter deals with supply of technology starting with an overview of supply situation followed by technology acquisition by both the public and private sector and S&T manpower. Chapter 3 and 4 analyse technology situation in the electronics and Motor Vehicle, Metal Working and Machinery industries respectively. The three other target industries i.e. Textile, Food and Jewelry and Plastics. The last chapter presents main finding strategies measures for general industries and specific measures for the target industries.

Table 1.1 : Selection of technologies for targeted industries

	ELECTRONIC	MACHINERY	PLASTIC	TEXTILE	FOOD	JEWELRY
Generic						
Computer aided Technologies	***	**	**	*	-	*
Management	***	***	***	***	***	-
Metal working	**	***	**	*	*	**
Auxiliary						
Energy cons.	*	***	**	***	***	*
Waste management	*	*	*	**	***	*
Specific Food : Tech.						
-Prod.Design	Product Circuit Mechanical (Mold/die)	Parts	Product Mold/die Compounding	Fabric Garment		
-Prod.Specific	PC CT PABBX FAX ASIC	Engine Transmission Steering Axle Mold/die	Engineering plastics Intermediate plastics	Fine Yarn Fashion fabric Fashion garment		
-Process Tech.	PCB SMT IC fabrication	Casting Forging Machining Heat treatment Plating Welding Stamping	Compounding	Textile chemistry Machine Utilization	Sterilization	Metallurgy (alloying)

Note : *** = Extremely important
** = Important
* = Not so important
- = Unimportant

Source : The Identification of Key Technologies for Industrial Development

CHAPTER 2: TECHNOLOGY SUPPLY SYSTEM

Technology acquisition is a means to increase the supply of technology, which may be imported from abroad or indigenously developed. In this chapter section 1 deals with the overall picture of technology acquired through import from overseas while section 2 examines the indigenously developed technology. Technology acquisition by the private sector through the patent system and by direct development by government research agencies are discussed in the final section.

2.1 TECHNOLOGY ACQUISITION THROUGH IMPORT FROM ABROAD: AN OVERALL PICTURE

Foreign technology may be imported in several forms. They include purchases of foreign machinery, technology contracts, direct foreign investment and so on. Purchase of foreign machinery has been the most popular channel of technology acquisition in Thailand. Machinery import has grown rapidly in accordance with the growth of the Thai economy. In 1988, Thailand imported machinery totalling 203,013 million baht. In 1989, the imported value went up to 251,000 million baht.

At the same time technology acquisition through technology contracts with foreign firms also increased, from 3,440 million baht in 1988 to 5,334 million baht in 1989. According to the Bank of Thailand, the cost of technology acquisition through contractual arrangement with foreign firms are classified into four categories, i.e. royalties, trademark fees, technical fees, and management fees. However the classification is not well-defined and is based on contract titles. For example for licensing agreements which may involve the use of patented technology, the costs of contracts are classified as royalties. On the other hand, for technical assistance agreements most of which involve the transfer of production experiences such as know-how, supply of industrial expertise to help with production system and skill training, would be classified as technical fees. Earlier studies

on technology transfer (Santikarn, 1981 and ESCAP/UNCTC 1984) revealed that different definitions and coverages are common among contracts and this prevented exact comparisons. In many cases of licensing agreements, whether the transaction involves patents or trade secrets was not clearly specified. In some cases, licensing agreements covered a widerange of services including technical assistance and skill training. Sometimes trademark agreements may include technical assistance as well. Therefore the above mentioned classification is only a rough approximation.

In 1989, on the basis of ISIC 3 digit the auto part industry (ISIC code 384) was ranked as the industry with the highest payments for technology acquisition by contractual agreements (including trademark agreements) i.e. 903.82 million baht (Table 2.1). Most payments were for royalties (845.81 million baht). Production of other chemical goods (ISIC code 352) was the industry with second highest payment i.e. 443.47 million baht out of which 307.19 million baht was payment for technology licensing.

For the six target industries in the study (Table 2.2) licensing royalties accounted for the largest payments, while technical fees were the second largest. The motor vehicle, metal working and machinery industries was the industry which paid highest fees for technology acquisition (1,185 million baht) while the plastic products industry paid the lowest fees (7.94 million baht). No data were categorized for the gem and jewelry industry. Industries with large number of small firms, such as the plastic products industry generally do not generally acquire software technology through contractual arrangements.

Foreign investment (measured in terms of net capital inflow) increased from 6,908 million baht in 1986 to 28,244 million baht and 44,742 million baht in 1988 and 1989 respectively (Table 2.3). From 1988 to 1989 the industry with the largest amount of foreign investment was electrical and electronics i.e. 15,942.9 million baht. Next was the chemicals and chemical products industry with foreign investment valued at 5,339.9 million baht. Other industries with large amount of foreign investment included metal works and food with total net capital inflow of 4,835.2 million baht and 3,615.7 million baht respectively.

Thailand has an open arm policy for foreign investment for almost all industries. There are some restrictions according to Alien Occupation Law and Alien Business Law but these have not been considered an obstacle to foreign investment in Thailand. For purchases of technology through contractual agreements, on February 6, 1989 the Board of Investment agreed to register technology import agreements. It was agreed that three private sector organizations, i.e. the Federation of Thai Industries, Thai Chamber of Commerce and the Thai Banking Association in coordination with the Board of Investment and the Bank of Thailand, were to review the administration processes of technology import. At the time of this survey the matter is still under the consideration of JPCC.

Details of technology important enterprise level will be presented in the next chapter.

2.2 TECHNOLOGY ACQUISITION THROUGH LOCAL RESEARCH AND DEVELOPMENT

At present, the development of local technology in Thailand occurs mainly in the machinery industry. This is due to the fact that the country industrial development is still at the level of being dependent mainly on machinery and equipment. In 1986 local machinery production totalled 15,846 million baht or 26.5 percent of total imported value. In 1988 the figure went up to 24,802 million baht but accounted for a lower percentage (16.7%) of total imports. Rapid need for technology in the industrial sector has led to a higher level of import of foreign technology and therefore lower percentage of locally produced machinery.

The government may induce the development of local technology by giving appropriate incentives to the private sector. The incentive system being used at present is the Patent Act. Moreover, the government may acquire technology by financing R&D in various universities and research institutes. Financial support for research may be granted to the private sector and universities through government agencies e.g.. The Science and Technology Development Board (STDB), the three centers of the Ministry of Science, Technology and Energy.

Table 2.1 : Cost of technology acquisition from abroad by contract agreements in the budget 15 industries, 1989

unit : million baht

ISIC Code	Major Group	Royalties	Trademark Fee	Technical Fee	Management Fee	Total
	Activities not Adequatesly Defined	530.77	16.60	718.30	42.51	1,308.18
384	Manufacture of transport equipment	845.81	0.11	56.00	1.90	903.82
352	Manufacture of other chemical products	307.19	4.65	122.16	9.47	443.47
311	Manufacture of Food, Beverages and Tobacco	64.64	101.36	166.39	3.62	336.01
383	Manufacture of electrical machinery, apparatus, appliances and supplies	142.93	1.11	184.16	0.78	328.98
321	Manufacture of textiles	94.98	4.83	213.96	9.07	322.84
351	Manufacture of industrial chemicals	157.80	2.90	98.89	27.86	287.45
382	Manufacture of machinery except electrical	230.64	1.77	22.96	0.00	255.37
353	Petroleum refineries	105.89	2.58	98.78	0.00	207.25
500	Construction	40.91	0.44	160.55	0.46	202.36
832	Business services except machinery and epuipment rentals and leasing	148.30	0.00	3.13	13.37	164.80
610	Wholesale Trade	90.18	4.37	39.13	22.54	156.22
312	Food manufacturing	85.30	34.65	28.98	0.00	148.93
355	Manufacture of rubber products	91.68	1.84	54.86	0.00	148.38
632	Hotels, rooming houses, camps and other lodging places	66.69	0.00	14.18	38.99	119.86
	Total	3,003.71	177.21	1,982.43	170.57	5,333.92

Source : Technology Transfer Center, Ministry of Science, Technology and Energy

Table 2.2 : Cost of Technology Acquisition in Target Industries, 1989

unit : million baht

Industry	Royalties	Trademark Fee	Technical Fee	Management Fee	Total
Motor Vehicle, Metal Working and Machinery	1,086.47	1.86	95.40	1.90	1,185.65
Food	158.38	136.01	216.90	3.62	514.90
Textile	162.81	8.15	244.43	12.58	427.96
Electric and Electronics	142.93	1.11	184.16	0.78	328.99
Plastic Products	5.65	0.00	2.29	0.00	7.94
Total	1,550.59	147.15	740.89	18.88	2,457.50

Source : Technology Transfer Centre, MOSTE

Note : Gems and Jewelry are included in other category, not classified separately

Table 2.3 : Net Flow of Foreign Direct Investment in Thailand Classified by Business

unit : million of baht

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1987-1989
1. Financial Institutions	(546.3)	(173.0)	674.1	(480.3)	996.5	156.0	(1,239.7)	510.2	4.0	2,723.8	3,531.4	6,259.2
2. Trade	341.3	750.5	479.8	696.9	1,697.7	1,893.5	1,081.8	1,783.4	653.3	3,932.5	6,934.9	11,720.7
3. Construction	293.8	782.6	1,276.8	736.9	741.6	1,066.2	1,585.3	1,234.9	1,349.1	1,938.7	3,909.9	7,197.7
4. Mining & Quarrying	154.3	596.7	767.7	1,682.2	1,464.3	2,787.1	515.9	240.2	192.0	472.6	574.9	1,239.5
4.1 Oil exploration	145.2	440.9	730.6	1,631.7	1,099.7	2,654.8	430.0	236.4	251.3	399.0	533.7	1,184.0
4.2 Others	9.1	155.8	37.1	150.5	364.6	132.3	85.9	3.8	(59.3)	73.6	41.2	55.5
5. Agriculture	4.5	209.8	7.5	15.6	48.1	67.6	76.9	202.2	285.9	307.3	571.3	1,164.5
6. Industry	723.8	1,014.8	2,526.0	1,231.0	2,567.5	3,167.0	1,358.1	2,123.8	4,749.2	16,345.0	20,401.1	41,495.3
6.1 Food	51.8	91.2	156.9	(257.3)	217.8	105.8	394.8	286.9	436.6	1,229.5	1,949.6	3,615.7
6.2 Textiles	(10.4)	(1.5)	(32.2)	420.7	13.3	452.5	59.9	55.7	995.7	1,119.5	686.4	2,801.6
6.3 Metal based and Non-metallic	32.9	47.8	149.0	123.5	1,022.1	78.3	(125.7)	(22.6)	365.1	1,960.1	2,510.0	4,835.2
6.4 Electrical appliances	351.4	446.2	624.4	666.7	393.9	1,046.3	260.0	617.0	1,136.5	6,309.2	8,497.2	15,942.9
6.5 Machinery & Transport Equipment	59.7	92.2	129.5	227.3	421.7	119.9	32.0	(14.9)	159.9	727.2	714.9	1,602.0
6.6 Chemicals	73.3	213.4	177.4	106.5	350.4	283.3	486.4	484.0	868.1	1,947.0	2,524.8	5,339.9
6.7 Petroleum products	126.7	2.2	1,246.8	(129.0)	0.0	934.2	0.0	8.2	(15.8)	833.6	(1189.6)	(371.8)
6.8 Construction Materials	(26.9)	1.4	12.5	8.8	19.1	5.6	38.3	5.4	6.3	26.8	85.4	118.5
6.9 Others	67.3	119.9	61.7	63.8	129.2	141.9	190.4	674.1	796.8	2,192.1	4,622.4	7,611.3
7. Services	156.1	696.8	662.7	447.1	719.1	506.2	1,063.5	813.4	1,171.4	2,523.9	8,567.3	12,262.6
7.1 Transportation & Travel	94.5	214.9	333.0	263.4	199.3	165.1	197.5	255.8	220.8	408.1	524.2	1,152.9
7.2 Housing & real estate	3.4	150.9	14.1	(3.9)	94.8	94.8	305.5	42.7	326.2	890.8	3,902.3	5,121.1
7.3 Hotels & Restaurant	1.9	87.7	91.8	137.6	86.5	96.7	222.9	100.3	94.7	558.7	3,075.5	3,728.9
7.4 Others	56.3	243.3	243.8	50.0	389.5	129.8	337.2	414.8	527.9	666.5	1,065.3	2,259.7
8. Others											251.5	251.5
Total	1,127.5	3,678.2	6,414.4	4,331.4	8,224.8	9,643.6	4,441.8	6,908.1	9,043.7	28,243.8	44,742.3	82,029.8

Source : Bank of Thailand

2.2.1 Technology Development under the Patent System

The purpose of the patent system is encourage technology development in the private sector by allowing monopoly right to the use of an invention to its owner during the period covered by the patent. However, as an invention will not be regarded as technology until it is used commercially patented inventions are only a rough approximation of local technology potential.

In Thailand, the patent act has been enforced since 1979. The system protects industrial designs and invention, The Thai Patent Act does not protect inventions in the following categories beverages, medicine, agricultural machinery, animal, vegetables, biological processing of animal and vegetable products, information system and computer software.

From 1979 to June 1990, there were a total number of 11,311 applications for patent rights, of which 1,827 or 16% were issued patents. Statistics giving details of patents classified by industry and nationality are given in Appendix 3.

Out of 1,827 patents issued, 1,304 (or 71%) were industrial designs. A closer examination of some industrial design patents at the Department of Trade Registration revealed that most of them have low level of technology. Examples of these include designs such as bags and belts, designs for ice-cream (e.g. shape of lion head or a smiling child) and Lever Brothers Thailand's push cart for selling Wall's ice-cream etc..

Most applicants for patents were individual persons with total number of 9,416 persons or 83% of total applicants. Foreign persons and corporations accounted for 72 per cent of those granted. In sum, the Thai patent system is being used by foreigners more than Thai nationals. Moreover, the number of applications from Thai inventors has not shown clearing a increased trend.

Up to June 1990, 523 and of total 7,950 applications for inventions were granted patents. Out of those patented, 183 of them were engineering inventions out of which 129 (or 70.5%) were foreign owned; 340 were chemical inventions and 320 (94.1%) were foreign owned.

When patents are classified by legal status of inventor and owner/user Table 2.4 shows that most inventors, both Thai and foreign, were individual persons but patent owners were mostly corporations. There is also a distinct pattern between patents owned by Thai and by foreigners. Out of 456 foreign owned patents, 433 (95%) of the owners were corporations. For patented items invented by Thai nationals, only 10 out of 63 (15.9%) were owned by corporations.

Questionnaires were sent to 57 Thai inventors who were granted patents. There are a total number of 63 persons but the Patent Office could find addresses for only 53 persons. Only 13 questionnaires were responded, 10 by mail and 3 by telephone interviews. Attempts to contact the Thai inventors were rather difficult as many have changed their addresses and most did not leave their telephone numbers with the Department of Trade Registration.

From the 13 questionnaires received it was found that the highest education level acquired by most inventors, i.e. 9 out of 13 was bachelor's degree or lower (Table 2.5). Most of them relied on their own income for funding. Most inventions required rather small amount of money. Only two inventors spent more than one million baht for their inventions. Six of then spent less than 100,000 baht. Thai inventors are different from foreign inventors in that most of them to worked alone while the latter worked as a team (Table 2.6).

Table 2.4 : Inventors and Thai patent owners, classified by nationality, and legal status (July 1982 - August 1990)

Inventor	Applicant				Total
	Thai		Foreign		
	Person	Corporation	Person	Corporation	
Thai person	53	10	0	0	63
Thai corporation	0	0	0	0	0
Foreign person	1	4	18	433	456
Foreign-corporation	0	0	0	0	0
Not Specified	0	1	0	6	7
	54	15	18	439	526

Source : Department of Trade Registration, 1990.

With regard to the commercialization of patents, it was found that only 4 out of 13 had been commercialized. One was used for production by the inventor himself. One was transferred to a government agency with no payment received. One was transferred to a government agency and the payment received was set as a percentage of total sales. One received funding from a private firm and the right to use the patent commercially was then transferred to this private firm.

With regard to problems encountered in the commercialization of patents (Table 2.7) five respondents specified the problems as that these inventions were only conceptual with no machine prototypes. Skilled person could not be found to produce a prototype and insufficient capital to produce one. Two respondents could not reach agreements with buyers. Other 2 respondents could not find any firm willing to put their inventions into commercial use. Three respondents had no problem as the invention were invented for their own use.

Table 2.5 : Qualification of Thai inventors and funding sources

Qualification and source of funding	No. of respondents
1. Education level of inventor	
– High school or lower	3
– Bachelor degree	6
– Master degree	3
– Ph.D.	1
Total	13
2. Inventory Time	
– Less than 1 year	4
– 1–5 years	8
– More than 5 years	1
Total	13
3. Invested Capital (baht)	
– 1 – 10,000	5
– 10,000 – 100,000	1
– 100,000 – 1,000,000	2
– Over 1 million	2
– Not specified	3
Total	13
4. Funding Sources	
– Own savings	11
– Private company	1
– Government	1
Total	13

Source : Own survey

Table 2.6 : Patents classified by national of inventors

Inventor	Nature of invention	No. of patents	Percentage
Foreigners		456	100.00
	- Invented alone	193	42.32
	- Jointly invented	263	57.68
Thai nationals		63	100.00
	- Invented alone	60	95.24
	- Jointly invented	3	4.76
Not specified	-	5	-
Jointly invented (Thai and foreign)	-	2	-
Total	526	-	

Note : Number of patents from July 1962 to August 1990

Other commercialization problems stated are varied. One local patent owner claimed that he took a foreign firm to court for copying his product. Other patented inventions were prohibited to be commercialized under another law and therefore cannot be used commercially. For example the invention of a gun component which enabled a more rapid and safe firing is not legal under the Weapon Act of B.E. 2490 and therefore can not be commercially produced. An invention of biological fertilizer does not conform to the requirements of the Fertilizer Act of 2518. The Act clearly specifies the level of the nutrients, the size of the pills and the humidity ratios.

Table 2.7 : Commercial use of patents

Commercial use/ Problem	No. of observations
1. Have been contacted to purchase/hire/transfer for use commercially	
- Have been contacted/have been in use	4
- Have not been contacted/have not been in use	8
- No answer given	1
Total	13
2. Commercial use of patents	
- In process of transferring patent right	1
- Have not been used commercially	8
- Have been used commercially	4
Total	13
3. Problems encountered*	
- No prototype/no funding capital/can not find skilled person to produce prototype	5
- Agreements with enterprises cannot be reached.	2
- Others	2
- No problem at all	3

Note : *Each respondent can answer more than one question.
Source : Own Survey

It may be concluded here that the Thai patent system has not yet been successful in inducing the development of technology within the country. The present system only assists in only protecting foreign patents of inventions developed abroad. Its failure may be explained by

the following three main reasons. First, industrial technology in Thailand is still embryonic. At the same time it is not difficult for business firms to acquire technology from abroad. They therefore are interested in only using it most efficiently than trying to developed technology. R&D are directed towards modifying foreign technology to suit their raw materials, local environment and the skill of local workers. R&D which could lead to inventions which are sufficiently novel to justify for patenting are thus rare. Secondly Thai inventions are still more of applied science and not technology as they still are conceptual. R&D with high capital investment and good teamwork has a better chance of being applied commercially. However Thai inventors normally work alone and have small funding. As a result patented inventions are very often far from the stage of being used commercially. For example after a biochemist have been successful in identifying and medicine ingredients from local herbs the medical effectiveness of the ingredient must be tested. It is therefore necessary that he has to jointly work with specialists in other fields such as a pharmacist, a physician and an engineer who could help specifying in designing process technology. In some cases machinery designs and pilot plant are necessary. Very often an individual inventors does not have sufficient capital and Thai firms lack in-house R&D lab and machine workshop that can compliment the inventor. Consequently, they do have little potential to link up with inventors. The problem of agreements on benefit sharing stems from the fact that inventors normally think that their inventions are of great value. The business firms, on the other hand tend to overvalue the additional investments needed to commercialize technology. From the example given above, a firm may need a horticulturist to experiment at farm level to secure the appropriate quality and quantity of raw materials. Thirdly, the private sector is rarely informed of the patented inventions. Even the research team of this study found it difficult to get in touch with the inventors due to either incorrect addresses or only mailing address is given without a telephone number. Therefore the Ministry of Science, Technology and Energy, the Technology Transfer Center of may keep an updated record of inventors' addresses.

2.2.2 Technology Development in the Private Sector

The research jointly conducted between the UNESCO and the Ministry of Science, Technology and Energy estimated in 1983 that Thai firms spent not more than 0.1% of total sales on R&D. In 1987 the National Research Council estimated that Thai firms accounted for 6.8% (181.6 million baht) of the total R&D expenditures of the country. Which is very low by international standard. In developed countries private sector's spending on R&D accounted for about half of the total R&D expenditure. A study on R&D of private sector (TDRI, 1990) revealed that R&D activities in local firms were minimum standard technology is normally employed. Machinery and raw materials suppliers played important role in the transfer of technology. R&D activities were not common even in firms with total yearly sales as high as 1,000 million baht. Firms which were engaged in product and process development were still very few in number. Local firms with proper R&D activities are normally those of large sized and have subsidiaries abroad or are subsidiaries of translational corporations. These firms could afford to employ foreign scientists and purchase technology through business acquisition.

Reasons given by Thai firms for not engaging in R&D (TDRI, 1990) included the following. (1) Most firms produced standardized products which require no modification. In cases of joint-ventures with foreign firms, local firms normally relied on R&D of the foreign partners (3) Government measures restricting production capacity in some industries had reduced competition, which in turn depressed the need to invest in R&D. (4) In the recent past most Thai business executives allocated most resources for expansion to cater for explosion of demand and put no emphases on R&D.

2.2.3 Government Technology Support and Services

Government participation in technology development and support can be categorized according to the specificity of technology as follows:

(1) Services and Support for Specific Industries

In the six target industries studied direct S&T support can be found only in three industries i.e. food, textiles and machinery. The government agencies directly involved are (1) the Institute of Food Research and Product Development, Kasetsart University (2) Textile Industries Division, Department of Industrial Promotion and (3) The Metal-working and Machinery Industries Development Institute, Ministry of Industry. However, the Institute of Food Research and Product Development emphasizes more on nutrition than processing technology.

(2) Support for Specific Technology

Major government agencies concerned include the STDB, the National Center for Genetic Engineering and Biotechnology, the National Center for Metal and Material Technology, the National Electronics and Computer Technology Center.

(3) General Support

Government agencies concerned are the Thailand Institute of Scientific and Technological Research, the Department of Science Services, Ministry of Science, Technology and Energy; and the Thai Industrial Standards Institute, Ministry of Industry.

(4) General Technology Transfer for General Industries

The Government agency directly responsible for technology transfer is the Technology Transfer Center, Ministry of Science, Technology. and Energy.

(5) Basic Knowledge in Science and Technology

This includes both formal and non-formal education.

Details of functions and responsibility of the above mentioned government agencies are given in Appendix 4.

The following section will deal with only activities in technology support and technical services.

(a) Technology Development

A government agency which deals directly with technology development in the Thailand Institute of Scientific and Technological Research (TISTR). In 1990, TISTR received 127 million baht for research and technical services to the private sector (Table 2.8). This accounted for 29% of total research budget. The institute is faced with several obstacles. First, the Institute has insufficient flexibility in the administration of technology department due to rigid rules and regulations. Second, the Institute is faced with problems of producing prototypes of machinery and equipment. Third, there has been braindrain from the Institute to the private sector. This is due partly to higher income received in the private sector and partly due to inflexibilities of government's regulations. These obstacles have the TISTR's lowered potential in technology development.

A study on organizing R&D system to promote industrial development (TDRI, 1991) revealed that technology development by government agencies has been ineffective with no clear direction. R&D agencies are faced with insufficient resources both in term of financial and manpower and there is no mechanism linking the private sector with public R&D agencies.

The three centers under the Ministry of Science, Technology and Energy are not responsible for technology creation directly but are concerned more with the administration of R&D. Their budget and manpower involved are presented in Table 2.9. In 1990, the three centers together received a total of 149.35 million baht for research. Most researchers are university lecturers.

Table 2.8 : Research and Development Budget of Science and Technology Agencies

unit : baht

Source of Fund	1985	1986	1987	1988	1989	1990
1.						
- NCMMT			1,150,000	12,431,000	31,582,350	65,025,108
- NECTEC				23,286,265	24,812,520	54,160,000
- NCGEB	3,800,161	19,364,069	22,142,610	24,971,065	23,291,800	30,735,000
2. STDB			56,739,292	90,580,562	61,789,900	103,467,638
3. NRC	16,116,955	13,865,035	16,097,008	7,557,180	12,384,200	21,814,563
4. TISTR	35,290,000	104,780,000	49,730,000	52,460,000	69,840,000	127,290,000 *
TOTAL	55,207,116	138,029,104	145,858,910	211,266,072	223,700,770	402,492,309

Note : * Of the amount, 77.02 million baht, 13.28 million baht and 36.99 million baht were allocations from government budget, support from foreign countries and support from the private sector respectively

Table 2.9 : Budget and manpower of science and technology Institution (Fiscal year 1990)

	Operating (Million baht)	R&D Subsidy (Million baht)	Manpower Government Offical	Temporary staff
National Centre for Metal and Material Technology	3.26	65.55	9	3
National Centre for Genetic Engineering and Biotechnology	4.50	30.74	9	6
National Electronics and Computer Technology Centre	12.63	53.06	8	6
Technology Transfer Centre	1.94	30.00	31	12
Thailand Institute of Scientific and Technology Research	98.86	77.03 * 50.27 *	590	40
The Metal-Working and Machinery Industrial Development Institute	10.48	-	58	32

Note : (a) The budget for the Revolving Fund for Research and Development administered by the Technology Transfer Centre does not included in the center's total budget

(b) Including financial support from other sources

* The amount 77.03 million baht is allocated from government budget

The Center with relatively high level the private sector is the National Electronics and Computer Technology Center. A major obstacle in involving more cooperation with the private sector is patent right agreement on use of inventions. At present, the Ministry of Science, Technology and Energy is the owner of these inventions, has no clear policy regarding agreements on patent uses.

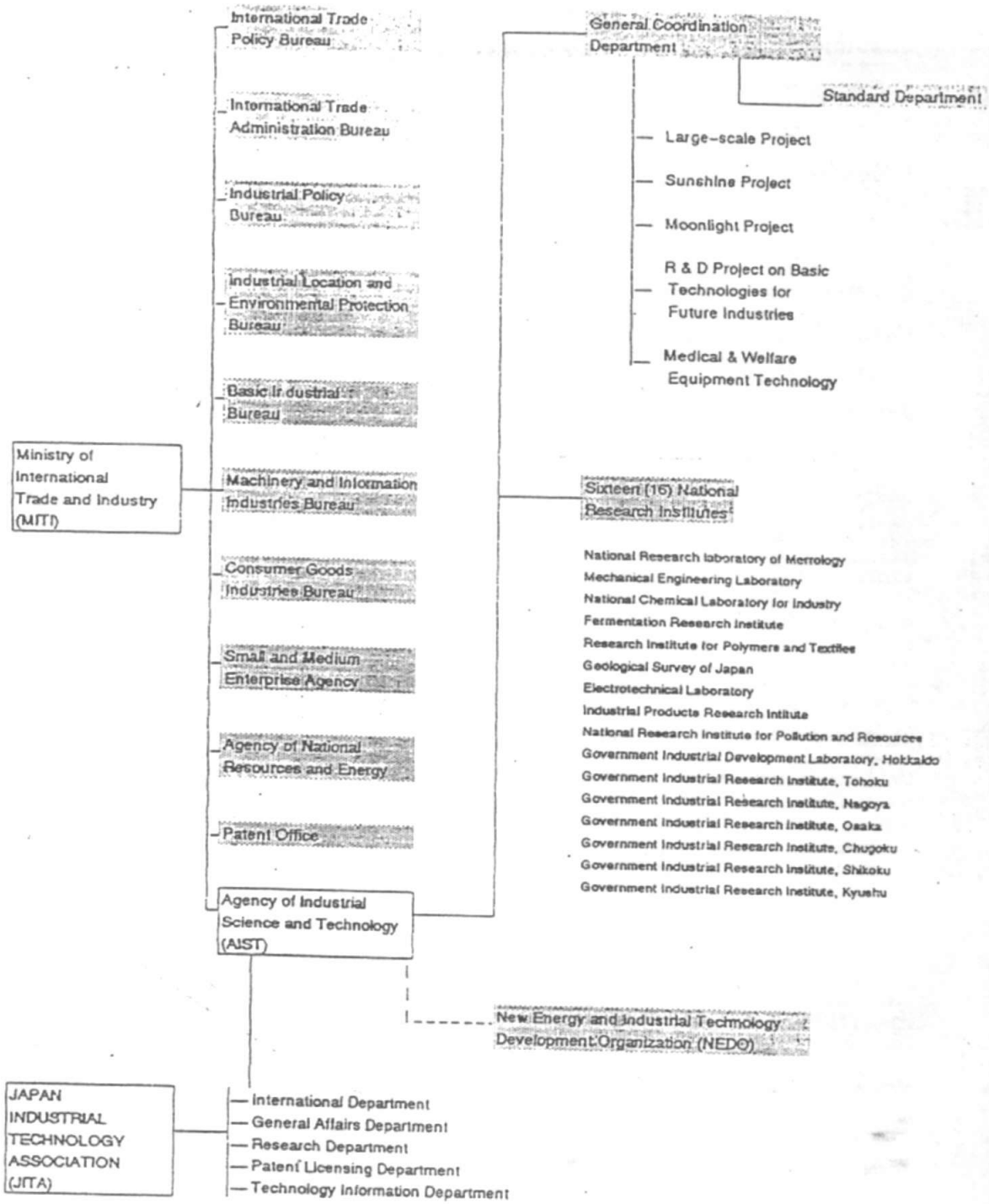
The administration of Thai R&D has relied mainly on government instruments. To date the promotion of local patents is entirely up to patent owners. In Japan, the agency responsible for the administration of government R&D is a non-government organization i.e. Japan Industrial Technology Association (JITA) with support from various government agencies concerned (See chart 2.1). The association is responsible for dissemination of R&D results from government laboratories to the private sector, both inside and outside Japan. JITA receives an annual financial support of about 1,200 million yen from the Japanese government yearly budget, while its annual financial support from Japanese private sector is about 360 million only. The ratio of government financial assistance to private assistance is thus 4:1. Therefore even in a developed country like Japan, the government still plays a very important role in the supporting for technology development in the long run.

Besides the agencies already mentioned the Metal-working and Machinery Industries Development Institute has begun to develop domestic technology such as designing and producing two directional Boring to Thai firms. However such development has been limited due to insufficient funding and manpower.

(b) Technology Information Services

The STDB has been engaged in the Support for Technology Assessment and Mastery Program (STAMP) which gives assistance to the Thai industrial sector. The Program has enabled business firms to purchase and upgrade machinery and equipment for. Such assistance is given in various forms such as technical consultation, information on

Figure 2.1 : Relation of MITI, AIST and JITA



technology, as well as financial support in the evaluation and acquisition of technology. This program receives reasonable attention from business firms. Since August 1990 11 firms have received assistance of 7 million baht from the program. Besides this program the STDB also provided assistance through the Technical Information Access Center, TIAC. However the activities of this Center are limited by government rules and regulations regarding public procurement. For example TIAC was to purchase of computers which was delayed by such rules and regulations. The purchase was further restricted by the government's limited budget. As a result the Center's computer system is capable of handling data below the level that was planned initially.

Technical information may also be accessed from the Department of Science Service library which has a good collection of journals and other printed materials on science and technology as well as information on patents but the library is not widely know due to lack of publicity and administrative personnel.

General technical information is disseminated by the Technology Transfer Center. The Center issues two newsletters. One is on rural technology transfer with 1215 subscribers. The other is on the transfer of industrial technology with 750 subscribers. The Center also provides consultations on technology acquisition to firms in every industry. In 1990 a total number of 40 firms received such assistance. The Center also acts as a match maker between overseas technology owners and domestic firms as well as government agencies concerned. In 1990, the Center provided such services to 27 firms/agencies. Out of this number, 3 were concerned with use of technology from the Federal Republic of Germany and the rest were that of the U.S. The Center also publishes Thai Technology Offers which is an annual publication on technology information whose owners are willing to exchange. The Center also produces video series on technology in both agricultural and industrial sectors. In 1990, 480 copies were produced. However due to its limited resources, the Center may need to concentrate its effort in giving assistance to a more narrow target industries.

(c) Technology Promotion and Services

Technology promotion and services are in two major forms:

1. Financial Support for R&D

Financial Support for R&D which include the following:
- Revolving fund for R&D in science and technology.
- Allocation of R&D loans by the Bank of Thailand through the IFCT.
- Company directed RD&E supported by the STDB.

1.1 The Ministry of Science, Technology and Energy

The Ministry of Science, Technology and Energy has set up a revolving fund for R&D since 1985. Between 1985-1988 an amount of 15 million baht was allocated yearly from the government budget for the fund. The amount allocated has increased to 30 million baht per year since 1989. The Technology Transfer Center is responsible for the administration of the fund for the promotion of industrial technology in the private sector in four areas as follows:

- testing techniques,
- research and development,
- improvement of production process and
- applications of R&D results leading to new production, especially the development of domestic technology. Credit support is given with the following conditions:

- loans for used for R&D, not to exceed five million baht with 4% interest rate and
- loans for the development of new production line, not exceeding 10 million baht with 6% interest rate.

Only private firms are eligible for this assistance. In the first two years, credit users have to pay only the amount of interest due, but not the capital. However the loans must be repaid within 10 years. Since only 30 million baht a year has been allocated to this program only 5-6 applicants can be provided will such support.

The Center has announced the availability of credit support through newspapers and various associations concerned. At the time of the survey, the amount of revolving fund was 105 million baht. Interest received is regarded as income to the fund and can be used for further lending.

So far, the administration of lending by the Center may be considered as being relatively successful. The Center has been able to use up its allocated budget for lending. In contrast, the IFCT was able to give credit of 10 million baht to only one applicant while the Center has released a total of 75.28 million baht of credit to 10 applicants. Each year the Center receives applications for credit support with total amount of about 180 million baht. Credit available for R&D is far below the level needed by the TTC's clients.

The major problem was faced by the Center in the administration of the revolving fund, insufficient fund to meet the demand. Each year about 180 million baht of loans are requested but only 30 million baht can be granted. Secondly project evaluation process is lengthy. Project proposals for credit support are evaluated by a committee whose members are from both the private and public sector. Meeting schedules are difficult to arrange. The Center itself does not have well qualified personnel to conduct project evaluation. Moreover private firms are not accustomed to writing project proposals with official language. Thirdly most applicants are small and medium firms which do not engage in R&D. Their requests are mostly for new production lines.

1.2 Loans from The Bank of Thailand

Since April 1989, the Bank of Thailand has allocated "the third long term loan" of 100 million baht to the IFCT for credit support to business firms. The IFCT began to release this credit support in 1990. So far 16 applicants have been granted such credit support.

Loans are granted with the following conditions.

- For loans which are for the development of small industries such as purchase of machinery, construction of plant and related facilities, the amount of loan should not exceed 5 million baht per project, and must be fully repaid within 6-7 years. Interest rates vary according to market rates. So far 14 applicants have been granted loans of this category totalling 18 million baht.

- For R&D loans, the maximum amount granted is not to exceed 10 million baht, with repayment period of 5 years. Interest rate is 5% per year. So far only one project has been granted such loan.

The problem facing the IFCT in granting R&D loans is how to define R&D activities. Applicants must also have R&D projects under the promotion of the BOI.

1.3 The STDB R&D Fund on Science and Technology

The Fund was set up on 22 December 1987 in cooperation with three financial institutions, i.e. Bangkok Bank, Krung Thai Bank and the IFCT with total amount of fund of 55 million baht. The main objectives are to give financial support to private firms for R&D projects in three areas : biotechnology and bioscience, material technology, and applied electronics and computer science. The amount of credit granted is not to exceed 5 million baht per project, with an interest rate equivalent to half of the interest rate on one year deposit plus 2.25 but not higher

than the interest rate on savings account. Those who are granted such support must contribute their own capital to the project not less than the amount applied for. Up to 1990, five out of 11 projects have been granted loans totalling 25 million baht.

Besides the above mentioned fund the STDB also provides free financial support to promote the development of R&D in the private sector. The fund for this program of 36 million baht was provided by USAID. The STDB has set a target of allocating such fund to 12 projects or 3 million baht for each project. Up to 1990, no project has been granted this free support.

In general, it may be said that though the STDB's supporting activities are directed towards private firms, but these firms are normally capable of supporting themselves. Small and medium firms rarely have access to the STDB's support. This is due to the fact that for any project to be granted financial support, a full collateral is normally required by the two commercial banks and the IFCT.

2. Technical Services

Technical assistance provided by the government is in several forms which include the following:

- training,
- direct technical services at plant level,
- testing services and so on.

The Industrial Development Support (IDS) of the STDB consists of the following activities (1) Standard, Testing and Quality Control (STQC). The STQC unit is responsible for organizing training courses in order to disseminate knowledge on production standard, testing and quality control. (2) Diagnostic/Research Design Service (D/RDS). D/RDS provides services in soling technical problems at plant level by providing specialist consultation. The services

provided also include research designs for problem solving which is often required by small and medium enterprises. However, the promotion of industrial technology through the STDB's IDS is restricted in its activities due to limited budget. Only 12-15% of the STDB's total budget is allocated to the program while R&D program receives nearly 70% of the total budget. Moreover by the time the D/RDS started to take of, the U.S. government withdraw funding support and the program has to rely only on government budget secured from the Ministry of Finance. Its activities are also limited by lack of qualified and experienced experts in providing technical assistance at plant level Salaries/or honoraria received by these experts are relatively low due to limited budget.

STDB's dependence on financial support from other countries has also resulted in more complex and tedious process of double approval, i.e. approval has to be given from both the USAID and the DTEC. For example the STQC, has to subject to the restrictive condition that machinery and equipment used are to be imported from the U.S. and have to be transported by U.S. airlines. In certain cases, appropriate machinery and equipment are produced in countries other than the U.S.. More importantly financial support from a foreign country may be withdrawn for political reasons but this in turn has long run effect of destroying the image and creditability of the government agency concerned. It also has negative impact on working morale of the public employees.

A study carried out by the Department of Industrial Promotion in which 238 small and medium firms in textile and plastic industries were interviewed revealed that agencies responsible for industry-specific services such as the Textile Industries Division, is more widely known than agencies that give general assistance such as Thailand Management Development and Productivity Center, Department of Industrial Promotion. The study also suggested that most producers interviewed relied on services provided by raw material and machinery suppliers more than on government agencies. Those producers believed that dealing with government agencies may cost them in terms of tax expenditure. These

producers were also found to seek minimal assistance from educational institutions and none ever used the services of the Thailand Institute of Scientific and Technological Research.

From our own study, it may be concluded that government agencies are met with the problem official regulations which do not facilitate technology generation and services. Expansion of support and services is also restricted by limited budget. Government agencies are not allowed to retrain and accumulate donated funds to be used for future assistance. For example the operation of the Metal-working and Machinery Industries Development Institute is restricted by a government regulation that income received from sales of obsolete or donated machinery has to be returned to the Ministry of Finance and cannot be used to buy new machinery. Any amount of net income incurred from organizing seminars/training courses must also be sent to the Ministry of Finance and cannot be used to purchase office equipment.

Moreover, government agencies concerned have to compete with private firms for qualified personnel. Lower income offered by the government sector is an obstacle in recruiting and retaining high quality personnel.

2.2.4 Technology Promotion in the Private Sector

Up to 1991, the Technological Promotion Association (Thai-Japan) has been the only active non government organization in the promotion of technology. Other associations such as the Thai Textile Industry Association, the Thai Plastics Industry Association are not engaged in providing technology services as most of their members do not see the importance of such activities. In 1991 a new phenomenon has appeared, i.e. the establishment of the Foundation for the Development of Metal-working and Machinery Industries to promote the working of the Metal-working and Machinery Development Institute (MIDI). However the Foundation is only in its first year of operation. In this paper only the Technological Promotion Association (Thai-Japan) will be mentioned.

The Association's activities are concentrated on providing short training courses of 1-3 days, and not longer than 7 days. Training fees are approximately 800 baht for one day courses and between 1,000-1,100 baht for two day courses. Since 1973, 125,832 of such courses have been organized. Details of the Association's activities are presented in Table 2.10 below. Most training courses organized by the Association are for general application to all industries and not specific for some industries only.

The Association receives financial support from Japan's Ministry of International Trade and Industry (MITI), which at present accounts for 40% of its operation budget. Income received from training courses accounts for the rest. Financial assistance from Japan is free donation with no strings attached. One fifth of the donation is contributed by the Japanese private sector.

So far the Association has not received any contribution from the Thai government nor from any private firm in Thailand. The reason is that donations to the association are not tax-deductable. As for linkage with the government the Association once organized a training course for Thai government agencies but did not receive training fees until 6 months later.

The Association has been requested to organize special training courses for some private firms. So far such requests have not yet been met due to its limited resource persons. The Association still have to rely on external lecturers/trainers for its training courses. These lecturers normally regard their teaching as a charity rather than commercial enterprise. At present the Association pays 500 baht per one hour session while the government rate is only 200 baht and about rate of 1,200 baht for MBA course.

The Association has a plan of setting up a center for technology training to develop specific labor skill for technical schools graduates. This should partially help in solving the problem of insufficient engineers. The courses take three months with practical exercises. A large number of firms have shown interest in this project.

Table 2.10 : Activities of Technological Promotion Association (Thai-Japan)

Year	Project	No.of courses	No.of trainees
1973-1990	Journals	115	-
1973-1990	Research	159	-
1973-1990	Language	1,157	35,738
1973-1990	Seminar	462	22,940
1977-1990	Industrial measuring equipment and tools	402	14,619
1981-1990	Energy technology	193	8,847
1983-1990	Q.C.	183	14,047
1987-1990	Technology Information center	19	1,624 USERS=19,483
1987-1990	Computer	185	5,259
1989-1990	Correspondance	8	2,473
1989-1990	Effective maintenance	40	2,426
	Total	2,923	125,832

Source : Technological Promotion Association (Thai-Japan)

The Center will be set up with a donation of 200 million baht for building construction and equipment installation from the Japanese government. It is expected that training fees will cover about 80% of the Center's operating costs.

The difference between the current operation of the Association and the proposed activities of the Center is that courses organized by the Association are short (3-4 days) with the objective of stimulating trainees to further acquire more knowledge. The Center however, will be responsible for longer training courses with emphasis on practical application of knowledge. At present the Association can not organize longer courses (3-4 months) due to its limited resources, both in term of personnel and equipment. The Center may be extended to become a college of technology and eventually an institute of technology if its operations are successful.

Since the association is a meeting place for people of the similar professions, extension of courses to cover longer time will not only mean an opportunity for technology human resources to continue develop themselves but also a good opportunity for engineers and technicians to meet in the long run. This may lead to the setting up of other professional associations or clubs in the future.

2.3 SCIENCE AND TECHNOLOGY MANPOWER PRODUCTION

A survey of bachelor's degree graduates in engineering from government universities (Table 2.11) reveals that in 1988 the number of engineering graduates was 3,244 while the number demanded by the industrial sector in the same year was 4,730 (TDRI 1989). In some important fields such as metal science, only 73 graduates were produced during the past 10 years. Lack of manpower in some scientific areas is an important obstacle to the acquisition and development of technology at present.

Table 2.11 : Number of bachelor degree graduate (Ministry of University affairs)

unit : person

Field	Area of specialization	78/79	79/80	80/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88
1. Science	Biology	161	216	232	281	168	226	239	272	277	305
	Biochemistry	26	15	16	16	15	14	20	14	16	18
	Chemistry	297	316	379	314	222	345	395	375	408	425
	Physics	113	110	119	109	61	128	137	160	161	139
	Physical Science	54	68	126	136	483	101	69	65	120	131
	Geology	36	45	40	52	56	48	38	43	66	46
	Marine Science	3	15	20	12	10	16	12	4	3	3
	Materials Science	23	26	26	27	36	30	35	31	53	48
	Mathematics	95	148	132	177	78	238	238	197	218	228
	Statistics	198	176	261	289	171	199	239	256	314	438
	Computer Science	36	33	49	43	25	29	49	65	69	57
Sub total		1042	1168	1402	1456	1324	1376	1471	1482	1705	1838
2. Engineering	Agricultural Engineering	19	26	29	45	50	26	48	46	59	91
	Chemical Engineering	105	85	103	90	112	114	111	178	215	237
	Civil Engineering	318	403	444	538	531	553	637	629	689	706
	Computer Engineering	42	16	15	17	19	20	82	36	106	65
	Electrical Engineering	374	366	448	468	643	618	659	752	1026	828
	Industrial Engineering	113	124	315	319	278	283	365	363	375	355
	Mechanical Engineering	273	260	331	396	431	428	437	500	479	510
	Metallurgical Engineering	6	8	4	3	4	7	9	10	5	17
	Mining Engineering	19	16	9	6	14	18	22	38	31	30
	Production Technology	94	103	124	174	237	239	253	308	367	377
	Sanitary Engineering	16	16	24	17	17	16	19	34	39	28
Sub total		1379	1423	1846	2073	2336	2322	2642	2894	3391	3244
3. Agriculture	Farm Mechanics	7	10	0	0	0	2	0	1	0	90
	Plant Science	276	291	174	253	244	279	364	554	430	397
	Soil Science	21	28	5	10	7	4	35	56	25	27
	Animal Science	200	208	264	304	236	196	286	394	337	342
	Fisheries	39	34	51	57	86	79	79	107	111	127
	Forestry	58	64	90	93	105	107	122	127	130	118
	Food Science and Technology	67	83	83	105	88	125	140	185	205	287
	Agricultural Product	43	104	121	149	88	149	245	290	277	308
	General Agriculture	37	147	544	429	544	229	430	172	491	474
Sub total		748	969	1332	1400	1398	1172	1701	1886	2006	2170
Total		3169	3560	4580	4929	5058	4870	5814	6262	7102	7252

Note : 1.1 including Botany and Zoology 2.3 including Irrigation Engineering 3.2 including Entomology and Plant Pathology
Source : The Demand Forecast and Direction of S&T Manpower Development, Chula Unisearch, Chulalongkorn University, September 1990 p.41

Table 2.12 Number of graduates from government institutes of tertiary education
(under the Ministry of University Affairs, Raj Mongkol Institute of Technology and Department of Vocational Education)

unit : person

Major Fields	Areas of specialization	78/79		79/80		80/81		81/82		82/83		83/84		84/85		85/86		86/87		87/88	
		P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH	P-V-S*	P-V-CH
1. Science	1.1 Biology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.2 Biochemistry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.3 Chemistry	32	38	45	39	41	12	35	12	31	23	39	23	39	19	41	30	45	32	43	24
	1.4 Physics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.5 Physical Science	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	1.6 Geology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.7 Marine Science	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.8 Materials Science	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.9 Mathematics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.10 Statistics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.11 Computer Science	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub total		32	38	45	39	41	12	35	12	34	23	39	23	39	19	41	30	45	32	43	24
2. Engineering	2.1 Agricultural Engineering	39	50	41	122	47	24	98	90	91	21	111	104	96	119	160	110	143	118	211	165
	2.2 Chemical Engineering	47	0	68	0	59	17	58	22	67	43	119	64	109	39	131	43	125	48	74	39
	2.3 Civil Engineering	1589	4123	1718	3399	1488	3382	1747	3898	2115	4016	2904	5848	2717	3906	6378	6878	4475	6831	4080	6543
	2.4 Computer Engineering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0
	2.5 Electrical Engineering	1589	4042	1591	3705	1715	3440	2005	4843	2326	5506	3613	8014	3629	6162	6755	12869	6904	15101	6979	16158
	2.6 Industrial Engineering	20	0	25	0	25	0	71	19	82	23	50	27	29	25	49	15	40	21	34	22
	2.7 Mechanical Engineering	2216	7878	2437	5607	2104	4706	2877	5803	3180	5947	3496	8392	3382	6195	6689	12781	5488	14364	5344	14849
	2.8 Metal Engineering	698	2009	748	2323	1031	1951	1018	2379	1205	2661	1337	3522	1340	2589	1287	3008	1100	3148	1078	3039
	2.9 Mining Engineering	0	0	0	0	0	0	0	0	0	0	30	0	0	0	41	0	20	0	24	0
	2.10 Production Technology	258	140	221	8841	617	10987	433	10074	1027	12144	1995	24991	3668	18585	1758	173	1790	122	1526	187
	2.11 Sanitary Engineering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub total		6448	18242	6839	21997	7067	24578	8305	26528	10093	30388	13855	50982	14968	37600	23131	35677	20085	39753	19398	40974
3. Agriculture	3.1 Farm Mechanics	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3.2 Plant Science	0	0	0	100	23	214	24	84	213	80	178	0	193	0	775	0	821	0	569	0
	3.3 Soil Science	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3.4 Animal Science	0	0	1	97	14	137	18	73	51	68	0	0	0	0	21	0	141	0	91	0
	3.5 Fisheries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	180	0	191	0	140	0
	3.6 Forestry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	3.7 Food Science and Biotechnology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	56	0	74	0
	3.8 Agricultural Production	93	0	163	0	0	0	0	0	15	0	2	0	0	0	379	0	456	0	368	0
	3.9 General Agriculture	1072	3130	1592	5746	1992	5251	2268	11179	3378	8654	7615	11130	9418	7452	9158	7820	8099	6718	4573	4576
Sub total		1165	3130	1756	5943	2029	5602	2314	11338	3657	8794	7795	11130	9609	7452	10545	7820	7784	6718	5779	4576
Total		7645	21410	8640	27979	9157	30192	10654	37874	13784	39177	21489	62115	24616	45071	33717	43527	27894	46581	25220	45574
Grand Total			29055		36619		39349		48528		52961		83604		69687		77244		74395		70794

Note : * including P-V-S, Diploma Progress and P-V-T Level (Graduate the first in 1987)

Source : The Demand Forecast and Direction of S&T Manpower Development, Chula Unisearch, Chulalongkorn University, September 1990 p.42

For the production of manpower in science and technology at technical college level, Table 2.12 reveals that in 1988 there were only 24 graduates in science 40,974 graduates in engineering and 4,576 graduates in agriculture. The lack of manpower with qualifications bachelors' degrees is specific to only some fields of studies such as casting electroplating and welding. Even though the number of technical school gradates is relatively high, but their quality is regarded as not very acceptable by most enterprises interviewed. They are seen as having only general knowledge with insufficient technical knowledge for practical use.

The problem of lack of qualified technology graduates is well known and widely accepted. Due to the fact that educational services do not earn high rate of returns, other incentive or promoting measures have to be introduced. Although education services may receive support from the BOI, but educational services provided by a foundation or an association are exempted from the BOI to support. Moreover imports of tools and equipment for educational purposes are exempted from import duties only if the countries of origin.

2.4 CONCLUSIONS

It may be concluded that technology in Thailand is supplied mainly from abroad. Acquisition through the development of domestic technical know-how is still limited. In the private sector, firms prefer to rely on imported technology which has been commercially proven. Moreover the structure of most Thai firms is such that they are not capable of creating or developing their own technology. The Thai patent system does not seem to generate sufficient incentive for local enterprises to invest in R&D. Government's activities in technology promotion are restricted by a number of limitations herent in the organization of general government. Technology promotion through NGOs which is the approach successfully used in Japan is still not widely know in Thailand and in spite of the success of the Technological Promotion Association (Thai-Japan). At present what is immediately needed in Thailand is the creation of technology manpower necessary for the acquisition and development of technology in the future.

CHAPTER 3: THE AUTOMOBILE, METAL-WORKING AND MACHINERY INDUSTRIES

Although the automobile, Metal-working and machinery industries (MMMI) is considered big when compared with other Thai industries, technological capabilities of Thai entrepreneurs have progressed very little. Thai entrepreneurs lack design capability for motor vehicle, machines and parts thereof. Meanwhile, the manufacturing capability for metallurgical products is still limited, due to two main factors: demand and supply. In terms of demand, the motor vehicle industry which is considered as the main industry is in the hands of Japanese joint-venture companies, so most of the high-value and necessary parts. In terms of supply, the technology diffusion has slowly diffused while the industrial attitudes of local entrepreneur are another significant obstacles in accumulating the technological capability. Therefore, Thai entrepreneurs still lack the capability and experiences in manufacturing processes, especially in designing.

However, after the change on foreign exchange in the East ASEAN countries and the increasing labor wages in Japan, Taiwan and Korea, the needs for Metal-working products from Thailand arise. Meanwhile, such needs in Thailand itself are also rapidly increasing. Currently, Thailand can manufacture 300,000 automobiles and 700,000 motorcycles a year. The trends on substituting machines for human labors in the agriculture sector and the expansions of manufacturing sector, bring about a good change for a continuing expansion of these industries.

3.1 INDUSTRIAL DEVELOPMENT

The development of automobile, Metal-working and machinery industries can be divided into four periods: 1960-1970, 1971-1980, 1981-1984, and 1985-1990.

During the period of 1960s, the industry clearly grew up along the rapid increase of the country's infrastructure, especially roads throughout the country. However, at that time, the industry was in the stage of the initial development, so all supplies for machinery and machine tool were totally imported. Meanwhile, the manufacturing of all Metal-working parts still lacked the proper manufacturing procedure, which caused the under standard and low quality outputs. Mostly, the entrepreneurs copied all genuine spare parts without the engineering base knowledge.

Then, in 1971-1980, the industry had more development when the manufacturing of the simple machine tools like lathes drilling machines, and stamping machines for local use took place. Meanwhile, production machines for other specific industries were manufactured and then adapted for local uses such as husking machine. By the way, when compared with the imported ones, Thai machines were still left behind in the technological aspects. The automobile manufacturing industry had a huge growth rate, which led to the establishment of the multi-national firms and joint-venture companies. It was because there was an imposition of the local content for commercial cars in 1972. The Metal-working industry also grew up enormously and many firms were founded for manufacturing metal components like casted and forged parts, mold making, and sheet Metal-working to supply the electrical and electronics industry and the automobile industry.

However, during the period of 1981-1984, owing to the increasing of local contents and the ban on imported cars, the manufacturing of supporting systems for automobiles increased significantly. These were be example, exhaust system, brake system, fuel system, absorbing system, under bonnet parts and interior trims. During this period entrepreneurs in Thailand not only improved in volume but also quality especially Metal-working parts such as casted, machined and pressed parts. Meanwhile, the machinery industry stayed still. The entrepreneurs of the machine tools turned to manufacture parts for the automobile industry and for the general industrial factories like sugar factories, rice factories, garment factories and paper factories. The companies that had initiated the production

machinery for specific industries stopped their development. They turned to manufacture the equipment for factory transportation such as belts and conveyor cranes, and offered services for installation of the imported equipment while manufacturing the made-to-order machines for specific purposes.

In 1985-1990, the Thai Government encouraged export promotion by providing the low-interest loan, easing the local content requirement, compensating taxes for locally manufactured parts, decreasing the guarantee money for exporting cars, and prohibiting imported cars. This subsequently created more demands on automobiles, which encouraged the manufacturing of automobile parts and components in Thailand. As a result, locally manufactured parts and components nearly covered all the necessary parts for car assembly, especially for a one-ton pick-up truck. However, the manufacturing of machine tools was increasingly adversed. The main reason was that the standard of the tools made in Thailand was rather low compared with the manufacturing level and structure moving towards higher quality products. Even though some Thai firms could export machine tools like lathes and drilling machines, they were technologically simple. This also held true for the entrepreneurs of production machines. Besides, the metallurgical industry could rapidly expand the capability in manufacturing and improve the quality of the products such as press and sheet metal work of auto body, iron casting for auto machine, and precise iron machining, which enabled the entrepreneurs to export their products.

3.2 TECHNOLOGY STATUS

According to the firm survey, expert interview and literature survey, the industry's technological profile can be examined through its design capability include design technology and product specific technology and manufacturing capability (process technology and production-management technology) as follows:

3.2.1 Design Capability

(a) Design Technology

Design technology is the basic technology needed in the process of translating ideas, product specifications, formulas, etc. into prototypes. Usually, closely related products have indifferent design technologies. For example, in designing any parts of machinery and automobile, the designers must have the knowledge of metal forming precision measuring, prime moving and power transmission technologies. In addition, knowledge on designing equipment and tools such as CAD/CAM is also very useful. However, to design a product, a designer must also have the specific knowledge on such a product so that he/she can know the specific condition on product design.

(b) Product-specific Technology

Product-specific technology is the principle and specific technology of a particular product, which assigns the duty of parts and other components for harmonious and efficient work. If such a product lacks this technology, it cannot be called as such a product. For example, automobile necessarily rely on engine and power transmission technologies while the engine itself needs internal confusion technology and power transmission require technology concerning gear and rotary. However, in any change and development of a product, a designer must possess a knowledge on design technology, so that he/she knows the conditions and limitations of such a design.

3.2.2 Manufacturing Capability

(a) Process Technology

Process technology means technology enables the parts and components of a prototype to be commercially manufactured and then assembled into a ready-to-use product as initially designed. The important process technologies in the automobile, Metal-working and machinery

industries technologies concerning various metal work such as is the various technologies concerning Metal-working such as casting, forging, machining, plating, welding, pressing and so on. The difference in those principle process technologies lie in the aspects of precision and complexity. For example, casting technology for engine blocks needs process technology differently from that of machine tool beds.

(b) Production-management Technology

Production-management technology means engineering and production-management technology that facilitate and support process technology to achieve high productivity and product quality in the production line. They are, largely related to quality control, time-saving, maintenance, and work flow management. These technologies are, for instance JIT, MRP II, TQC, TPM, and SPC.

3.2.3 The Metal-working Industry

The Metal-working industry is the mere industry in which Thai entrepreneurs do have some capability is compared with its machinery and automotive counterparts. However, the number of such entrepreneur is very few. Most of Thai entrepreneurs are subcontractors producing metal parts for other industries.

(a) Design Capability

Thai entrepreneurs design capability is very low. Usually, the contractors are responsible for all designs work by providing blue prints or products themselves, as well as assigning the metal and mechanical characteristics of some parts. Although some of them are capable to design molds and dies, the outputs are still unsatisfactory, except a few of them receiving technology from abroad or being a joint-venture. Furthermore, Thai firms often rely on ready-made molds and dies for reproduction.

There are many reasons why Thai entrepreneurs have low design capability (knowledge in design technology and in specific products). Firstly, Thai entrepreneurs are largely subcontractors manufacturing metal parts that need not learn and utilize any technology in design (e.g. knowledge about materials, metallurgical technology and computer technology). Therefore, they just produce parts repeatedly without accumulating technology for specific products. This includes metallurgical, physical, and mechanical knowledge concerning the important conditions for product design. There are very few entrepreneurs that can design delicate and complicated molds for producing metal works.

(b) Manufacturing Capability

Though entrepreneurs in the Metal-working industry tend to possess low level of design capability, they nevertheless have better manufacturing capability than the automotive and machinery industries. Still, the majority of Thai firms lack the capability to manufacture metal parts for the automotive and electronics industries, particularly high precision (of less than 10 micron accuracy), high quality surface finish (of less than 5 micrometer) and parts with high physical and mechanical properties needed for examples for automotive engines and transmission systems, as well as cutting tools. Generally, these Thai firms are however capable of making a range of general metal works and at the same time continue to improve their product quality. A case in point is the Thai automotive and in particular the pick-up truck industry which currently has a local content in metal parts exceeding the level required of.

Although Thai entrepreneurs have a better manufacturing capability compared to design one, it tends to be limited for process technology only. Although Thai entrepreneurs have developed and improved process technology in casting, machining and pressing, they still lacks production-management technology that brings about cost reduction, quality assurance, and fast delivery.

The manufacturing capability according to process technologies can be divided into seven groups as follows:

(1) Casting

Casting can be divided into two groups: gravity casting and pressure casting. Gravity casting factories are largely small and use traditional furnaces and natural sands. Quality is controlled by eye-sight. Product specification is orally defined and accepted. It was found that among the 70 surveyed factories, most of them (42 firms) have defects at 6% up. These are related to blow holes, pinholes, dropping sands and the inconsistent quality of the product. (Unisearch 1990).

However, there are a few big casting factories and being able to manufacture high quality products induction furnaces using. They also have measurement tools to check the molecular structure of metal. The highly efficient casting factory surveyed by the researchers is able to produce outputs at five tons per head per month. The defect rate is also below 4%. It also has college-graduate engineers to design its own metal parts. Meanwhile, there are another 15 casting factories that manufacture parts of compressors and motors. Such factories can create their own design and manufacture a made-to-order product. Their defect rate is at 6% (Unisearch 1990).

For pressure casting, the expansion trends depend on aluminium die casting which is the casting work relating to the motor vehicle, the electric appliance and electronic industries. This group possesses higher capability compared with that of the former casting group, since the higher industrial standard is required.

(2) Pressing

This group has long been existing. During the past 15 years, there has been a development in technology in two aspects: safety for workers and mold technology. While stamping and drawing still need import molds, stamping itself has been developed during the past couple of years due to the rapid growth of the motor vehicle, electric appliance, and electronic industries. In addition, a number of Thai entrepreneurs have begun investment in progressive die pressing.

(3) Forging

The forging work has rooted in Thailand for 20 years. According to the JICA's survey in 1984 (Unisearch 1990), there were 14 forging factories which were manufacturing knots, screws, and parts of agricultural machines as well as auto parts. At present, 30 forging factories have the annual gross production at 6,000 tons. Most of them still use drop hammer. The forging work load is not exceeding 3 kilogram per piece. In this respect, they cannot produce large metal items such as crankshaft (Siwa 1990), due to the lack of machinery molds, and mold-designing skills. Also, there are very few forging factories using mechanical and hydraulic press machines.

(4) Welding

When compared with other metal forming equipment, welding equipment are not costly. Thus, most of the entrepreneurs are able to get access to modern equipment. However, although there are a number of welders who are trained by the National Institute for Skill Development and gained experiences overseas, they still lack knowledge concerning welding theory which is not available in educational institution (Siwa 1990). In addition, Thailand still encounters shortages in skilled labor and engineers who are knowledgeable in welding engineering. This clearly prevents from being contracted for large projects such as suspending bridges and gas pipes.

(5) Machining

The core of machining work is the fundamental understanding of design specific. As a matter of fact that most Thai entrepreneurs are largely job-shop business constitute a large number of skillful and handy workers, their knowledge on reading design and cutting tools such as ceramic and diamond-head cutting tools which are more efficient than steel and carbide cutting tools. Furthermore, there are only a few factories that manufacture products with high precision (less than 10 micron) in a mass production manner. Instead they have started using flexible machinery and equipment for small-batch manufacturing.

(6) Heat Treatment

Heat treatment Technology has not been widely developed because of lack of demands in the local market. Owing to the lack of technical know-how the manufacturing just use the primitive method of heat treatment. Thus, the products tend to be not long lasting and does not under standard. Only few entrepreneurs which can produce high quality heat treatment products tend to limit to in-house production such as Mahajak Co., Ltd. and Thai Roller Chain Co., Ltd.

(7) Plating

The electrical plating is usually the last process of Metal-working. This kind of work has been expanding for the last five years. Even though this industry is small (the total sales not over 500 million baht), the expansion rate is at 10-15% per annum and the export trend has gradually increased (Chula Unisearch 1990). Most of the plating work includes zinc and chromium plating, copper/nickel-chromium plating for the spare-parts market rank second. However, the entrepreneurs producing their own parts tend to use a new method so called nickel/nickel-chromium for their own use.

In conclusion, according to the status of the Metal-working industry based on the current process, the technological capability among Thai firms can be classified respectively as follows: pressing, casting, machining, mold and die making, forging, and heat treatment.

3.2.4 The Machinery Industry

Although the machinery industry, including production machinery, machine tools and molds and dies, are important for the nation development, the technological capability of Thai entrepreneurs is still low. They lack both lack design and manufacturing capability, except a few products which are not complicated and precise.

(a) Design Capability

It can be said that Thai entrepreneurs lack all design capabilities (design and product-specific technologies) for machine tools. Reasons are twofold: firstly, they lack basic knowledge on Metal-working which necessitates for product imitation of foreign machine tools. Secondly, they miss the opportunities to accumulate their technological capability based upon simple machine tools since the demand for machine tools increasingly focus on high quality machine tools to match with the manufacturing structure for export and high quality products.

However, local entrepreneurs do have some design capability for some production machinery such as rice-milling, cotton-spinning, and plastic-blowing machines. They tend to be used for specific purposes and their technology is not too complicated but required to adjust to the local raw materials. That is why the Thai entrepreneurs can command some design and product-specific technologies. With regard to cotton-spinning and plastic-blowing machine, the local firms can accumulate and develop their own capability to design the machines because of there being a large production base in Thailand which requires a constant maintenance and adaptation to meet local condition.

In general, Thai firms lack design technology on molds and dies. The entrepreneurs tend to have knowledge on physical design only, not including chemical, heat, and mechanical characteristics. However, in general, they are able to design molds and dies which do not need precision and complexity such as sand molds, plastic molds, pressing dies, and casting dies.

(b) Manufacturing Capability

Thai entrepreneurs not only have no design capability on machine tools and have little design capability on production machinery, but also manufacturing capability. Thai entrepreneurs have process technology only for very simple machine tools only such as conventional lathes and boring and drilling machines which require over 100 microns. Others machine tools that requires higher accuracy (for example, less than 10 microns) cannot be manufactured yet. However, they do have some manufacturing capability for machine tool parts such as machine bed, gears and shafts. Although Thai firms' capability on molds and dies manufacturing has been gradually improved, the development rate is still not satisfactory, except a few joint-ventures or firms acquire know-how from aboard.

In addition process technology, local entrepreneurs lack knowledge in production-management technology too. This is because the production of machine tools, production machinery and molds in Thailand still depend on craftsmanship made to order. Thus, they have never realized the importance of such a technology.

The manufacturing capability for these industries can be classified as follows:

(1) Machine Tools

There are 24 machine tool entrepreneurs in Thailand: press entrepreneurs, 14; grinding, 3; lathing, 2; milling, 2; and shaping tool, 1. Most of them are small with capital investment at about five million baht and sales around 15 million baht. They also do not have testing and measuring equipment and tools for tensile strength, roughness, and so on.

(2) Production Machinery

The manufacturing of production machinery grows very slowly during the past 30 decades. Most of Thai firms grew up from the part entrepreneurs (the repairing workshop for textile, food, and cement factories). The machines used comprised simple machine tools, accurate at around 100 microns. The reverse engineering and made-to-order system has been the made of production so far. Furthermore, the number of entrepreneurs is decreasing since they turned to manufacture parts and components for the motor vehicle industry, instead. At present, there are only six factories that constantly manufacture production machinery for rice-milling, plastic-blowing, and cotton-spinning machines. The others only concentrate on the manufacturing of parts and components for sugar factories, cement factories, and paper factories, for instance.

(3) Agricultural Machinery

Most of the entrepreneurs are Thai who start their production by imitating products form Mainland China and Taiwan in combination with their own knowledge on welding and machining. Thus, they tend to rely on skills, rather than knowledge. For example, they design power transmission without taking into account strength and tensile. This made the products worn out quickly (ibid. Siwa). Also, the entrepreneurs tend to minimize cost, by using substituted materials. Owing to the low, condition, for example, they tend to product gear blocks by using steel sheets rather than casted steel produce gear shafts

by using casting rather than forging process. It can be said that they lack knowledge metal property for specific uses. In addition there are a few standard parts in agricultured machinery parts. Since the entreprenurs independently produce their own parts caused by the small size of the business and the monopolized market.

(4) Molds and Dies

Mold and die making in Thailand can be generally stamping dies, injection molds, and casting dies.

The entrepreneurs are also classified into two groups: those who are general vendors and those who produce for themselves. The number of the entrepreneurs of dies for metal works is smaller than that of injection molds. Most of the entrepreneurs still use simple machine tools for mold and die making while new foreign investors and joint-ventures start using better machinery and equipment such as EDM, wire-cut EDM, digital read-out grinding, copy milling, and CNC milling. However, the designers are still Japanese experts. Only few of them are capable of manufacturing progressive dies. Table 3.1 has concluded the level of technology used in the mold and die industry.

3.2.5 The Motor Vehicle Industry

The motor vehicle industry is the biggest among the three industries: the motor vehicle, Metal-working, and machinery, industries. It is also the upstream industry of other industries, especially the Metal-working industry. However, most of the entrepreneurs are Japanese and their joint-ventures. Thai firms are largely capable of manufacturing parts and components.

Table 3.1 : The Characteristics of Mold and Die Factories in Thailand

Level 1	Level 2	Level 3	Note
- No mold design	- Mold design by manual drawing	- Mold design by professional designers and drawers	
- No selection on proper raw materials	- Some selection on raw materials	- Careful selection on raw materials	
- Surface smoothening by turning and shaping machines	- Surface smoothening by turning shaping, and grinding machines	- Surface smoothening by turning, shaping, milling, and grinding machines	
- Drilling by simple drilling machines	- Drilling by radial drilling machines	- Drilling by radial drilling machines	- Profile grinders are needed for some parts, but never be used yet
- Forming by turning machines and carving by wedges	- Forming by turning, milling and hydraulic copy milling machines	- Forming by turning, milling, copy milling machine and EDMs and wire cut EDMs	
- Checking quality by caliper, vernier and physical part comparison	- Checking quality by vernier, micrometer, and height gauge	- Checking quality by micrometer, height gauge, magnetic stand gauge block	
- No heat treatment and hardchrome processes	- Heat treatment and hardchrome processes in main parts	- Heat treatment and hardchrome processes	
- Scrubbing by sandpapers	- Scrubbing by sandpapers or scrubbing machines	- Scrubbing by sandpapers, chemicals, scrubbing machines, and stone scrubs	

Source : Adapted from the Report on the Status of Mold Industry in Thailand by The Metal-working and Machinery Industrial Development Institute (1987)

(a) Design Capability

Thai firms have very little design capability on motor vehicles. The car assembly factories in Thailand virtually depend on CKD parts from mother companies abroad. Thai firms start accumulating design capability on peripheral parts such as radiators, exhaust pipes, and autobodies. Most of them still copy designs form overseas. There are only two Thai firms that can design the additional body parts of the one-ton pick-up trucks.

The main reason is that the dearth of basic knowledge in metallurgy as well as product-specific technology among Thai firms. In addition, this industry requires a huge amount of investment and the economy of scale. Thus Thai firms tend to concentrate on manufacturing of parts and components.

(b) Manufacturing Capability

Even though the motor vehicle industry is a very large industry, Thai firms still lack design and product-specific technologies and command weak process particularly production management technologies. Thus, the overall manufacturing capability of Thai firms in this industry is quite low, except some Metal-working technology. So far, there has been only one Thai manufacture that can assemble trucks. However, it just puts all parts together without any design activities. Some parts and components can be manufactured locally are, for instance, exhaust system, brake system, under bonet press parts and body suspension system. Parts have not yet been manufactured locally are those moving parts, precision parts, high tensile and heat resistant parts.

Manufacturing capability of Thai entrepreneurs can be classified as follows:

(1) Motor Vehicle Assembly

There are 12 Thai firms for this type: eight are Japanese-Thai joint-ventures, three are European-Thai joint-ventures and one Thai owned firm. Thai owned firm, constituting production capacity below 2% of the total output, still uses manual handling process, not conveyor system. Welding is still using jigs designed for temporally uses, not well-designed ones. Painting is also typical, not EDP system. The quality control and testing are relied on human-eyes, not computerized system. Besides, Thai firms are also constrainted by the unavailability of critical parts such as engines which there are only four entrepreneurs (for their own use) and are not allowed to be imported. Moreover, due to the lack of knowledge on design, Thai firms have been in a disadvantageous position. Neither can universities nor government institution alleviate, because they do not have enough practices and experiences.

(2) Automotive Components

The automotive component industry can be divided by technology level into three levels (Ninnart 1990). The first group includes about 200 firms, which use a lot of manual labors and low production technologies. They largely produce fake and imitative spare parts for the spare part market. They just can copy the outlook of the products without knowledge on product specification and underlying technology. Besides, they do not use proper and appropriate process. For instance, they tend to use casting instead of forging process for connecting rods. The second group includes about 100 firms which have technical assistance from abroad. In general, they have some experiences in manufacturing process and are able to manufacture OEM products. They are largely qualified by automotive assemblers (but the in manufacturing efficiency is still lower than that from abroad.) (Alongkot 1990). The third group includes joint-venture firms that are affiliated from foreign car entrepreneurs. They possess high technological capability and use modern machinery and equipment.

At present, the components manufactured in Thailand are largely basic parts such as brake drum or other simple parts such as exhaust manifold and clutch housing parts for the OEM market which do not require high precision are also manufactured locally. Other critical components which have not get manufactured in Thailand, for instance transmission gear, camshaft, and crankshaft.

In conclusion, most of the problems in the motor vehicle, Metal-working, and machinery industries are the problems of small firms. The transfer of technology within these group of firms may basic and simple technological knowledge which are widely available in the industry and taught in the higher education institution overseas are not existed in Thai firms. They, in general have little knowledge and few experiences, thereby, keeping them exclusively within the family. Even some highly educated entrepreneurs also set the system that preventing knowledge transfer. Furthermore, public universities and other organizations lack capability to transfer knowledge to the firms, especially the design capability on machinery and automotive.

The overall technology status of Thai firms can be said that they almost have no design capability. Furthermore, only a few firms have only some manufacturing capability. In conclusion, they have no design, product-specific, and production-management technologies (See Table 3.2).

3.3 TECHNOLOGY ACQUISITION

Most Thai entrepreneurs are small business owners who rely on their experiences from apprenticeship and family training. Some may rely on advice from the material or machinery vendors as well as from their own general education. As a result, systematic technology acquisition, whether in the form of machinery and equipment, production know-how, materials and components, and others, is still low. Only recently have Thai entrepreneurs begun to invest more for technology. For instance, a machining

Table 3.2 : Summary of Thai entrepreneurs' technological status

Industry and Product group	Entrepreneurs' characteristic	Level of technological capability			
		Design Technology	Product-specific Technology	Process Technology	Production Management Technology
Metal-working industry	Most Thai entrepreneurs in this field own small business. Very few of them have good technological capability. Most have only process technology such as casting, machining, and pressing, but not product-specific technology nor design technology.	Thai entrepreneurs do not have the capability in designing products and parts at all. They may be able to design the mold, but not to a good level.	Thai entrepreneurs lack this technology because mostly they have paid no attention to standard production. They thus have never accumulate product-specific technology.	Thai entrepreneurs' capability to produce metal works is good and higher than that in automobile and mechanical industries. Entrepreneurs have developed and learn more technology in casting, machining and pressing.	Thai entrepreneurs lack production management technology, such as the techniques to reduce production cost, to control quality and to plan raw material and product supply in a short time.

Table 3.2 : Summary of Thai entrepreneurs' technological status (cont.)

Industry and Product group	Entrepreneurs' characteristic	Level of technological capability			
		Design Technology	Product-specific Technology	Process Technology	Production Management Technology
Machining Industry	Most Thai entrepreneurs in this industry have low design and production capability. Most Thai production is simple and imitated from other countries, without correct knowledge of engineering process.	Thai entrepreneurs do not have mechanical design capability nor design technology at all. Their capability to design low precision machinery has just started to develop and is still very low.	Thai entrepreneurs low capability is due to lack of fundamental knowledge in metallurgy, and of experience accumulation. Chances are open to learn product-specific technology of simple machinery and machine tool, which can be adapted to emulate products.	Thai entrepreneurs's process technology is low and limited to simple machine tools such as lathe, and drilling machine. Their capability has not been much developed.	Thai entrepreneurs still lack production management technology, because the Thai production of machinery and machine tools is based on skill in producing to order.

Table 3.2 : Summary of Thai entrepreneurs' technological status (cont.)

Industry and Product group	Entrepreneurs' characteristic	Level of technological capability			
		Design Technology	Product-specific Technology	Process Technology	Production Management Technology
Automobile Industry	There is only 1 Thai entrepreneur in this industry. Others conduct business with Japanese joint-ventures. More are in part and component industry. Their technological capability is still low.	Thai entrepreneurs do not have design capability at all. Contractors provide all designs and products. Thai entrepreneurs have some emulative capability, only for moving parts such as radiator, exhaustion pipe and automobile body.	Thai entrepreneurs lack much of the product specific technology.	Thai entrepreneurs have weak process technology. They can produce only the parts which know-how can be bought from abroad and can be emulated without engineering basis.	No production management technology is applied in this industry.

factory has acquired technology through the acquisition of a small factory in Britain. Foreign experts has been employed in another casting factory to transfer the technology. Technology can also be acquired through training abroad, as happened in a die forged steel factory which has had its employees trained in Taiwan. In brief, most entrepreneurs will have more systematical technology acquisition as their business expands. For instance, when their business makes good progress, they will make contract to buy production techniques abroad.

Big entrepreneurs who realize the importance of technology find that technology acquisition by the means of buying know-how abroad may save the expenditure more than attempting to develop the technology by themselves. For instance, it is necessary to buy know-how abroad for the engine block which may need degas as or vacuum casting to prevent blow holes.

In the mechanical, automobile and Metal-working industries, technology transfer through subcontracting proceeds very slowly. The automobile part and component industry, for instance, produces parts for the automobile assembly industry (which normally is foreign, mostly Japanese, joint-ventures). Most entrepreneurs in automobile part industry acquire technology from the holding companies abroad by buying production license. Technology transfer by subcontracting is, therefore, limited mostly to the Japanese joint-ventures. Most of the Japanese joint-ventures are still either Japanese-owned or jointly invested by the Japanese especially in producing high value-added parts or the major parts of the automobile.

Normally, the Japanese company can be classified into three groups: affiliates, close associates and general vendors. The business association normally begins as a Japanese company contacts its Thai counterpart as a general vendor. Once the former is satisfied with the latter's quality, sound management and efficiency, subcontracting may be acceptable. In this process, the Japanese company expects its Thai counterpart to accept low margin with the hope for joint business profit in the long run. As a result, it is not easy for the Japanese company to transfer technology

to the Thai entrepreneurs who lack technological basis. This process, however, should be regarded as another means of technology acquisition.

3.4 THE ENTREPRENEURS'S OPINIONS ON PROBLEMS AND OBSTACLES

3.4.1 Lack of Necessary Capital for Technological Development and High Interest Rate

Most Thai entrepreneurs in motor vehicle, Metal-working, and machinery industries own small to medium-sized factories. They usually use old and inefficient machinery. Although the government has granted tax exemption for modern, expensive machinery, they still cannot afford the high interest rate.

3.4.2 Tax Structure

The present import tax structure still encourages the manufacturing which imports for CKD assembly rather than manufacturing for domestic machinery and automobile assembly. This is due to two factors. First, the import tax structure of the CKD parts is lower than: that of the raw material/intermediate parts for conversion and adaptation, and that of the raw material/parts in protected industry such as mirror and pipe. The second factor is the cascading taxes when material are adaptive in the form other than the CKD form. For instance, the tax on adaptions of local manufacturing for automobile body is as high as 44% while no tax is required for certain adaptations by the automobile assembly factory. Besides, the tax system also discourages subcontracting promotion.

3.4.3 Limited Number of Manufacturers in Supporting Industry

There is a limited number of entrepreneurs in supporting industry. Therefore, the final product entrepreneurs, especially the Thai entrepreneurs, face limitation in advancing their products because they cannot find necessary parts and components for development. This

is because the full capacity of the entrepreneurs in supporting industry has been reached due to the fact that a limited number of entrepreneurs is available. Or, there is not sufficient capability because the present capability is enough to serve the market. Two other consequences include: high production cost as resulted from lacking the process to reduce the production cost, and lack of efforts to enhance skill and to develop product-specific technology.

3.4.4 The Taxing Method of the Customs Department

In the formerly used CCCN tax system, taxing aimed to gain maximum revenue. In 1987 the tax system has been changed from the CCCN to harmonized system, which taxes according to the utilization objectives. The new system, however, is not correctly implemented. For instance, the purchase of a computer-aided manufacturing, which includes printer and plotter, should be taxed 5% since it has the objective to assist the manufacture. The Customs Department, however, regards it as a writing apparatus, the import tax of which is 35%, making the total tax burden as high as 50%. The investment on computer-aided manufacturing is thus higher than it should be.

3.4.5 Import of Used Machinery and Machine Tools

The machinery entrepreneurs face competition from the importation of cheap, used machinery, particularly from Japan, Korea and Taiwan. The entrepreneurs believe that the used machinery and machine tools have less precision and thus there should be domestic production to save foreign exchange as well as to develop the Thai entrepreneurs's capability.

3.5 PROBLEMS AND OBSTACLES IN MAJOR TECHNOLOGY ACQUISITION

The major technologies for the automobile, Metal-working and machinery industries include:

- basic metallurgical knowledge,
- Metal-working technology
- CAD/CAM computer-aided design and manufacturing technologies
- production-management technology

3.5.1 Basic Metallurgical Knowledge

The Thai entrepreneurs still lack fundamental knowledge in metallurgy such as: the knowledge in physical, mechanical and chemical property; capacity, efficiency and mixture of the metal for mechanical and general utilization; the understanding in the molecule structure and property testing and measurement; and, the mixing and changing of the property of the metal and other alloids in diverse temperature, pressure, time and mixture so as to get appropriate material for the desired application. The major obstacles in knowledge arrangement are as follows:

(a) Lack of Personnel

One of the reasons that discourage the metallurgical knowledge is that there are too few graduates in this field during the past 10 years. Academic institutions in the higher-education level can produce only 73 metallurgical engineers. Metallurgical engineering is not popular because the working condition of this industry is not comfortable. More importantly, the limited market of the Metal-working industry causes lack of demand, and relatively low salary, and thus does not motivate students to be in this field. Besides, the fundamental metal production, i.e. the mining and smelting, has not been developed since the high overhead investment prompts Thailand to export the mineral in the ore form. This, in turn, discourages the demand for knowledge in metallurgy. Furthermore, several important minerals for industry, such as iron, copper, aluminium, and nickel, do not exist in Thailand.

(b) Problems in Metallurgical Teaching in Academic Institutions and Governmental Agencies

As a matter of fact, the fundamental knowledge on material taught in high academic institutions cannot be applied in production. The university always teaches the students in terms of science, rather than technology, of metallurgy. The government agencies, on the other hand, always disperse the knowledge in metallurgical technology, in terms of theory rather than practice, to the entrepreneurs who have no fundamental knowledge in metallurgy at all. In fact, the universities and governmental agencies lack the capability and knowledge on metallurgy in industrial aspect, especially in the commercial production.

3.5.2 Metal-working Technology

Apart from lacking fundamental knowledge in metallurgy, which cripple their design capability, the Thai entrepreneurs also lack metallurgical technology. They usually do not know the technology in the production process in order to produce metal parts of desired size, shape and mechanical property. For instance, most Thai casting entrepreneurs lack knowledge on the property in the metal casting and melting process; and on the machinery and tools in the casting factory. As for the machining, most entrepreneurs lacks knowledge in the machining sequence; in the working of the machine tool; in the schedule determination; in the deviation control; and, in the design of knife and jig, etc.

The obstacles in Metal-working technology are as follows:

(a) The Demand for High-quality Goods

Traditionally, the Metal-working industry provides maintenance service mostly to customers in the agricultural-related industry, which does not require high-quality standard. As a result, modern production process has not been developed and alternative production process can be applied. The agricultural machinery industry, which accounts for

a big market, does not require high-quality goods. For instance, casting parts are always used although die forged parts may be more appropriate. Traditionally, the industries which require high-quality goods, i.e. the electrical equipment and automobile industries, account for small market. Several production is worth investing only in mass production. Private business organizations have conducted the cost/benefit feasibility study of the establishment of the factory. The result shows that it is not worth to establish a factory to produce metal parts, such as die forging through mechanical press or hydraulic press or upsetting (Alongkot, 1990). The lack of demand for high-quality goods means lack of motivation to apply high precision technology. Domestic demands for automobile and electrical equipments have just expanded during the past few years, so is the technological development in the Metal-working industry, such as in the iron and steel casting, and aluminium die casting.

(b) Knowledge, Skills and Know-how

The past studies (Siwa, 1990, TDRI 1989, Chula Unisearch 1990), as well as the survey of this research team, have shown the same conclusion on the problems of lack of knowledge, skills and know-how in Metal-working technology. Such fundamental knowledge include that: in the metal property and the molecule organization once the metal is heated and mechanically activated; in the molding design and the system of water circulation in the metal (the holes for water input, output and circulation); in how and when to anneal; in impurity to create stress relief cracking; in molding design which requires additional understanding in molding lubrication, molding cooling, and working temperature of the mold; in the value of each variation in the plating process such as the concentration and temperature of the substance, the electricity, the number of electrodes, the distance among each hanging piece; the technical knowledge of the machinery such as its stability, structure, control system, and its depreciated condition that may affect the quality of the final product.

The Metal-working technology needs high personal skill. For instance, having good equipment is not enough in welding works. Welders must be able to adjust the speed of the machine and the working sequence. Therefore, a good final product requires skillful and experienced workers. Most existing factories have highly skillful and experienced workers but they still lack fundamental knowledge in technology. On the contrary, many institutions may have knowledgeable workers with limited skill and experiences. In big factories, personnel may be knowledgeable and skillful but they lack know-how, because they have never had the chance to practice before. They also lack production-management technology to produce a great number of high-quality goods.

This, however, does not mean that Thai Metal-working industry has no knowledge, skills and experiences. On the contrary, it means that all of these three factors scarcely or do not exist in the same organization. Therefore, attempts should be made to link these three factors together as much as possible.

(c) Precision Measuring Techniques

Thai entrepreneurs still lack understanding, knowledge and skills in precision measurement to find fitness, environment measurement and maintenance and utilization of different measuring equipments and tools. The realization of quality in terms of the precision measurement in the automobile, Metal-working, and machinery industries is very important to the production and marketing. While using rough measurement techniques, most entrepreneurs do not meaasure down to the level of molecule and micron structures, which require electron, spectro, or optical microscopic inspection.

(d) Tool Design

The entrepreneurs do not like using fundamental tools such as jig to control the quality since imported jig is very expensive. They also lack skill in designing molds and dies. This results in low efficiency and quality. The obstacles in tool supply are as follows:

1. Thai entrepreneurs do not realize the importance of using jig, since they traditionally provide maintenance service which do not need to produce many high-quality products in the same time.

2. There is no information on the possibility and benefits of using the high-precision and modern tools.

(e) Attitude Toward Technology Acquisition

Since Thai entrepreneurs have less experience in manufacturing industry and are accustomed to machine-embodied technology, they do not understand the importance of the technology from accumulating experiences and know-how. Therefore, they do not want to pay for technology acquisition by importing know-how. On the contrary, they prefer trials and errors, which at the end may be more costly than buying know-how. For instance, for the high-quality heat treatment it is necessary to buy know-how and trade secrets from Japanese and Canadian producers, which is expensive in the standards of the Thai entrepreneurs who are not accustomed to buy machine-disembodied technology.

3.5.3 Computer-aided Technology

At present, computer-aided technology has played an important role in enhancing the efficiency of production. For instance, the computer-aided design (CAD) can create data bases, determine tolerance and change the design within a short time. It can also be instantly linked to the computer-aided manufacturing (CAM) without writing a new program. The present problem is that Thai entrepreneurs do not understand the actual benefit of the CAD. On the contrary, they believe that the CAD can replace employees; therefore, no skill is necessary to be applied to the CAD. As a result, the CAD is not utilized to its full capacity. The main obstacles in computer-aided manufacturing are that, firstly, the software is expensive. Secondly, since Thai medium and small firms do not have good management system, thus computer-aided technology cannot be used. For instance, computer-aided manufacturing cannot be used in the factory that imitate products without prior drawing.

3.5.4 Production-Management Technology

The objectives of the production-management technology, such as QCC, MRP II, JIT, and TPM, are: to control the quality of the products; to increase the production efficiency; and, to provide working safety, all of which will reduce the production cost and increase the working quality. Such technology face problems of technology acquisition in the same way as above. That is, the entrepreneurs do not understand the importance of the production-management technology, which is costly in terms of time, resources and efforts to correctly using it. Besides, the entrepreneurs have never had the necessity to produce a large number of products. They always assume that the technology is for maintenance only. As a result, the technology is not seriously utilized. Another obstacle is that, as a novelty, the entrepreneurs do not understand the benefit, nor want to stand other investment such as the seminar and training costs.

3.6 OPPORTUNITY AND OBSTACLES IN THE INDUSTRY DEVELOPMENT IN THE FUTURE

The study on The Identification of Key Technologies for Industrial Development Project reveals that among the automobile, Metal-working, and machinery industries, the automobile industry has the highest growth rate and growth trend, while the mechanical industry has the lowest. In the past the growth of the automobile industry, however, has been possible through the roles and policies of the Japanese companies and joint-ventures. The analysis on the opportunity and obstacles of Thai entrepreneurs in industry, in terms of marketing, technology and production, will use the automobile and Metal-working industries as analytical base. With the analysis that emphasizes on short term five year span like this, the product and technology selected for analysis will depend on market pull rather than technology push.

3.6.1 Marketing Opportunity and Obstacles

In the year 1988, 25% of the sale of the first 100 biggest companies in the world (in terms of sale figure) is that of the automobile industry, totalling US$ 593 billion (Fortune 1989). This figure is higher than that of the petroleum industry (US$ 509 billion or 22%), and that of electronic products (US$ 340 billion or 15%). International financial corporations (IFC, 1989) has assessed that the world automobile demand will increase from 49 million cars in the year 1988 to 69 million cars in the year 2000. This information not only shows the huge size of the automobile market, but also reveals the potential growth of the automobile industry. From this figure, the Thai automobile industry in the year 1988 produced only 0.15 million units or about 0.3% of the world market. When the market for automobile parts and components is considered, the Thai export is only US$ 0.08 billion, or only 0.14% of the US$57 billion in the world market in the year 1988.

As for the domestic market in the year 1988, about 6% of the sale of the first 100 biggest companies (in terms of sale figure) is also that of the automobile industry, totalling 20 billion baht. This figure is second to the 106 billion baht of the petroleum industry (30% of the total sale). After the economic recession in the year 1985, the number of automobile sale in local market increased from 78,467 cars in the year 1986 to 146,492 cars in the year 1988 and to 218,718 cars in the third quarter of the year 1989, which accounts for the 29.2% annual growth rate (Automotive Industry Association, 1990). In the total automobile sale which values at least 7 billion baht, the one ton pick-up truck has 50% of market share. Besides, the market of automobile parts and components, both the original equipment (OE) and the replacement equipment (RE), is substantially large. It is assessed that the OE market for important parts and components values about 27% of the total automobile part and component market (or 15% of the total sale value, totalling 1.05 billion baht). The value of the RE market must be at least double this figure.

Despite its huge size, the automobile market belongs mostly to Japanese companies. Obviously, the opportunity for the Thai companies to compete with the Japanese companies in the world market does not exist, except for being production base. This is the case of MMC Sitthiphol Co., Ltd. which produces passenger cars to export to Canada under the Mitzubishi brandname. As for the local market, the Thai entrepreneurs also have little chance, especially for passenger cars, due to several reasons. First, the technology necessary for designing and producing passenger cars change rapidly in response to personal needs such as beauty, convenience, safety and luxury. Second, in order to respond to such changes, it is not worth to produce in small number to serve the local market. Third, the government's regulations do not allow new car assembly factory to be opened (See details of the policy on automobile industry in Annex 6).

On the contrary, the Thai entrepreneurs seem to have some chances in the local market share in the commercial cars such as the one ton pick-up truck due to several reasons. First, pick-up truck has large production base (about 80,000 trucks per year). Since its technological development change more slowly than that of passenger car, the Thai entrepreneurs can accumulate their production capability through licensing agreement. Second, beauty and convenience are emphasized less in the pick-up truck than in the passenger car. Third, the market for pick-up truck in Thailand is very large, second only to that of the United States. Fourth, most important parts and components of the pick-up truck can be produced locally, except for the transmission, axle, and steering. Fifth, presently there is no regulations prohibiting the establishment of new factory to produce commercial cars. Finally, apart from the local market, there are several other potentially large markets for pick-up truck such as in the Indochinese countries and other developing countries.

Apart from the automobile industry, the Metal-working industry is also another related industry which provides promising market. This supporting industry can be both supporting and obstructing factor for the Thai entrepreneurs in the pick-up truck production. Because of the Thai entrepreneurs' lack of capability in Metal-working technology for producing

important parts, not only is the opportunity in this large market lost, but this also affects their competitiveness. In terms of the one ton pick-up truck, the marketing opportunity is good for the parts and components presently not produced in Thailand, i.e. the transmission, axle, steering and mechanics. In the case of engines though there have already been four entrepreneurs, the supply is still not sufficient. The RE market is also large. The parts and components presently produced in Thailand include:

- exhaustion system such as the exhaustion pipe, noise absorbing exhaustion pipe, and the tip of the exhaustion pipe,
- brake system such as the brake drums & disks, mechanical brake sets,
- fuel system such as the fuel tank, fuel meter, fuel pipe and fuel filter,
- anti-vibrating system, such as choke, leap spring, bumper, vibrating pipe,
- light system such as the plate light, room light, rear light, head light and signal light,
- pressed parts such as the floor, roof, door, under bonet parts for the side and floor of the car,
- interior trim such as roof, door, floor, noise absorbing trim.

Therefore, the supporting industry such as the Metal-working industry is necessary, since the metal works cover several products and production process, such as:

- metal casting, such as the grey and ductile cast iron and the aluminium die cast,
- metal forging, such as die forged steel,
- machining, such as iron, steel and aluminium, and the precision and contour form machining,
- heat treatment such as nitridzing, carbonizing and quencing,
- stamping, such as steel and stainless steel stamping,
- plating, such as galvanized, boronized and hard chrome.

However, the obstacles of the Thai entrepreneurs in automobile industry (including the automobile assembly industry and automobile part and component industry) is that the industry is still in the hand of Japanese joint-ventures and their affiliates. Thus, the Thai company cannot easily seize the market share for the one ton pick-up truck from the Japanese companies and Japanese joint-ventures. The latter must contain the new entrepreneurs by controlling the supply of parts, such as engines. Engine importation is not presently allowed and it is normally assembled for internal use only. Izuzu, which sells a limited number of engines to Mazda, is an exception in this case. The same is true for the production of other automobile parts. As in the past, the Japanese joint-ventures tend to establish new companies or associated companies to produce parts and components to serve its chain companies. As for the level of Metal-working industry, the Japanese joint-ventures which control the automobile sale has played an important role in determining which parts will be produced locally and by whom (i.e. produced by or not by the companies in their groups).

3.6.2 Technological Opportunity and Obstacles

The market opportunity for Thai entrepreneurs in pick-up truck production exists, but it is not substantial because of the Thai entrepreneurs' very low technological capability. The Thai entrepreneurs lack design capability, ranging from designing the pick-up truck model to designing engines and other parts and components. However, the technology in this aspect can be acquired by acquiring from the consulting engineering companies abroad. More importantly, the Thai entrepreneurs do not have product-specific technology, which is difficult to be acquired especially from the Japanese companies. However, the technology for the production of certain parts and components such as the engine, gear, axle and steering, can be acquired through licensing. The Thai entrepreneurs seem to have higher capability in producing other parts, since several entrepreneurs have already produced automobile parts and components.

Besides, the technology necessary for the production of pick-up truck is not state-of-the-art, but has already been technically and commercially tested. This allows the Thai entrepreneurs to use their accumulated knowledge and experiences to enhance the quality and production process. Furthermore, the acquired technology can provide base for the production of other products. For instance, the technology in producing a one ton pick-up truck include the design technology, process technology and product-specific technology, all of which can be applied to produce other light-weight trucks. The knowledge in transmission technology in automobile can be used as base in producing other machinery such as the agricultural machinery. Finally and most importantly, the opportunity in technology acquisition is still open since the aforementioned technology can be acquisition and utilized rapidly. Not much engineering effort is required to develop and utilize this non-state-of-the-art technology. For instance, it took less than five years for Taiwan to be matured in the technology on transmission, axle and steering.

However, the technological obstacles still exist due to the lack of industrial policy. This results of the lack of direction in the accumulation of technological capability, as well as in the research and development activities. Although the technology and products do not make much technological progress, nor do they require much research and development, they needs much time, resources and efforts to be able to compete in domestic market.

As for the Metal-working industry which is a supporting industry, there are more chances for the Thai entrepreneurs to learn the technology since it is not state-of-the-art technology. Actually, several Thai entrepreneurs have already had good knowledge in metallurgical technology. However, since the technological diffusion proceeds slowly, only a few Thai entrepreneurs benefit from this. They also keep their technology a secret while many other entrepreneurs cannot develop themselves and fail. Besides, the academic institutions in governmental agencies cannot disseminate the procedural and technical knowledge to the production level.

3.6.3 Production Opportunity and Obstacles

There is a high possibility for the Thai entrepreneurs in designing and producing parts and components through licensing agreement. This results from three factors. First, at present several entrepreneurs have already produced engine parts. Similar production process is utilized for the transmission, axle and steering production (particularly in metal works). Second, despite the Thai entrepreneurs' low technological capability, they have higher capability in several metal works such as in casting, machining and pressing, etc.. Third, huge capital is not required in investment for production; therefore, the Thai entrepreneurs cannot be easily held back, except for the production to compete with other big entrepreneurs in the world market.

However, the opportunity for the Thai entrepreneurs to develop their technological capability also depends on the government's policy and regulation. Two other major obstacles are, first, the market is totally controlled by the Japanese joint-ventures. Second, time, efforts and resources are required for the acquisition of the technology necessary for the part and component production as well as for the development of the product design and quality. The government may assist by granting some privileges to reduce the investment risk, such as improving and changing the tax and customs structure, as well as granting financial support for the research and development. More importantly, the Metal-working industry is both the supporting and obstructing factor. The weak supporting industry like the metal works will result in the low competitiveness of the final products such as automobile or machine because the supporting industry has played substantial roles in determining the cost, quality, supply and design of the final products.

CHAPTER 4: THE ELECTRONICS INDUSTRY

The electronics industry has been one of the fastest growing industries of Thailand's industrial sector during the past 30 years. This fast growth, however, has been the result mainly of foreign investment, and the technological level of Thai entrepreneurs is still low and not much developed. Although Thailand's electronics industry is moving toward being an exporting base for the other Southeast Asian countries, questions still exist whether this growth could be sustained in a long term, and to what extent this fast-paced growth will benefit Thailand.

However, some industrial electronics products,[1] such as personal computer, transceivers, PABXs seem to be some of the few products that Thai entrepreneurs have attained some design and production capability. Those produced in Thailand are still low-end products which require only matured technology. But there are some marketing opportunities for electronics products, including industrial ones and others, both in the world market (where the market is large and retains a high-growth rate) and its domestic counterpart (with its 3-million-line telephone project and other telecommunications projects). This means that the electronics industry, especially industrial electronics, has much chance for expanding in the future. Consequently, the policy of the government should be concentrated on investment for building up product design capability, and on creating supporting industry for future growth, instead of relying only on the old policy of protectionism through tax structure.

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[1] This study will divide the electronics industry into 3 sectors according to the types of products: (a) consumer electronics, such as radios, televisions, stereos, etc., (b) industrial electronics products, such as transceivers, PABXs, personal computers, etc., and (c) component electronic parts, such as printed circuit board and integrated circuit.

4.1 INDUSTRIAL DEVELOPMENT

The production of electronic goods in Thailand is said to be an assembling industry, one of putting together ready made parts according to the prototype or sample already conceived from abroad. These parts are manufactured in and imported from the foreign countries. If the electronics industry at present is divided according to the steps of manufacturing process, it could be so divided into equipment assembly, part sub-assembly, and standard component manufacturing industries. Examples of the latter include integrated circuits, transistors, and diodes. On the other hand, the electronics industry also needs parts from the metal and plastic industries. These part assembling are called supporting components. A production of goods will be complete when all these three constituents are present: design (including the products and their parts, and software), manufacturing of parts and components, and assembling the parts into finished products.

The development in Thailand started from the assembling of completely-knocked downs (CKDs) kits, then part sub-assembly and finally complete production, which begins from a production of non-critical parts in order to substitute for imports. Major critical parts have just been manufactured in Thailand only recently.

During the decade of 1960's the production of electronics goods took the form of importing CKDs from Japan for final assembly. This type of production was a response to the import substitution policy. However, since the domestic market was limited, the number of companies at this time was only 10, and the most important group among these was a number of joint-ventures with Japanese companies, such as Sanyo, Matsushita, Mitsubishi, Toshiba, and Hitachi. Nine out of ten promoted companies at this time produced consumer goods; there was only one company which produced industrial goods. The expansion during this period was due to the protection of domestic market, and the enlargement of the government owned radio and television network.

During the years 1971 to 1980 some American companies, namely National Semiconductors, Signetics, and Data General, came to Thailand in order to invest in IC production. Also there was production for import substitution. As for most Thai companies there was some development, such as minor modifications in home electronics appliances. When the production capability was higher, Thai producers began to want to lower the import of CKDs and started to design their own circuits, to gain higher profits from meeting consumer taste, aesthetic design, function enlargement, as well as designing peripheral parts, so that they could reduce the cost of production.

During the 1980's there was more production for export, which coincided with the entry of Japanese electronics companies, such as Minebea, Fujikura, followed by the American one namely Seagate. Near the end of this period there was a Thai company--Ngan Tawee Electronics--which was the first Thai company to produce ICs. As for the design and production of critical parts among Thai companies the first one was Kuang Charoen Electronics, which started to produce printed circuit board (PCBs). Nevertheless, the parts industry at this time was only intended for export, and there was no utilization of these domestically produced parts. Major domestic parts used were only metal or plastic intended for assembling products for the local market only.

The period from 1986 to 1990 was the time when Thai industry experienced the fastest growth. Within these five years there were as many as 236 electronics related projects which were promoted for investment. But if one counts the number of projects until the end of 1990 there were 574 applications to the Board of Investment (BOI). These approved projects have the total amount of 128,273 million baht in investment, and create 224,107 jobs. As a result the electronic industry is a very large industry in Thailand, and is rapidly expanding. This industry, unfortunately, rests on a weak technological foundation, which is constituted by the assembling of CKDs and other non-criticle parts. There is still only a few productions of major, critical parts.

4.2 THE STATUS OF TECHNOLOGY

From interviews of industrial experts and surveys of factories and research on documents concerning the status of electronics industry technology, one can discriminate between design capability (taken to include both design and product-specific technologies) and manufacturing capability (including process and production management technologies) as follows:

4.2.1 Design Capability

(a) Design Technology

Design technology is a kind of technology principal to creation of product and prototype. Design technology is a technological know-how which is necessary for the primary design of industrial products. Usually the design technology belonging to related industries are not different from one another. Examples could be found in electronics industry, where the designer has to possess knowledge about circuit design, such as analog or digital circuits, printed circuit design, integrated circuit, software writing, and knowledge of how to use computers to aid the work, which includes computer-aided design, prototype creation, circuit testing, etc.. In addition, in designing a particular product, the designer must also have technological knowledge specific to the product type, so that he or she could learn about the conditions in designing that product.

(b) Product-specific Technology

Product-specific technology is the main technology specific to a particular type of product. It is necessary for determining the working of the parts and other components in such a way that they all work together effectively according to the intended function of that product, which makes that product different from others. If this product specificity is lacking, then that product could not be said to be the same anymore.

Personal computers, for example, need the technology of microprocessor and central processing unit, or small PABXs require switching technology, for the intended functions. Personal computers then could use the ability of the microprocessor to the full, in order that fast speed is achieved, and the PABXs, even though employing microprocessors also, they are used for real time control so that the maximum level of consumer service is effected (However, in modifying and developing a certain product, the designer needs to possess design technology also, so that he or she knows about the conditions and limitations in designing for modifying and developing the products).

4.2.2 Manufacturing Capability

(a) Process Technology

Process technology is the technology needed for making the prototypes commercially feasible and able to be assembled into products that are able to function as designed. Important process technologies in electronics industry are not much different from one another. These include printed circuit board fabrication, assembling electronic parts onto printed circuit board, soldering, other parts assembling, testing of electronic functions, etc. The differences among process technologies are in the area of detail and difficulty of the products. For example, printed circuit board assembly might be done either by hand or by automatic machinery, and the testing of electronic circuitry could likewise be done by ordinary equipment, or by computers.

(b) Product-Management Technology

Product management technology is the technology that helps make the production process effective, yield high volume of output, and able to produce high quality products. These results are achieved by quality control, time saving, machine maintenance, work flow management, etc.. The product management technology comprises manufacturing resource

planning (MRP II), just-in-time production (JIT), total quality control (TQL), total productive maintenance (TPM), and statistical process control (SPC), among others.

4.2.3 Consumer Electronics

Consumer electronics industry is the industry which the Thai entrepreneurs have started before other types of electronics industry, and has long been protected (the protection wall has only recently been lowered). At present there are only four Thai entrepreneurs who are still producing televisions (not including the minor producers who are assembling SKDs), all of whom are less and less capable of competing in both marketing and technology when compared to the Japanese joint-ventures. The first Thai entrepreneur is a long standing enterprise, but has to suffer lower and lower competing potentiality and thus has to change its owner and managers. The second one is only starting to operate within the last two years; it aims at producing for the low end market. As for the other Thai entrepreneurs most have folded their operation or joined with foreign ventures.

(a) Design Capability

The design capability of Thai entrepreneurs in consumer electronics could well be said to be at a very low level. The reason is that the Thai entrepreneurs do not posses any ability to design consumer electronic items which are high in added values, such as microwave ovens, video recorders, and digital stereo system. Thai entrepreneurs have some degree of capability in designing radios and simple television sets, but there is only one among the four Thai entrepreneurs who are still producing televisions for the market. Besides, the radios that they can design are normal AM-FM ones having only mediocre tone quality, and only certain portion of color televisions could be designed (receiving and amplifying). Most entrepreneurs in this area, including the Japanese and Korean joint-ventures, are only assemblers of CKDs ordered from abroad.

That the Thai entrepreneurs suffer constantly lower capability to compete could be explained in several ways. The first of these is that they lack the design technology, such as in circuit design, the design of printed circuit board and integrated circuit, and software development, including the use of computers in aiding the work. The upshot is that Thai entrepreneurs could not copy foreign products. The major reason for this is that consumer electronic items now have been designed to function using their own application specific integrated circuits (ASICs); this fact contributes to even lower ability of Thai designers to imitate, since they lack the basic design technology. Secondly, Thai entrepreneurs do not have the product-specific technologies. Hence they have little chance to develop their own products. Even though a Thai entrepreneur has tried to develop his own color television sets, but the attempt failed, despite the fact that he possesses the basic technological knowledge of radios and black and white television. Due to this reason, Thai entrepreneurs then could do little to modify their products or to introduce new models.

(b) Manufacturing Capability

Although the Thai entrepreneurs' design capability is at a very low level, they possess some ability in production. That is, though the manufacturing capability of Thai entrepreneurs are not up to the standard of the world, they could still compete with many Japanese joint-ventures, owing to the fact that the manufacturing technology (which has the form of assembling products from CKDs) are very much the same. The difference, on the other hand, between the two sides lies in the production management technology. However, the process technology of Thai entrepreneurs still limits itself only to the production of radios, television, and common stereos; there is no Thai entrepreneurs at all who produce (assemble) other products yielding high added values, such as microwave ovens, video players, and digital sound system. The main reason for this is that these high value-added items require much more skillful craftsmanship (although they are not much more complex) in fabrication and assembly of PCB, soldering, primary circuit testing, other

assembling, and final testing of the manufactured products (i.e., neatness, tidiness, functioning, and quality standard). These manufacturing processes requiring more skill in crafting make the production management technology an important factor in the determination of the quality of the products, defect rate, and production costs, among others.

The general manufacturing capability level of the Thai entrepreneurs in this industry could be divided according the product types as follows:

(a) Radio

Since radio manufacturing is a low value-added industry, and the technology needed in manufacturing radios do not require much skill or complexity. The producers then are mostly Thai, most of whom assemble and sell their products in the provinces themselves, utilizing domestically available parts and components which could be obtained quite easily. The soldering involved is very simple. Some factories do so by using ordinary aluminum trays with molten lead heated by an electric stove. Or some still solder their wares manually. The testing is normally done by eyes without any precise measurement according to the engineering standard to ascertain the quality of the products. At present there are only two AM-FM radios producers which are up to standard, and only one who possesses some skill level at designing and developing the goods. Furthermore, none of these producers makes use of production management technology at all.

(b) Ordinary Sound Systems

The added values and the manufacturing technology in the process of producing stereo systems are not far different from those involved in radio production. Most of the producers are small Thai entrepreneurs who assemble and sell their products themselves, quite in the same way as radios. The technological level of these Thai manufacturers (not less than 20 in Bangkok alone) are not distinct from their radio manufacturer counterparts.

(c) Black and White Televisions

The process technology in producing television sets requires more skill and complexity than does radios or stereo systems because there are more components and parts, especially now that there are integrated circuits in television sets. These components and parts, including the integrated circuits, are still standard and easily obtainable. Thai entrepreneurs who lack the ability in designing could then produce them if they have some manufacturing capability. The printed circuit board for assembling the standard parts are still single-sided boards, using dual in-line package (DIP) integrated circuits, which is not difficult to solder (even manually). Nonetheless, the producers need to know-how to test and tune main the assembled circuit board. Consequently, small manufacturers who are producing radios and stereo systems could not produce black and white televisions. The manufacturers of black and white televisions sold in Thailand are still mostly Thai, since black and white televisions have low added values when compared with other consumer electronic items. Presently there are only four Thai manufacturers who are regularly producing black and white Televisions.

(d) Color Televisions

Though the process technology in color TV production has been more standardized in the production process, this does not mean that it will become any earlier. Assembling color televisions nowadays not only necessitates mass production, but the process also requires frequent changing of models, as well as adding more complicated electronic gadgetry. Moreover, some critical parts especially integrated circuits have changed from standard ICs to ones specific to certain tasks, and from packaging the ICs in DIPs into surface mounted packages (SMPs). So the production or assembly of color televisions needs much automation, which inevitably means capital, labor skill and more proficient management. The process technology will become much more complex and involve more steps, for example the automation insertion of the standard parts, pick and place insertion, circuit board testing by jigs and computers, and testing of

working life and working quality by computers, etc.. Due to the characteristics of more skillful and involved production process, production management technology, for example, total quality control (TQC), statistical process control (SPC), and manufacturing resource planning (MRP II), then assume a lot more importance in determining the quality of the outputs and effectiveness in the production process.

Considering the manufacturing process and the technology involved, one finds that the four remaining Thai entrepreneurs are still capable of producing color televisions for the domestic market, although they could aim their products only for the low end market. Besides, they possess lower process and production management technologies than the Japanese joint ventures in the areas of frequent introduction of newer models, addition of more electronic functions, less assembly defect rate, standard time in assembling, and the time needed for keeping an inventory of parts and components for assembling. For illustration Tiralap (1990) has provided Table 4.1.

(c) Other Consumer Electronics

Thai entrepreneurs not only lack the skill and ability to design other types of consumer electronic items such as microwave ovens, video players, or digital sound system, they also lack the manufacturing capability. Though at present there have been some Thai producers who try to assemble video game players from SKD, this is only on a small scale and the manufacturing is still mere assembling of major, ready made parts. There have not been any Thai entrepreneurs who assemble these products from CKDs.

4.2.4 Industrial Electronics

Although the market for industrial electronics items are smaller than its consumer counterpart, it is nonetheless growing fast due to the economic expansion and development of the country which necessitates more use of computers, telecommunication equipment, and office automation systems. And when one compares the technological level of Thai producers

Table 4.1 : Technical Performance of TV Manufacturer

Firm*	Standard (Minute)	Defect Rate		Inventory Time	
		PCBs	CTVs	Import Parts (Day)	Local Parts (Day)
1	90	5	3.2	30	14
2	120	3	1.5	30	3
3	120	10	5.0	45	30
4	180	10(a)	5.0(a)	60	30
5	–	10(a)	–	60	30
6	150	10(a)	–	60	–

Note : (a) estimate
: * Firm 1–3 Jointventure
Firm 4–6 Thai owned
Source : Tiralap, A (1990)

in this area with that in consumer and component parts producers, the former already possess much higher level of sophistication in design technology. The main reason is that the design and product specific technologies have been continuously accumulated. However, Thai manufacturers do not seem to have a high level of capability in turning out products, since the manufacturing is only small scale and intended almost for the domestic market only. Thus the entrepreneurs as a result do not feel a need to develop their process and production management technologies as they should.

(a) Design Capability

Even though the design capability among Thai entrepreneurs is not high compared to the foreign ones, it is still relatively high compared with the other groups of electronics industry. Many Thai entrepreneurs are beginning to learn the design and product specific technologies peculiar to the industrial electronics industry, such as personal computers, small PABXs, radio transceivers, hand held transceivers, cellular phones, integrated circuits for specific tasks, Uninterruptible power supply, and various kinds of computer cards.

The reasons why the Thai producers have accumulated skills in designing and thus can compete with imports are quite various. Firstly, the market for industrial electronics is small compared to the consumer one. And more importantly, imported industrial electronics products often need to be modified to Thailand's telecommunications environment, electric current, business size, and the numerous rules and regulations in telecommunications. The foreign ventures then are at a disadvantage in that they have to produce a small number of products to meet these specifications and to be able to adapt to requirements in Thailand. As a result, Thai entrepreneurs have had a chance to pile up knowledge and skills in designing, since they have to learn about the rules and regulations in electronic design (such as the design of electronic circuit, printed circuit board, software writing, and other mechanical designs) for the purpose of imitating and adapting foreign

products. Apart from this the Thai entrepreneurs have to compete against the products from abroad which always contain more and more technological advances. The upshot is that Thai producers must try to keep up and learn about product specific technology which is the main technology for improving the products. For example, the manufacturers have to know about microprocessors, switching technology, digital circuits, analog circuits, transducer technology, and software development, and so on.

The design capability of the Thai producers have been more developed when the National Electronics and Computer Technology Center has supported the manufacturers by joining forces with academicians and researchers in universities to develop electronics industrial products which have the tendency to become commercially feasible. This has provided both the academicians and manufacturers alike with acquired and accumulated technological knowledge in designing which is specific to the products, such as personal computers, telephones, cellular phones, application specific integrated circuit, and small PABXs. Although the products which Thai entrepreneurs have some capability at designing are not much more technologically advanced in the same product group, they are widely used in the country, and are the result of designing and development by Thai entrepreneurs themselves.

(b) Manufacturing Capability

As mentioned above, although Thai entrepreneurs possess some degree of capability in designing products, they still very much lack manufacturing capability, which has to do with the quality and costs of the products. This is firstly because the production process in the past was only small scale; the production management technology then was not much in consideration. The consequence was that there was no chance to accumulate the production management technology. And when the scale of production expanded, there were problems concerning quality control. Furthermore, when the production expanded, another problem regarding cost reduction ensued. Secondly, most of the manufactured products have

been intended for sale in the low end market. Thai entrepreneurs do not realize any need for production management technology; furthermore, they have no concern for capital accumulation, and development of technology. The quality and cost in manufacturing as a result were dependent more upon the skill of the workers than on the process technology. Another major hindrance of the skill level in manufacturing among the Thai producers in this area is the lack of producers of supporting parts for the end producer. The cause of this is that since the production is small scale, the production of supporting parts has to bear high costs. This is not a good incentive to producers who would like to enter this business. Consequently, the production process is also affected. The affected areas include the time needed to develop and modify product models, the delivery and keeping the products in inventory, and more importantly the production cost. It is then necessary for many manufacturers to produce the parts by themselves as much as possible. Such action results in higher cost due to the scale of production.

Thai producers' manufacturing capability is divided according to the following types of products:

1. Radio Transceivers and Hand-held Transceivers

When compared with other industrial products radio transceivers and hand-held transceivers have been produced by Thai entrepreneurs for more than 20 years, but this production has been done only as ordered by the customers, so the amount of production is not high. For example, Thai producers have produced according to the order from the military, police, and customs officials. Thai entrepreneurs cannot produce a large number of even standard ordinary transceivers used in fishing trawlers, owing to the small market, and the purchasing rules and regulation. As a result, there are only two Thai producers at present, and there has not been much development during the past 20 years. The part which has been more developed is the testing of quality, such as frequency, functioning of the parts, and so on. Manual assembly of the parts is still being used, and soldering still employs simple tools,

though now pick and place insertion has been introduced for accuracy. However, though process technology has been somewhat improved by introduction of newer tools and equipment, the production management technology is not utilized at all, or much under utilized. The areas in which production management technology is not used are those of quality control, production resource management, and statistical control of production. The reason is that each batch of production is very low in volume.

2. Uninterruptible Power Supply

The manufacturing technology amount Thai producers in producing interruptible power supply is not much different from that of transceiver production. Though Thai entrepreneurs do have some degree of design and product specific technologies acquired from copying which they have adapted to suit the requirements and conditions in Thailand, and though they can improve and design parts of the functional circuit by themselves, the production is still in the form of small batch assembly, especially for some large interruptible power supply of 50 KVA. This kind of production depends almost entirely on labor force, such as assembling of electronic parts into the printed circuit board, soldering, primary testing of main circuits, other assembling, testing of working properties of all parts, and testing of product lives. More importantly, the assembly line is not determined or considered for effectiveness in production. Thus cost controlling, for which one needs to know the standard time of production, defect rate in the production stages, and productivity, becomes difficult. Nonetheless, production management technology has not been of particular concern for this group of entrepreneurs, since profit per unit from the technological rent is still high. The process technology in production of standard sized interruptible power supply used with computers and other general electrical appliances, such as one sized at 500 VA, is not much different from that of interruptible power supply. However, production processes involve more stages, and quality control requires more steps and procedures due to larger volume of production.

3. Private Automatic Branch Exchange

Process and production management technologies among Thai producers of PABXs are the same as those of the producers of other industrial electronics products. The difference lies chiefly in the area of production volume, which in this case is somewhat larger, making it possible to use more machinery and other equipment, including different production management. The process technology starts from using computer-aided manufacturing, production of printed circuit board, computer-aided testing, and software writing in the Programmable Read-Only Memory (PROM). At present there are two Thai entrepreneurs capable of producing PABXs, and two others who are in the process of delivering them.

4. Personal Computer

The process technology in producing personal computers among Thai entrepreneur has been more advanced than that involving other parts of industrial electronics industry as a whole. The reason is that the development of computer technology is continuously moving ahead at a rapid pace. The assembly of computers in Thailand then has to keep up with this pace. Even though computers produced by Thai entrepreneurs are still intended only for the low end market, they still have to compete with imported products (especially from Taiwan, one of world's largest computer manufacturers). Since computers produced in Thailand utilize somewhat matured technology, and the products themselves are standard, the process technology is the only factor that is crucial for competition. This factor includes both cost and quality control, beginning from printed circuit board fabrication, assembling of electronic parts, main circuit testing, other parts assembling, circuit and working condition testing, and physical property and product life testing.

5. Other Industrial Electronics Items

Some other industrial electronics items of higher added values are manufactured by some Thai entrepreneurs who are able to design them, but cannot introduce them commercially. The products are application specific integrated circuits and mobile telephones, among others. The products which Thai entrepreneurs have yet to produce are, for example, CNC controllers and large PABXs.

4.2.5 Component Electronics

The market for component electronics is another large market because electronic components are at present mostly standard (though there have been some production of ASICs). Thus, electronic components become indispensable building blocks for any production of electronic goods. Technologically speaking, one can well affirm that this area of industry is the most advanced. That is to say, if the integrated circuits had not been produced, all other modern electronic goods would then have not existed at all. As one might know very well now, the capability in this area among Thai entrepreneur is unsatisfactory. Perhaps it is more accurate to say that they do not have any such capability at all. What little they do have is only some production ability in the area of process technology, since the essential production management technology, absolutely required in this area, is not well developed by the Thai entrepreneurs. Entrepreneurs in this area are merely subcontractors of the mother part/component maker companies.

(a) Design Capability

As mentioned above, the skill level in designing component parts among Thai producers is hardly existent. There are three main reasons for this:

1. The production of component parts usually needs a high amount of capital, since it is a large scale procedure relying on economy of scale for profits.

2. The production needs a high level of technology in design, product specific, processing, or production management.

3. The producers of component parts are usually those who have long accumulated manufacturing capability. As this is a mass production, any mistakes or defects however small can then become crucial or perhaps even catastrophic.

Due to capital, technology, and manufacturing skill, Thai entrepreneurs are not yet at the level of component makers or vendors. They can be only subcontractors receiving orders from mother companies. Hence, design capability is not necessary for conducting business among Thai entrepreneurs lacking both design and product specific technologies.

(b) Manufacturing Capability

Although Thai producers do not have any skill in designing, they have a fair degree of manufacturing capability. Examples include printed circuit board assembly, integrated circuit packaging, and packaging of such other electronic parts as crystallized oscillator, and solar cells. Since these products are mostly intended for export, which means that the producers have to compete strenuously with other foreign manufacturers in the market, the number of Thai entrepreneur is approximately fifteen. This unfortunately, is low when compared to the number of foreign joint-ventures, which is as many as 127.

The degree of manufacturing capability among Thai producers is divided as follows according to the types of the products:

1. Printed Circuit Board Fabrication

Although there is quite a large number of Thai entrepreneur producing printed circuit boards on order, there are only a few able to produce high quality products that can stand on their own in the world market. Most Thai entrepreneurs (numbering more than 50) possess only low level skill. They produce PCBs mostly for the domestic market,

and are still producing only simple type PCBs which do not need much sophistication and accuracy, such as single sided PCBs. There is only one Thai producer possessing some degree of process and production management technologies who is capable of competing with other eight foreign producers.

The just mentioned manufacturer has developed his production from single sided PCBs into producing double sided plated through hole PCBs, and multi-layer PCBs. The technology being used is on a par with that used in foreign countries, starting from copying, reducing, enlarging, and adding the pattern or the details of the boards by using computer-aided design (CAD) (Most Thai producers copy their patterns manually). The standard and technologically sophisticated procedure that this particular manufacturer is using includes: copying of the patterns onto laminated sheets by the lithographic procedure (which other Thai producers use sheeting with light sensitive substance), drilling the board with CNC drilling machinery accurate at the range of less than 10 microns. The machine used for drilling these holes is controlled by computers (CAM) and run by a CAD program, while other Thai entrepreneurs still resort to drilling by hand with ordinary motorized tools, or by a drilling machine with a tool that helps in measuring the points to be drilled. Furthermore, this manufacturer uses printed circuit board technology involving the use of many layers and steps of chemical compounds, and the drying of the board by hot air, while other Thai entrepreneurs do not use it at all. Besides these advances, this particular manufacturer uses gold plated board and other types of compounds for lamination, including the testing of the printed board and the quality of the product life.

Apart from the technology in production which has been continuously developed to keep up with the advances, this manufacturer is currently utilizing some other production management technologies, such as planning, critical part method production (CPM), calculation and planning of production lines according to the engineering process, other planning for production, quality control circles (QCC), statistical process control (SPC), and other technological know-how to aid in the production.

2. Integrated Circuit Packaging

The process of producing and assembling integrated circuit is a complex and sophisticated one involving more capital, technology, and skill in management than in PCB manufacturing. At present there is only one Thai entrepreneur intending their products for export only. The process and production management technologies are then on a par with the foreign producers, which number at five in Thailand. Due to the fact that the machinery and equipment in a production of ICs are up to the world standard in that they are both up to date and effective, the difference among the process technologies lies mainly in the volume of production. Though the process technology in IC packaging comes attached with the machinery, the knowledge of how to adapt the production procedure and machinery can cause much difference in production effectiveness (See Table 4.2). As the Thai entrepreneurs have to adapt, modify, and develop less process technology than foreign companies, this is a difference between Thai producers and their foreign counterparts. Another aspect of difference is the lack of skills in software writing for aiding production control, assembly line testing, and functional test of the ICs.

Generally, process technology is a production process controlled by computers. For example, in an assembling of plastic DIP integrated circuit (in fact there are many more such assembly methods), one commences the process by importing ready made silicon wafers (This is because Thailand has yet to produce them on its own). One then selects only perfect wafers to be wired with gold, silver, or other metallic wires (according to customers' orders). Afterwards, the wired wafers will be molded and printed by compounding machines. Then, the computerized testing machine will be used to detect any possible deficiencies. The finished wafers will be tested for their aging characteristics by heat, coldness, and vibration testers.

Table 4.2 : Technical Performance of IC Packing Firms

Firm*	Defect Rate (%)	Inventory Time (Day)
1	3	2
2	3	1.5
3	5	4

Note : Firm 1–6 foreign firm
Firm 3 Thai owned
Source : Tiralap, A (1990)

While Thai entrepreneurs have tried to learn how to utilize production management technology as have other manufacturers abroad (examples of production management technology are total quality control (TQC), statistical process control (SPC), manufacturing resource planning (MRP), critical path method (CPM), and general engineering procedure in production), the difference between the two is that the ability to adapt and modify production management technology among the former is much lower. This results in higher costs and lower effectiveness. This is so because component part production is normally of high volume, and of continuing type. Hence, only a small defect will engender much more serious consequences. Reversely, the effectiveness among manufacturers might be due to the ability to lower costs and to control product quality. Production management technology, then, is particularly important.

3. Production of Other Component Parts

As for other electronic component parts, Thai manufacturers have no production capability whatsoever, except for some items, such as microwave circulators/isolators, crystallized oscillators, and solar cells.

To sum up, Thai electronic industry has the following characteristics:

(1) It focuses mostly on component electronics.
(2) The production process still relies on assembling.
(3) Most entrepreneurs are foreign businessmen.
(4) It has few backward linkages.
(5) It has very little subcontracting.

The researchers have categorized the electronic industry in Thailand according to product types and technological potentials shown below in Table 4.3:

Within the present Thai electronics industry, progressive firms tend to be those which possess high technological potentials, relying on design, research and development of the mother company. These firms have high manufacturing capability.

Progressing firms are mostly Thai firms producing specialized products for foreign joint-ventures intended for the domestic market and small export markets. This group carries out imitative R&D and possesses a fair level of design skill.

Stagnated firms have the same markets as the second group, but lack further development in engineering design skill.

Declining firms are Thai producers of low priced goods for the low end market.

As for the consumer electronic sector, the production tends to be large for economy of scale. Mostly the market is controlled by foreign companies. Thai firms such as Tanin at first started out well producing radios and black and white televisions. Now they are trying to design and improve their products to suit the market and have recently imported CKDs to assemble color televisions. Yet, they still cannot compete with foreign firms. Other Thai entrepreneurs who have some degree of ability in electronic design are mostly in the industrial electronics market, in which it is necessary to modify the products to tailor to domestic needs, and in which the profits can be earned from designing. The survey finds that there are 8-9 such firms. However, this potential is being hindered because of the tax structure which promotes import of ready made products more than component parts. This problem will be discussed in the next chapter.

Table 4.3 : Classification of manufacturers of electronic products according to market conditions and technology

Development and types of the product	Types of Companies	Market	Technological foundation	Improvement and techno-logical effectiveness	Growth
1.Frontline -Electronic Parts	Foreign Companies	Export	-Machines and equip-ment need to be up to date -Labor has a high skill level, and has a high productivity or engineering capa-bility	High	High
2.Develop-ing -Electronic Parts	-Joint ventures Companies -Thai Companies	Export	-Rather up to date machinery -Educated labor force	quite high	quite high
-Industrial Electronics	-Thai Companies	Domestic	-Rather up to date machinery -Has the potential to design in order to improve foreign products to suit the local market -Educated labor force	quite high	quite high

Table 4.3 : Classification of manufacturers of electronic products according to market conditions and technology (Cont')

Development and types of the product	Types of Companies	Market	Technological foundation	Improvement and techno-logical effectiveness	Growth
-Consumer Electronics	Foreign Joint ventures	protected domestic market	-Some ability in design for improve-ment of products -Educated labor force	quite high	quite high
3.No deve-lopment					
-Electronic Parts	-Joint ventures and Thai Firms	Export market and low-end market	-Standard machinery -Low design skill	low	low
-Industrial Electronics	Thai firms	Domestic	-Simple testing equipment -Low design skill	low	low
-Consumer Electronics	-Joint ventures with for-eign com-panies	Domestic market	-Up to date machinery -Low design skill	low	low
4.Declining firms					
-Consumer Electronics	-Thai Companies	Domestic	-Simple machinery -Low design skill	low	low

Source : Tiralap, A. (1990)

4.3 TECHNOLOGY ACQUISITION

Generally speaking, Thai entrepreneurs do not pay much attention to technological acquisition. They only begin to do this when there is a real need to improve products quality. The way of searching for the technology is also different due to the difference among industries and products, although in most cases the manufacturers look for new technology be buying machinery and raw material.

4.3.1 Consumer Electronics

In this area Thai entrepreneurs acquire technology by buying machinery and parts from abroad. Since the technology in this area is fairly matured, especially for radios, cassette players and video players, improvement of the products and of the manufacturing process comes mostly from the producers of machinery and parts themselves, especially when Thai entrepreneurs lack design capability. Technological acquisition by buying machinery which has been tested and tried in assembly line and by buying CKD parts are so convenient that Thai producers can keep up with foreign ones. Moreover, technological acquisition by joint investment with foreign countries is another method used by Thai entrepreneurs when considering that they cannot accumulate and develop the technology on their own. Therefore, in order to out do their competitors, they depend on the technology of the joint investors.

4.3.2 Industrial Electronics Industry

Thai entrepreneurs of industrial electronic items not only seek technology by buying machinery and equipment, but they also employ consultants and try to develop their own technologies. Because of electricity, telecommunication, and government regulations, Thai industrial electronics products need to be improved and the working products modified. As a result, Thai producers cannot directly order CKDs to be assembled locally. They also need to gain some know-how in adapting electronic circuits and products. The method mostly used is inviting

university professors or outside researchers to head a special product development project. There is, unfortunately, little hiring of consultants or researchers. Perhaps this is because such a service is not widely available, and the manufacturers are not familiar with the employment of consultants. Developing their own research projects, the manufacturers thus begin to build up their own expertise. These projects at first stage are usually problem-specific tasks rather than developments of new products.

4.3.3 Electronic Component/Parts Industry

Thai entrepreneurs of electronic component and parts often seek their technology in terms of buying machinery and raw material, and of becoming subcontractors. Since they are normally only producers or merely assemblers, process technology is very important. It is often connected with machinery and raw material. The acquisition of technology by this method, then, is a faster way to develop manufacturing capability than other ways. However, the process technology acquired only from buying machinery and raw material is not adequate for a highly effective production and for high quality products. Thus, acquisition of product-specific technology via subcontracting is important. The reason is that, for the production and production management to be most effective, the producers must know the products well enough to plan the production process and quality control. This is so because generally the contractors determine the quality of the products to be offered, and recommend the needed production process and costs for those particular goods.

4.4 PROBLEMS AND OBSTACLES FROM THE MANUFACTURERS' POINTS OF VIEW

4.4.1 Tax structure

According to the current tax structure, there are three main products, namely televisions, radios, and computers. When production formulae for these products are submitted, the producers import CKD's with 10% tax rate. Singly imported parts, on the other hand, have

various rates. On average those electronic parts ordered as components or spare parts have the duty rate of 35%, making the overall tax rate of 49.8%. Furthermore, some industrial electronic products when ordered as ready made items have lower duty rates than when ordered as component parts. For example, transceivers when imported readily made have the duty rate of 5%, but when ordered as component parts, each part has a varying rate of 5-60%. Especially the battery, which is not produced locally, has as high a duty rate as 60%. This is due to the fact that the Customs Department levies the same rate as domestically produced batteries. Consequently, the joint-ventures tend to import CKDs, together with designs from the mother companies abroad. The accumulation of skill thus amounts to very little.

Apart from this problem, the already expensive measuring and R&D equipment is not in the category of machinery and equipment whose duty rates have been reduced to only 5%. Naturally, the price of such devices, essential for an independent production process for the purpose of elevating the level of Thai companies' performances, is prohibitively high.

4.4.2 Control of Domestic Raw Material and Selling of Component Parts

At present there is some production of component parts in this country. This is only intended for export; the producers are waived the duty rates of importing raw material. These producers are situated in export processing zones. Some have been promoted but are not situated there. Others are even outside the promotion area. But all lack bonded warehouses. Hence, the purchasing of parts among these producers involves complex procedures, causing a lack of incentives to subcontract the production and to purchase the parts from one another.

4.4.3 Shortage of Support Industry Producers

Support industry is very important in determining the price, quality, design, and development of electronics products. Hence, the fact that there is little support industry in the number of producers, product types, and quality, makes it the case that producers of end products suffer from lower competitiveness. More specifically, the reasons are:

(1) High cost due to the fact that the end producers have to manufacture the parts themselves.

(2) Inadequate quality due to the lack of experience in producing such specific parts.

(3) Lack of product modification and development because of the lack of essential parts for development, or lost opportunities when such parts arrive too late.

4.4.4 Lack of an Organization that Conducts Standard Certification and Calibration of Measurement Equipment

Another reason why Thai entrepreneur lack competitiveness is that they do not know the true value of electrical and electronic specifications of their products. Thus they cannot sell the products abroad or hire an outside firm to conduct the testing - a very expensive process. The manufacturers cannot improve and develop their products since they do not know the relative limitations between their products and their competitors'. Similarly, a Thai manufacturer who has gained a prototype with required electrical and electronic specifications may face a problem of not being able to control the quality of the product within the specified guidelines. This is because testing and measuring devices used to control these factors are not adequately reliable or not completely consistent without the producers knowing so. Therefore, the effectiveness of production and quality suffer completely if reliable devices are not utilized.

4.4.5 Closed Government Market

From the lessons of the Japanese and newly industrialized countries in Asia, we know that government purchase plays a big role in the technological development in the private sector. Any kind of technological development is not complete or has some weaknesses, resulting in high cost and low quality. Competition with more efficient manufactures then is not possible. To stand against more efficient producers, such as is being done by developing countries against the developed, is very difficult. This is because technological development, especially product development needs time in accumulating the knowledge. As a result, the private sector has a high risk factor in investment, and cannot accurately sense the need of the market in order to accumulate knowledge, skill, and technologies for production. Generally the private sector aims at profit, thus they do not normally care for development and raise their technological skill, which entails higher expenditure. However, if the market signal from the government sector is such that the producers know what types of products are to be purchased, at what time, with what specifications and engineering requirement, and what the products are like, then these will reduce the risk factor, especially in marketing. Moreover, this is also a promotion and encouragement to the private sector to develop their own technology, and to engage in more competition.

4.5 PROBLEMS AND OBSTACLES IN MAIN TECHNOLOGY ACQUISITION

From a study of The Identification of Key Technologies for Industrial Development project, the main technology is classified as follows:

(a) Design Technology

1. CAD/CAE
2. Knowledge of circuit design
3. Knowledge of the working principles of major electronic parts.

(b) Product Specific Technology

1. Microprocessor and memory unit product group
2. Switching technology product group
3. Analog circuit and transducer technology product group

(c) Process Technology

1. Printed circuit board and integrated circuit manufacturing
2. Component electronic parts assembly
3. CAM/CAT

(d) Production Management Technology

1. Production planning technique
2. Production control technique
3. Production improvement technique

Thai entrepreneurs face the following obstacles and problems in searching for the above mentioned technologies:

4.5.1 Design Technology

Generally speaking there is little acquisition of design technology. The design technology, including CAD/CAE, knowledge about circuit design such as digital and analog circuits, and knowledge about the working principle of the major electronic component parts. Such parts as microprocessors, memory, large ICs, and other semi-conductors are all basic technology and knowledge which can be readily obtained from university study and books. But the major obstacles are the attitude of the manufacturers, market conditions of the producers, and personnel shortage.

(a) Attitude of the Entrepreneur

Most Thai entrepreneurs still regard the acquisition of such helpful technology as CAD and prototype circuit making as neither necessary nor helpful. As far as the factor of an investment is concerned, involving purchases of tools, equipment, software, and time for training, Thai entrepreneurs still prefer the accustomed manual design and testing the working of the circuit from real samples rather than modelling the design by computers. Moreover, Thai entrepreneurs are used to copying other people's electronic circuits rather than trying to innovate their own. They see no point in an accumulation of knowledge in circuit design. Even the copying and modifying of other people's circuits is done without engineering knowledge.

(b) Market Structure of the Producers

Another obstacle in searching for design technology is market structure. Since the Thai entrepreneurs have low technological skill, they try to limit themselves only in producing and marketing their own electronic products concentrating on low end customers. As for the upper market, they limit themselves to producing by order only. Technology and product are rapidly changing. Therefore, by the time the manufacturers complete their studies on the main electronic component parts and electronic circuits, the technology and products have all changed. Thus, Thai entrepreneurs see no need to learn and use design technology.

(c) Personnel Shortage

Even though electrical engineering graduates have studied designing and have knowledge about the working of various electronic parts, persons who have the knowledge about design technology are very hard to find. Most university professors have no opportunities to design, which would make them knowledgeable about the limitations in designing circuits and other component parts.

(d) Non Availability of Ready Parts and Components in the Country

Another obstacle is non availability of ready parts and components in the country. This does not encourage creative thinking in electronic design. Design enables one to learn about the conditions and limits of circuits. A use of electronic component parts always needs constant experiment, testing, and modification. If a designer has an idea in designing a circuit but cannot find a part or has to waste a lot of time in finding one, the design task is more often them not abandoned without learning the conditions and limits of the circuits and parts.

(e) Import Duty on Computer Software and Testing Equipment

Import duty on computer software at present is as high as 20%. This does not encourage the use of software among the manufacturers to aid in their designs, creation of prototypes, or circuit testing. Thai entrepreneurs are especially unfamiliar with the idea of importing valuable software, which by nature is not a machine or raw material. Moreover, testing equipment necessary for designing activities is still levied a high tax rate. This definitely discourages the manufacturers from independently developing their products.

4.5.2 Product Specific Technology

There seem to be some obstacles in acquiring product specific technology, since it is the principal technology required in determining the working and functioning of the various parts and components in order that they all coordinate effectively as desired. As a result, manufacturers knowledgeable in this kind of technology usually conceal their knowledge. For example, the product specific technology of Intel's 486 chip set is guarded by its owner. However, product specific technology of widely available products having rather matured and saturated technology can be purchased in form of licensing. An example is the licensing of cathode ray tube (CRT) for color televisions from Mitsubishi to Thai CRT. Hence,

if manufacturers look for the technology specific to this particular product, they should have no problems. The major problems, on the contrary, are the attitudes of the manufacturers themselves, the lack of information, and the scale of production.

(a) The Manufacturers' Attitudes

As mentioned above, Thai entrepreneurs in general do not see any need to spend their money on knowledge about production, especially product specific technology. They view such an expense as not necessary as opposed to purchasing machinery and raw material.

(b) Information Source

Thai entrepreneurs who recognize the importance of technology acquisition still face the obstacle of the lack of information concerning the owner of technology, possibilities of technologies both in market and technical aspects, and a fair price of a technology, and so on. This is the case particularly when the manufacturers want to conduct a comparative study of technologies from various sources to find the most suitable technology for their own needs.

(c) Production Size

Another obstacle to technology acquisition is the small production size of most entrepreneurs. Even if entrepreneurs are ready and have all the necessary information to acquire a needed technology, technology suppliers often are not interested as royalties fees (normally charged at a fixed percentage of sales) involved are usually too little. On the other hand, though technology suppliers are willing to provide a certain product-specific technology, Thai entrepreneurs may find it uneconomical for the cost they have to pay due to small product output.

4.5.3 Process Technology

Most process technology is connected with production machinery and equipment capable of making the components and parts of the prototype commercially feasible and able to be assembled together according to the design. Thai entrepreneurs often seek process technology, and the vendors of machinery and equipment often have enough data to satisfy their needs. Most machinery and equipment producers also want to sell as many of their goods as possible. Consequently, the problem concerning an access to process technology is not particularly crucial. However, there are still some problems concerning the shortage of engineering consultants and the price of machinery and equipment.

(a) The Shortage of Engineering Consultants

As an acquisition of process technology requires engineering know-how which Thai entrepreneurs, starting from trading rather than manufacturing, usually lack. They often use data from the vendors of machinery and equipment to aid in their decision-making. This causes a lack of comparison among machines, and various production techniques for more effective and adaptable machines to lower their costs, to yield high productivity, and especially to acquire the most cost effective technology.

(b) The Price of Machinery and Equipment

Since Thai entrepreneurs are mostly medium or small sized producers, the price of machinery and equipment is one of the great obstacles for the technology acquisition. The improvement of process technology connected with many kinds of machines need a large scale production to justify its cost effectiveness. Small and medium sized producers, then, cannot see a justification for such use because the market is small and they lack adequate and low interest financing. They, in addition, cannot afford to buy automatic insertion machines or testing devices, electrical and electronic measurement equipment, and so on.

Since machinery and equipment are only a part, though a major part, of production, the know-how needed for utilizing such tools to the fullest extent, including the use of software, is very important. But the manufacturers cannot justify the cost effectiveness of such use.

4.5.4 Production-Management Technology

Production management technology is another weak point for Thai entrepreneurs, resulting in the difference between Thai and foreign manufacturers in effectiveness and product quality. Both have quite the same machinery and equipment, raw material, labor skill, and easy access to production management technology from foreign and domestic firms, universities, and other private organizations. The obstacle, however, in finding such product management technology lies in the attitudes of the manufacturers, and their production scale.

(a) The Attitudes of the Manufacturers

The attitude of manufacturers is still an obstacle in acquisition for almost any kind of intangible technology, or that which by nature is not machinery or equipment. Examples of such intangible technology are computer software, know-how, and various product management technologies. These manufacturers need to accept this kind of new technology in order to improve their production. Apart from more investment, they need to change the system, reduce the amount of reporting, and control the production in a different way. Besides, they need the skills, knowledge, as well as time to follow and improve production management technology in order that it suits real production conditions. All these are closely related with attitudes and labor skill regarded by the entrepreneurs to be confusing rather than useful.

(b) Production Scale

Although some Thai entrepreneurs are ready to accept production management technology, the production scale is also another limiting obstacle.

4.6 OPPORTUNITIES FOR AND OBSTACLES AGAINST FUTURE INDUSTRIAL DEVELOPMENT

From the study of The Identification of Key Technologies for Industrial Development Project, it is found that electronics industry is rapidly growing in economic and technological terms. However, technology and electronics industry have a tendency to cause economic expansion and development of more new products both in this and other countries. This analysis of opportunities and obstacles of Thai entrepreneurs in this industry in the areas of marketing, technology, and production will be limited to the next five years only. Thus, the selected product and technology for analysis are dependent on market pull rather than technology push.

4.6.1 Marketing Opportunities and Obstacles

The world market for electronics products is wide open. In 1988 the overall sales of the 100 largest firms in the world involved 340 billion dollars in electronics products or 15% of the overall sale, which made it the third largest industry behind automotive industry (593 billion or 25%), and petroleum industry (509 billion or 22%). Arthur D. Little Company (Arthur D. Little, 1990) has estimated that the demand in 1991 for electronics products in the world will be as much as 700 billion dollars, whereas in 1988 the figure was at only 500 billion. This estimate not only shows how large the market is, but it also shows the enormous potential for growth in electronics industry. Considering this figure, we find that Thailand's overall production of electronics products in 1988 amounted to only 2.5 billion dollars, or only 0.5% of the world market's demand.

As for the domestic market in 1988, the sum of overall sale of the electronics industry was at 13 billion baht or 4% share of all industries, which is the third largest sum behind petroleum industry (106 billion baht, or 30%) and automotive industry (20 billion baht, or 6%). Data from the Chula Unisearch, Chulalongkorn University show that the demand for electronics products in Thailand was estimated at 14 and 21.4

billion baht in 1988 and 1991 respectively. And when the three-million-line telephone project with the value of 150 billion baht and other telecommunication projects with the total value of several billion baht are included, Thailand's market becomes conspicuously large. This does not even include the normal industry growth rate.

However, although there are a lot of opportunities for growth. This does not mean that Thai entrepreneurs have an easy time prying into the world market because the competition is severe, and the technological level of the Thai entrepreneur is still low. This can be seen from the ratio between the import value of all parts and components and the overall production cost. The import of parts and components for domestic assembly is very high at 50-90% of the total production cost, and the types of the components and parts are middle level ones such as SKDs and CKDs. Hence, the most visible obstacles of the Thai entrepreneurs are product design and production cost.

Marketing obstacles for Thai entrepreneurs seem abound in consumer electronics since the competition tends to be closely related with trademark and production volume. The profit ratio becomes smaller because the technology is more saturated. Although Japanese and Korean firms are facing problems resulting from fluctuating foreign exchange rates, Thai firms are still not capable of competing in the world market due to their weaknesses in the production bases, such as automation, and in technological bases, such as electronic design. Even the domestic market can be regarded as one where That manufacturers cannot compete, since it is dominated by joint ventures with Japanese and Korean firms. Thai manufacturers have no capability of designing and producing many electronic parts such as transistors, capacitors, microprocessors, and memory unit. The reason is that the process requires a mass production and high level of design and production technology.

On the contrary, some opportunities still exist for Thai entrepreneurs in the area of industrial electronics industry. For example, personal computers and telecommunications equipment and office automation equipment have been produced by Thai entrepreneurs with some success. The reasons for this are:

(1) The market for these products is large and the trademark royalty of the customers is not as high as in consumer electronics.

(2) The technology changes very rapidly, and automation technique is still not possible in economic and technological terms,

(3) The technology is not matured, so there is more room to develop more products yielding higher added values.

(4) The price of standard parts such as microprocessors and memory chip have lowered, and the profit margin of this industry is still high. The capability of the developing countries to compete in the low and medium end market is likely to exist therefore.

(5) Thai entrepreneurs have some in-house capability, making them able to compete and maintain business in the domestic market.

Support industry also has quite a lot to do with the opportunities and obstacles of the manufacturers. Without this industry, Thai entrepreneurs would not only lose a large market in this sector, but they would also lose the capability of competing in end products. Although the size of this market is difficult to estimate, and although the use of supporting components and parts is different from products to products, one can still estimate that a production of electronics goods needs to have subcontracting to produce the parts of at least 20% of the total cost. A very visible opportunity in support industry for Thai entrepreneurs are:

- printed circuit board fabrication and assembling of printed circuit boards,
- electric cords, cables, and computer cables
- aluminum extrusion
- metal forging
- precision machining
- plastic parts
- rubber and foam parts.

However, two major obstacles also exist:

(1) Large foreign corporations which have the power to purchase and help develop support industry of Thai firms tend to purchase parts from their own companies an affiliates (mostly from Japan), and import from abroad, mostly form Asian NIC's. Few firms declare an intention to do business with domestic subcontractors, which might perhaps be due to Thailand's lack of capability in technological skills.

(2) Import duties for raw material are very high, and this situation is further compounded with cascading taxes. This, to say the least, does not encourage industry development in the country, especially licensing and supporting industries. The controlling procedures of the Customs Department, such as bonded warehouses and export processing zones, do not encourage the growth of support industry either.

4.6.2 Technological Opportunities and Obstacles

The technology of computer equipment, telecommunications products, and office automation is changing very fast with more and more new products yielding higher added values and being developed by the world's leading firms. As a result, entrepreneurs in developing countries have some opportunities in the low end of such products as:

Communication Layers	World Competition	Thailand's Niches
Processing unit	Workstations	PCs
Exchange equipment	Public exchanges	PABXs
Communication line	Satellite telephone	CTs
Image input/output	Laser scanners/printers	FAXs
Integrated devices	ISDN - chip sets	ASICs

The reasons why Thai entrepreneurs might have some technology opportunities are:

(1) The technologies of industrial electronics products suitable for Thai manufacturer's skill level in the next 5 years, such as the low end products of personal computers, PABXs, mobile phones, facsimile machines, application specific integrated circuit (ASICs), are all proven to be commercially feasible. This will help reduce technological inconsistencies and marketing risks of the manufacturers.

(2) The technologies of these products have continuous development. This means knowledge of technology and production gained from accumulation will enable one to make products which are high in added values.

(3) The technology of these basic products involves basic knowledge of computers and telecommunications, which are widely used.

(4) The technology for low end products can be readily found, perhaps in the form of licensing, and can be utilized quickly, because this technology is not the state-of-the-art which requires a large number of engineers to develop and utilize it.

However, technological obstacles still exist because of the lack of technological and industrial policies. This results in the lack of direction and of accumulation of technological capability. These obstacles need to be addressed to and quickly so by a cooperation of the government and private sectors in order to determine targeted products, to create markets, and to implement technological research and development. Even so one still needs time, resource, and determination to develop this accessible and already acquired technology in order to make the products able to compete in the world market.

As for the support industry technology, opportunities and/or obstacles in developing products are dependent upon management technique. Technological opportunities in this industry are definitely present, especially in simple parts and components which are accessible and not too complex. Thai entrepreneurs have some skill level in producing such simple non-electronic parts. Some obstacles, on the other hand, are

prevalent concerning basic technological knowledge and know-how. When a Thai entrepreneur intends to produce some electronic and non-electronic parts, yielding high added value, he needs time, resource and determination. Examples of such products are:

- Multi-layer flexible PCBs
- Multi-layer SMT PCBAs
- Anodized and plated sheet pressing
- Precision (less than 100 microns) casted parts
- Precision (less than 10 microns) machined parts
- Precision (less than 10-100 microns) plastic parts

4.6.3 Production Opportunities and Obstacles

Considering from the readiness in assembly, present technology and size of capital points of view, opportunities for Thai entrepreneurs are possible due to several reasons:

(1) Many manufacturers are producing personal computers, PABXs, and have developed application specific ICs for use in their products, while others are developing mobile phones and facsimile machines.

(2) Even though the Thai producers' technological level is still weak, there is an accumulation of basic know-how, since they also design their products and not merely producing them.

(3) Investment to produce such goods does not need so large an amount of capital that Thai investors be prevented from entering the arena.

Design, cost and quality of the products would not be the main obstacles against production if the government had a clear policy in supporting the private sector in technology research and development and market creation. The major obstacles for Thai manufactures, on the other hand, are tax structure, capital, lack of technicians, and research support. However, another big problem is a weak support industry which makes the end products not able to compete, since this particular type of industry is crucial in maintaining overall competitiveness. This includes production cost, quality, delivery, and design.

At present there are at least 10 Thai producers making personal computers in the form of SKDs. They, on the other hand, only assemble main parts and have no engineering testing; they only test that their products work. However, there is a manufacturer who has changed from manual to automation assembly. For example, they use pick and place insertion technique for SMT type integrated circuit. Soldering also changes from manual to one using specialized tool and automatic drying of the PCBs. The testing of the main PCBs changes from one done by ordinary tools such as oscilloscope and multimeter to one using jig under computer control. This also includes the testing of functioning and from these process technologies, product management technology has also been developed. Examples of production management technology are quality control circle (QCC), and manufacturing resource planning (MRP). However, process technology and production management technologies are still new to most Thai entrepreneurs. They need more time to study and develop these newly acquired technologies so as to enhance their effectiveness in production. The manufacturers need to have a firm grasp of such technologies because at present the defect rate stands at a high level (about 10%), and the quality of the products brought to the market cannot be consistently controlled.

CHAPTER 5: STATUS, PROBLEMS AND OBSTACLES IN TECHNOLOGY ACQUISITION IN THE TEXTILES, FOOD, GEM AND JEWELRY, AND PLASTICS INDUSTRIES

The textile, food, gem and jewelry and plastic industries are traditional industries. In Thailand, the technology employed in these industries is labor intensive. However, competition in the world market and changes in income of the world community, including a rise of labor wages in the developed countries, have led to technology development in these industries. This has created both opportunities for and pressures on the Thai industries. In this chapter, we will analyse the status and obstacles in technology acquisition of the four industries.

5.1 THE TEXTILE INDUSTRY

The textile industry[2] is composed of, first, the upstream industries, involving the production of natural synthetic and other chemical fibre. Second is the midstream industries, including, spinning, weaving/knitting, bleaching, dyeing and finishing. Third is the downstream industry, comprising sewing of garments, hats and other products. In this report the upstream sections of the textile will not be dealt with.

According to the statistics from the Department of Industrial Works, Thailand had 65 spinning factories in 1987, 446 weaving factories and 404 knitting factories in 1988. Production capacity has greatly expanded since the government allowed an increase in the number of spindles and weaving machines in May 1987. At the present time, Thailand has around 3 million spindles.

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[2] These figures are quoted from the report on The Identification of Key Technologies for Industrial Development, TDRI, 1991a.

In terms of employment, statistics available from the Association of Thai Textile Industries show that in 1989, spinning factories employed altogether 48,936 workers, weaving factories had 48,774 workers and knitting factories employed 45,377 workers. In 1989, the production of synthetic fibres totalled 229,134 tons, 248,022 tons for cotton yarns, 1,626 million square yards of synthetic fabrics, 1,278 million square yards of cotton for fabrics; synthetic knitted fabric output was 80,248 tons and cotton-knitted fabric output was 340 million square yards.

At present, there are about 400 bleaching, dyeing and printing factories in Thailand. They employ about 40,000 workers altogether. The total production capacity is 1,800-2,000 million square yards per year while domestic demand is as high as around 2,300 million square yards.

As a as the garment industry, the number of factories registered with the Ministry of Industry was 2,150 in 1989. It was estimated that they employed about 700,000 workers. From this industry, Thailand enjoys a surplus in the balance of trade reaching several thousand million baht annually. According to the statistics of the Bank of Thailand, in 1988, the garment export of Thailand was valued at 44,560 million baht while garment import was only 42 million baht.

The trend in textile technology development, is to speed up the production process in order to increase output. This is done by changing from a batch system to a continuous system, such as in spinning, so that the necessity of moving raw materials during different stages of production is reduced. Automatic devices are used in place of human labor in splicing yarns and changing shuttles. Also electronic devices are used to make production more accurate and to reduce production cost.

5.1.1 Status of Technology in the Thai Textile Industry

In this study, an emphasis will be put on the four main production processes. These are spinning, weaving and knitting, bleaching, dyeing and finishing, and garment production.

(a) Spinning

At present, the Thai textile industry uses the spinning technology which has been employed worldwide for some time. Ring spinning has been developed to the speed of 20,000 RPM (See details of textile technology in The Identification of Key Technologies for Industrial Development TDRI 1991a). Spinning in Thailand is almost entirely the ring spinning system totalling around 2.8 million spindle. Many firms have also utilized a more automatic ring spinning system. The main purpose is to save labor. Automatic ring spinning can save 30% of labor and by this system, production and quality control of products can be computerized.

Open-end (OE) spinning is a system invented at the end of 1960's. It is a system which can produce per rotor 3 to 5 times more output than a ring spindle. This method was first introduced in Thailand in 1974. It has become more widely used nowadays and there are about 40,000 rotors in Thailand. Since OE spinning produces more yarns per rotor than ring spinning, the current OE production capacity is equivalent to 120,000 spindle. This is equivalent to 5% of the total production capacity in the country and there is a tendency that the use of OE spinning will increase. However, this system is suitable for low-number yarns. Producers of yarns from number 30 upwards will not use OE spinning.

At present, a Murata air-jet spinning system, which was first used commercially eight or nine years ago, has been introduced in Thailand. But this system is being used only in one acrylic factory where the yarns have to be made into double strands in order to solve the problem of yarn strength which is the weak point of this system of spinning.

Most spinning factories are of big size because it is an economy of scale production. Production cost per unit would decrease rapidly when production size increases up to 20,000 rotors (Santikarn, 1981). After that production cost would decrease slowly. Thus most

spinning factories would have the production capacity of not less than 20,000 rotors and this needs investment of hundred million of baht. Spinning entrepreneurs are therefore persons with big capital. They can employ knowledgeable and capable staff. Search for technology is not a difficult matter since this can be found in the world market, from journals and there are international organizations such as the United Nations Industrial Development Organization (UNIDO) which is widely facilitating technology transfer.

Spinning technology used by various factories is not very different from one another since they are all big factories with high capital. Differences only arise when different products are produced. Most factories have no obstacles in the search and use of technology. This is because the main obstacle caused by expensive machinery has been overcome by the fact that the Government has reduced duties on imported machines.

(b) Weaving and Knitting

In the weaving industry, the important technology consists of the loom which can be classified into two kinds. These are:

(1) Shuttle loom which has the speed of around 150-200 RPM,
(2) Shuttleless loom which can be divided into 4 types, namely, projectile loom having the speed of about 330 RPM; rapier loom having the speed of around 300 RPM; and being suitable for low-number yarns; air-jet loom which is suitable for natural fibre or water-jet loom having the speed of 600-800 RPM.

At the present time, both kinds of looms are in use in Thailand depending on which kind of loom is suitable for a particular type of work. This is up to the structure and width of cloth including type of fibre. However, most factories still employ shuttle looms. Large sized modern factories employ both shuttle and shuttleless looms.

In Thailand, there are both large sized factories, i.e. those having over 100 looms, and small sized factories, i.e. those having 20-30 looms. Large sized factories usually have production processes which are connected to spinning factories and produce large volume for export. Small sized factories often use secondhand machines from big factories or from Taiwan and some use machines made inside the country. The markets for small sized factories are domestic. The biggest market is Sampeng market which burp various levels of products whereas rural and border markets demand low quality products. In addition, there are some small sized factories which weave dyed yarns. Since the demand for each lot of this kind of products is still low, large size factories do not normally weave dyed yarns.

As for the knitting industry, this is a relatively new industry with short production processes. Thus there are a lot of small sized factories both registered and unregistered with the Department of Factory. Some factories have only 2-3 knitting machines. Small factories would use horizontal knitting machines whereas big factories would use knitting machines with rounded pedestals which give higher production. In more modernized cases, electronic devices are used to control knitting. This enables the machines to produce diverse patterns and to adjust the speed in supplying yarns, including the tautness of the yarns.

(c) Bleaching and Dyeing

Bleaching and dyeing in Thailand are mostly done by a batch method and rely very much on experienced technicians. Nowadays, there are textile factories which are integrated mills consisting of spinning, weaving and bleaching and dyeing where continuous technology is used. Various automatic bleaching and dyeing processes are employed, for instance, the system of color matching by computer can work to analyse the color given by customers and provide different blending formulas immediately. Also, automatic dispensers and blind dyeing system are used, the latter being an automatic dyeing method where the temperature, water and certain chemicals are controlled in order to give consistent quality.

Of all the 400 bleaching and dyeing factories, less than 5% of them are modern factories which perform the work with accurate quality. Factories possessing standard technology are usually foreign or joint-venture companies, such as Tokai Co., Ltd. and Luckytex Co., Ltd.. Thai factories which bleach, dye and print cloth with high quality performance are those factories belonging to Sahaunion Group and Sampran Printing Factory etc..

The choice of technology in bleaching and dyeing business depends on the characteristics and size of markets, and also the type of fibre. Since most bleaching and dyeing factories in Thailand are small sized and mainly bleach/dye cloth made of natural fibre and cotton mixed with polyester fibre, the principal bleaching and dyeing machines would normally employ the batch system. These are the jigger and winch machines. The first is suitable for dyeing thick cloth and the latter is good for dyeing thin cloth and knitted cloth in robe form. This type of bleaching and dyeing means that bleaching is performed in an open system at the temperature of not more than $100^{o}C$. For bleaching of synthetic fibre, the work needs to be performed in a closed system at high pressure and temperature of over $100^{o}C$.

Nowadays, bleaching and dyeing machines have been developed to make dyeing more efficient and to produce higher quality work. For instance, the pulling force and speed of the jigger machine can be adjusted to produce consistent color. Also, a new generation of the jigger machines has been developed to employ a closed system which is capable of operating at some pressure and temperature as high as $130^{o}C$.

In cases where factories receive an order from customers for a quantity of more than 100,000 yards per each lot, the use of the batch system as mentioned above, which is capable of dyeing only about 1,000 yards at a time, proves to be unsuitable technology. Under this system, dyeing would have to be operated several times and this causes different lots of cloth to have uneven color. Thus, it is necessary to change to the continuous system. The decision to use the batch or the continuous system depends on the market size of the business whereas

the choice of machines, for instance, whether to use the old or the new generation of jigger machines, depends on the quality required. For customers at the border areas who use old jigger machines can still make some profits. Where higher quality products are demanded, new technology needs to be employed. At this stage, a particular entrepreneur's capital and knowledge become important variables. This is because the use of new technology does not only mean that color formulas need to be changed, but also that the culture in business and marketing need to be altered. This later change is an important reason why entrepreneurs do not want a change in technology which involves high risk.

(d) Garment Production

Although garment production generally requires intensive labor, new technology has started to become in use. The core technology of this industry lies in a sewing machine and an attachment machine. Once an attachment machine has been imported, other machines can be reproduced in Thailand by copying the original one.

However, the technology which is needed to reduce production cost in the long term is that of computer-aided design/computer-aided manufacturing or CAD/CAM for short. CAD and CAM are used for designing and enlarging designs, controlling design sketch and cloth cutting to enable raw materials to be used most productively. At present, there are merely three factories which have a CAD system and only two of these are operating efficiently.

5.1.2 Acquisition and Transfer of Technology

The technology market of the four processes in the midstream and downstream textile industry is an open and unmonopolized market. Essential machines and materials are generally available for sale. For large firms, they would always be visited by suppliers of technology. Besides, international technology exhibitions act as a forum for disseminating technology. Thus search for technology is not a difficult matter.

Indeed, many private firms in Thailand have already possessed the highest level of technology according to international standard.

As for medium sized and small sized producers, they rely on a transfer of technology from suppliers of raw materials. For instance, fibre producers would introduce new patterns to their customers, i.e. weaving factories. They would advise their customers as to how to analyze fabric structure and which type of yarns should be used. Similarly, suppliers of color and bleaching/dyeing chemicals would provide services in analysing color, selecting color formula and solving problems arising from the bleaching/dyeing process for small bleaching and dyeing factories.

The Government has provided specific industry services for textile factories through the Textile Industry Section affiliated to the Ministry of Industry. Through this agency, the State provides training, testing service, technical advice and information service by issuing a quarterly periodical. At the time of this study, the Textile Industry Section was advising weaving factories on the use of computer for the analysis of weaving mill productivity and quality.

Textile factory owners who were interviewed are of the view that the Textile Industry Section possesses knowledgeable, capable and dedicated personnel, although they still have little industrial experience. In their opinion, the work of the Section should be mainly providing training and acting more seriously as a source of information. Besides, the administration of the training service should be more facilitated.

5.1.3 Technological Problems and Acquisition of Principal Technology

Factories in the textile industry can be classified into two major groups. First are those factories which are integrated mills, i.e. those having at least two production processes included in the same business, for example, spinning or weaving coupled with bleaching and dyeing; spinning or weaving coupled with garment production. Factories in this group are usually large with several hundred millions of capital,

such as Sahaunion Group, Thai Melon Group, Luckytex Group, and K. Cotton Group. The second category comprises small sized factories which produce or are subcontracted to produce at any particular process. Factories in this group are independent weaving, knitting and dyeing factories. This dual structure of having both large sized and small sized factories in the same industry is more visible at the stages of weaving, knitting and bleaching/dyeing. The first category of factories is large sized (employing 200 workers and over). The second comprises medium sized and small size factories.

(a) Machine Utilization Technology

The few large sized factories turn out to have high technological potential because their activities are promoted by the Board of Investment by allowing them to import machines and devices without having to pay duties. Therefore these factories have modern technology according to developed countries' standard. They can afford to hire experienced technicians from abroad. During the research team's survey of large sized spinning and weaving factories, it is found that some factories have 97% productivity and over in their use of machinery. Since large sized factories hardly have any problem in the search for machines and devices, their attention is now concentrated on factory management, production planning and increase of workers' efficiency.

As for medium sized and small sized factories, the Textile Industry Section has conducted a survey of 189 factories in order to explore their production potential (Pranee Opasanon et al., 1990). Their findings are summarized in tables presented in Appendix 5. The study indicated clearly that these factories have serious problems concerning their use of technology, especially in the case of knitting factories where it is found that an average of around 9% of the goods are not up to standard. The same thing is found in the cases of weaving mills and bleaching/dyeing factories where 7% and 6% respectively of the goods are not up to the required standard. On the average, garment-making factories seem to have fewer problems than others in this industry, that is, most

of them do not need sophisticated technology. From interviews conducted by the research team, it is found that small entrepreneurs, especially in the case of knitting factories, do not have basic technological knowledge. They are incapable of determining the causes which make their machines break down. Some factories do not even know how to set knitting needles.

It may be concluded that small entrepreneurs and their workers still lack knowledge and skill in operating machines efficiently. Thus they do not understand the value of systematic production management.

(b) Chemical Textile Technology

While spinning and weaving are a mechanical process, bleaching/dyeing and finishing are a complicated chemical process. Modernized bleaching and dyeing industry in Thailand still relies on experienced foreign personnel because there are not enough local skilled personnel. Most small sized factories are not capable of controlling color shades. In some cases dyed cloth needs to be left remaining in the dyeing machine while part of it is cut out to test the color shade. If the shade is not right, the dyeing process would need to be repeated. This leads to higher cost of production. The obstacles in acquiring technology has been summarized earlier under 5.1.5.

(c) Waste Water Management

The chemical textile industry is an industry which causes a large amount of waste water. Since disposal of waste water requires high investment, technology for treatment of waste water is not normally brought to use though it is generally available. Besides, the chemicals needed for waste water treatment are expensive and it costs about 0.60 baht per one yard of dyed cloth. The essential chemical is Flucalang which requires a payment of 40% import duty. Thus factories which possess waste water treatment units often do not put the equipment to full use.

At the present time, the Government has regulations concerning waste water providing that it must not contain "distasteful" color but it is not specified as to how we judge waste water to be distasteful. In addition, the Government has rules dealing with factory location that a factory must be situated away from the four main rivers at a distance of not less than two kilometers. It also contemplates confining factories in one area but the Department of Factory has not issued clear regulations on the matter.

(d) Energy Saving Technology

Most entrepreneurs have no knowledge concerning energy saving technology. As a result they are not so much interested in consumption of energy by types of machines. For instance, they do not know which type of shuttleless loom, air-jet or water-jet, consumes more energy than the other. They have no knowledge of the standard consumption of energy in their industry. One of the reasons why entrepreneurs are not interested in energy problem is the fact that the cost of all types of energy is less than 5% of the total cost. As the cost of raw materials is as high as 60-70%, it thus receives more attention.

5.1.4 Obstacles in Technology Acquisition of the Thai Textile Industry

From interviews with entrepreneurs, the problems and obstacles can be summarized as follows:

(a) Bottleneck in the Bleaching/dyeing Industry

At present, the Thai textile industry has vastly expanded especially the garment industry which employs as many as 0.762 million workers in 1989 and had occupied 10.8% share in the value added of the manufacturing sector. However, the garment industry still has to rely on imported fabrics which takes up 40% of the total value of fabrics consumed by this industry. In 1989, cloth export was valued at 15,000 million baht but import of finished fabrics totalled 14,000 million baht. The local

bleaching/dyeing industry does not have enough production capacity to meet the demand and is not capable of producing goods of sufficient quality for export standard. Thus, the bleaching/dyeing industry becomes a bottleneck problem in the development of the whole system in the textile industry. The reasons why the bleaching/dyeing industry lacks technological development and production capacity in line with other production sectors can be explained as follows:

(1) Government's measures to provide incentives for investment in the bleaching/dyeing, printing and finishing industries are less attractive when compared to the spinning and weaving industries. Measures which do not facilitate development include the following:

- Important raw materials such as chemical colors are taxed 30% to protect the few existing color producers in Thailand who can produce only limited colors. Apart from this, a 60% import duty is imposed on other raw materials such as polyester film which is used for pattern designing.

- Measures to give export quotas to exporters according to their previous export practice encourage producers to continue to produce raw fabrics more than to invest in the bleaching/dyeing industry.

- Import duties imposed on laboratory and printing devices are still high. For example, heat setting and resin finishing machines (code no.9031.80) has to pay 35% import duty.

- A lack of clear policy in environmental control, especially that which concerns waste water management.

- The garment industry is exempted from paying import duty for imported finished fabrics and therefore is encouraged to use imported more than domestic materials.

(2) The sophistication and complexities of the bleaching/ dyeing, printing and finishing technology.

The bleaching and dyeing industry is a branch of the textile industry which bears more complexities than other branches. This is due to the fact that it is a chemical process instead of being a mechanical process as is the case in the spinning and weaving industry. Thus the bleaching and dyeing industry requires high investment per work place and it needs more experienced planning, production control and procurement than in other branches of the textile industry. As a result, the comparative advantage of this branch in Thailand occurs more slowly than in the branches of garment production, weaving and spinning, respectively.

Another difficulty in carrying out bleaching and dyeing activities is that it is a downstream industry. Technical problems which are invisible or hard to detect by sight during earlier production processes may appear during the bleaching and dyeing process. Thus disputes between producers often occur. For instance, when dyeing produces mottled results, this may be due to irregular structure, uneven mixture of fibre, or irregular thickness of the yarns and thus, stripes of color appear after dyeing. Sometimes the problem is caused by the fact that a weaving mill has changed dyeing powder or a knitting mill has applied too much lubricating oil. A dyeing factory, therefore, is a port where various problems are gathered and this makes the industry gain low profits. So long as a dyeing factory could not control the quality of fabrics which comes to the factory, it is not worth investing in high-priced machines.

(b) Capacity Regulation of the Industry

The Ministry of Industry has regulated the capacity of the textile industry specifically. In the weaving industry, there have been periodic prohibitions on expanding the number of spindles and looms as indicated in Table 5.1. This is to prevent excess capacity. While there

is a capacity regulation of weaving mills which are manufacturing, exemptions are given to weaving of Pha Khama, sarong and silk which are almost cottage industries and thus are allowed to expand production capacity. This leads to the fact that the bleaching and dyeing factories (most of which take subcontracted work) have only customers who demand goods of subordinate quality which requires merely basic technology. Even during the period when Thailand was capable of exporting textile goods, capacity regulation still exists as far as production for domestic markets was concerned and only new factories which produced exclusively for export are allowed to set up. Since another downstream industry such as garment production is subject to less capacity regulation, it has been able to expand quickly, particularly in its production for export. As a result the bleaching and dyeing industry cannot adjust itself and keep up with the demand both in terms of quantity and quality. In a way, the restriction on expansion of the industry becomes a restriction on the acquisition and development of technology.

(c) A lack of Specialized Personnel

Government's educational institutions now produce about 40 university graduates, 30 graduates of higher certificate and 120 graduates of vocational certificate each year in the branches of textiles and chemical textiles. These numbers can be considered very low when compared to the size of the work force in the textile industry which is estimated at one million workers.

The trends of technological changes in the future will increase the need for more formally educated workers. For instance, from a comparison between two model of factories which have equal capacity, one employing ring spinning system, the other using OE system, it is found that the OE system requires a larger number of workers who have completed higher certificate or university education, i.e. there are 22 higher certificate holders, and the same number holding a university first degree while the number of unskilled workers is 100. In comparison, the ring spinning system employs 17 high certificate holders and 11 university

Table 5.1 : Summary of Capacity Regulation in the Textile Industry

Date of Announcement	Type of Industry					
	Synthetic Fibre	Spinning	Weaving	Knitting	Bleaching/Dyeing Finishing	Garment
1 Oct.1971			Suspended expansion and setting up of new factories			
22 Dec.1971			Exemption made for silk, narrow-width, netting fabrics, blankets	Suspended control over knitting factories		
8 Mar.1973			Permitted expansion only in production for exports promoted by BOI			
			Silk and knitting production allowed to expand not more than 50% of the existing production capacity			
20 Feb.1974			Permitted expansion of promoted projects			

Table 5.1 : Summary of Capacity Regulation in the Textile Industry (Cont')

Date of Announcement	Type of Industry					
	Synthetic Fibre	Spinning	Weaving	Knitting	Bleaching/Dyeing Finishing	Garment
13 Feb.1976			Suspended expansion of silk factories			
4 Oct.1976			Permitted canvas production and expansion			
20 Jan.1978	Suspended setting up and expansion of factories except those on promoted by BOI before 10 March 1978					
			Accepted application to set up and expand production of silk etc.,saronge, Thai skirts, hankerchiefs			

Table 5.1 : Summary of Capacity Regulation in the Textile Industry (Cont')

Date of Announcement	Type of Industry					
	Synthetic Fibre	Spinning	Weaving	Knitting	Bleaching/Dyeing Finishing	Garment
28 Sept.1979						Permitted setting up/expansion of garment factories provided that the total number of machines did not exceed 30 except those production which were restricted by quota
15 Oct.1980			Permitted factories producing decoration fabrics to set up/expand			
28 Jan.1981	Announcement made to unlicenced factories to apply for permission within 45 days					
18 Sept.1981	Accepted to consider application made by factories which involved polymerization	Suspended setting up and expansion of factories			Expansion/setting up of factories permitted provided that new machines were used	

Table 5.1 : Summary of Capacity Regulation in the Textile Industry (Cont')

Date of Announcement	Type of Industry					
	Synthetic Fibre	Spinning	Weaving	Knitting	Bleaching/Dyeing Finishing	Garment
1 June 1984			Exemption made for woven bands, mark bands, lace bands and dyed yarn fabrics			
21 Nov.1984		Accepted to consider application for setting up/expanding production for export				
20 May 1987	Accepted to consider application for setting up/expanding on conditions concerning location and technology of factories					

Source : Ministry of Industry

first degree holders. Similarly, when one compares between the air-jet and the ring spinning systems of production one would find that the former employs 12 technicians per 130 workers whereas the latter, with the same volume of production, employs only 3 technicians per 220 workers.

Apart from this, the fact that factories have a tendency to use more electronically controlled equipment means that there is a need for more specialized personnel in this area. This specialized knowledge will have to come from formal education more than on-the-job training which is the present practice.

5.1.5 Obstacles in Technology Acquisition at Producers' Level

(a) Market Restrictions

Producers who do not employ high quality technology are often small producers who have only basic technology and little capital, especially producers in the bleaching/dyeing industry. These producers are usually those producing for markets at the border areas or low-income markets which do not demand high quality goods. They demand low-priced products because the cheaper these are, the easier they are to sell. Thus a low level of technology which requires little capital investment is appropriate for these markets. Besides, the necessity to produce hastily in order to supply the markets when the borders are open from time to time leads to the fact that producers would not exercise neatness in production. A change in technology will not come about so long as the demand of the markets does not change. A change of markets means that the business culture of both personnel and entrepreneurs would need to be changed and this requires very higher level of capital investment. Therefore entrepreneurs lack motivation to produce high quality goods for high income markets. A change of markets will be possible only if entrepreneurs' descendants could absorb the new business culture through formal education and take over the business from the old generation of entrepreneurs.

(b) Lack of Information

The textile industry is a highly competitive industry. Moreover, markets and technology change relatively but lack of information makes entrepreneurs unable to appreciate the value of technology since they do not know how far other entrepreneurs have progressed. A large number of entrepreneurs wanted an establishment of a Textile Intelligence unit affiliated to the Textile Industries Division, so that entrepreneurs could utilize the information to make better decisions concerning investment and choice of technology.

(c) Obstacles Which Hinder State's Access

Many small producers who have a low level of technology competence do not wish to use technological services provided by the Government for fear that an enquiry will be made into the income of their factories which may lead to higher taxation. It follows that the Department of Industrial Promotion will have more occasions to service large sized factories than small sized ones despite the fact that it is the latter which need knowledge, experience and information more than the former.

It may be concluded that a study of the textile industry indicates that Government's measures can form major obstacles to the expansion of the industry and to the development of technology. To abolish capacity regulation measures and to promote the industry by providing adequate information service will enable the industry to compete more efficiently in the world market.

5.2 THE FOOD INDUSTRY

Initially, food processing in Thailand concentrated on processing agricultural produce and cereals into food products such as flour and noodles. Nowadays, processing of food takes more diverse forms such as canned food, frozen food, oven-dried food, liquefied food and so on.

Raw materials which are used in processing also become more diverse, including vegetables, fruits, poultry and sea-animals. However, this study will concentrate particularly on canned food and frozen vegetables and fruits industries.

5.2.1 Status of the Food Processing Industry[3]

In 1989, the export of canned food was valued at 29,344 million baht. This can be broken down as first, 21,125 million baht of canned seafood; canned pineapple comes second being valued at 4,400 million baht. Canned vegetables and canned fruits (excluding pineapple) were valued at 2,557 and 1,262 million baht, respectively.

(a) Canned Vegetables and Fruits

Considering the increased value from 1980 to 1985, one would find that the canned fruit and vegetable industry expanded by 15% and in 1986 and 1987, the rates of expansion were 41 and 55% respectively. There are altogether 37 canned fruit and vegetable factories. The total production capacity is 672,800 tons per year. If we consider the canned fruit industry alone, we would find that 95% of the products are canned pineapple. Canned pineapple is the most important exporting canned fruit product. Major foreign markets are in the United States and the European Community. As far as the canned vegetable industry is concerned, 29 and 21% of products are canned bamboo and canned young corn respectively. Ninety-five percent of the markets for canned vegetables and canned fruits in Thailand are export markets because Thai consumers prefer fresh vegetables and fruits to processed products. The important export markets for canned vegetables and canned fruits are the United States and Japan.

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[3] These figures are quoted from the report entitled The Identification of Key Technologies for Industrial Development, TDRI 1991.

(b) Canned Vegetable and Fruit Juice

In the years 1987, 1988, and 1989, the total volumes of canned fruit juice are 30,750, 48,953 and 60,825 tons respectively. Thailand is the second biggest exporter of canned pineapple juice in the world, the first being the Philippines. The major exporting markets for Thailand are the United State and the European Community. As for canned vegetable juice, the amount of production is still small, accounting only for 0.06% of the whole processed vegetable and fruit industry. In 1989, the most important exporting markets for canned tomato juice are New Zealand and Canada which imported 40 and 30% of the Thai export respectively.

(c) Canned Sea Food

In 1988, the export of canned sea food was valued at 20,089 million baht. The main product was canned Tuna fish, the export quantity being 200,967 tons or 12,964 million baht in value or 59% of the total canned sea food export. The major export markets are the United States, England and West Germany. In 1989, the export increased 21,125 million baht.

(d) Frozen Fruits and Vegetables

This branch of the food industry is still small because the domestic markets prefer fresh vegetables and fruits which are available all year round. Entrepreneurs in this industry are also few and their factories are mostly situated in the provinces in the outskirts of Bangkok. The production tends to be a big-scale industry because it requires expensive machinery. Thus, there is still little export of frozen fruits and vegetables to the world market. In 1989, the export was 45,993 tons, valuing 519.8 million baht.

Most of the exported vegetable products are beans and asparagus. The major foreign markets are Japan, Malaysia and Hong Kong. Similarly, the volume of exported frozen fruits is still small. In 1989, the export of frozen fruits was 51,929 tons, valuing 783.7 million baht.

Most of the exported frozen fruits are sliced pineapple, the major foreign market being Hong Kong, Malaysia and Singapore.

5.2.2 The Status of Technology in the Food Industry

(a) Canned Food Industry

The canned food industry is an industry which attracts constant interest for investment because investment capital can vary from a few million baht to several million baht. Besides, it is an industry where sources of technology are easily acquired and it seems, raw materials are plentiful. This perception is due the fact that Thailand has a large number of farmers and a vast amount of land and resources which are used for agriculture. However, it seems that in this industry, bankruptcies of newborn businesses are very common.

One of the causes of bankruptcy is that Thai entrepreneurs do not base competition on a productive process. Of all the three main activities conducted by producers, namely, purchasing, manufacturing and sales, producers can control only manufacturing activities. As for prices of raw materials and products, these are determined by either the international or the local markets. Thus in the food processing industry, production management is an important matter.

The canning industry is an industry where hardware technology has been stabilized for a long time. Therefore, the productivity of this industry depends on not only hardware technology but also the capability to manage production as an important factor. Production management means that producers must be capable of controlling production according to a work plan and solving unexpected problems which may arise. For instance, when fish are bruised, a way must be found to extract the blood so that the fish's skin would glow and look fresh without having to discard the raw material. Most importantly, there must be minimum weight loss or maximum yield and this depends on the state of the raw materials, methods used in sealing cans and sterilization.

Canning in Thailand is mostly done by a normal seamer system. This method causes a lot of weight loss. As for the stem flow system, which is done by spraying hot steam to expel air from the head-space and seal the cans quickly, this is a process which causes less weight loss and has now been brought into use by some big firms. Another system which causes least weight loss is the vacuum system. This system is suitable for very large firms because the machinery required is expensive. Nowadays, Thai technicians can create almost all the machines used in the normal steamer system but they have not been able to create machines for the steam flow and automatic seamer system.

As for sterilization, there are at present two methods. First is pasteurization which requires a temperature lower than 100°C. This method can evade some microorganisms especially those dangerous ones and those causing diseases. However, by this method, the food can be preserved for only a short time and can become spoiled after a while. The other method is sterilization requiring a temperature over 100°C. This method can kill all microorganisms. Food can be preserved for a longer time within a completely sealed container.

Sterilization in canned food is a process which requires knowledge and experience in order to produce food which is free from germs. The method of sterilization would have to take into account the acidity of the materials which can be classified into 4 categories as follows:

(1) Low acid foods. These are food which has a pH value of 5.3 and higher, such as canned beef, prawns, fish, beans and corn etc.,
(2) Medium acid foods. These mean food having a pH value between 4.5 and 5.3, such as canned soup, bamboo shoots, young corn and vegetables and mushrooms etc., and
(3) Acid foods are food which has a pH value of between 3.7 and 4.5. These are canned tomatoes, longans and lichees etc..

(4) High acid foods are food which has a pH value lower than 3.7. These include canned pickled vegetables, strawberries, persimmon fruit, fruit jam and roselle juice etc.

In factories which produce low acid foods (the first and the second categories), sterilization has to be performed by a particular method whereas in the case of high acid foods, microorganism called clostridium botulinum, which is harmful to the human body, cannot grow. Sterilization in low acid foods may require some adjustment of the acidity in the food and a higher temperature, that is around 116-127°C, at a pressure of 10-20 lb. to the square inch.[4] As for the time required for the process, this would depend on the size of the cans and pieces of the food material, the concentration of the food, initial temperature of the tins before sealing, quantity of food substance and the arrangement of cans in the autoclave.

The markets of machinery used for can sealing and sterilization are not monopolized. Thus, producers of canned food have an equal opportunity to acquire machines. The competition lies in the production know-how which each firm would learn by experiments and experiences as to what temperature, length of time and how to manage in order to gain maximum yield and save the most energy. This know-how would come by industrial experience which requires hiring skilled technicians or acquisition of experienced firms.

A problem of canned food which often occurs is swelling of cans. This may be caused by inefficient control of the quality of raw materials, contamination, delayed production process and adequate control of the sterilization process etc.. The solution to this problem

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[4] For high acid foods (the third and fourth categories), sterilization can be done by boiling the food at a temperature of 100°C or using hot steam at 105°C.

would need a correct and strict production control and management. This means that producers must have some scientific background and technical knowledge.

Containers used in the canned food industry are mostly made of iron sheet coated with tin and there has not been much development on this. By contrast, the fresh milk and fruit juice industries have developed technology in making containers so as to provide convenience for consumers, for example easy opening cans and using of paper box containers treated by UV light. The latter is being produced by the Tetra Pak Company and are now being used by the ready drinking milk industry in Thailand. In foreign countries, this kind of paper box containers are used for containing fruit juice in order to reduce weight, eliminate contamination problem and avoid problems caused by erosion of metallic containers. One of the reasons why there has hardly been development in the local canned food containers may be a lack of competition in this industry, as there was a period of time when production capacity was regulated and consequently there was only one producer. However, this regulation has now been dropped.

(b) The Frozen Food Industry

The frozen food industry will become a very important exporting industry in the future. In this study, special attention will be given to frozen vegetables and fruits. At present, there are two systems of freezing. These are (a) plate freezing (b) air freezing, such as air blast and individual quick freezing (IQF). The choice of which system depends on the type of products, the demand and size of the markets. For instance, in using strawberries as raw material for making jam, plate or air blast freezing must be employed. But if strawberries are to be sold as fruit, IQF must be employed. IQF is suitable for freezing vegetables and fruits whose fresh quality is to be maintained. This system needs high investment and suits producers who have certain export markets. Nowadays, the IQF system has been applied to durians,mangoes and mangosteens.

In a survey of provincial factories, it is found that IQF has recently become popular in the north. The IQF system has been installed in Lam Phun and Chiang Mai and will soon be installed in Lam Pang and Chiang Rai. Interviews with factory owners, revealed that there is no problem concerning use of imported machinery because the machines are relatively new. Instead, there are problems with regard to factory auxiliary devices supplied by local firms. For instance, belts which are made in Thailand would often break down. Every factory is more concerned with a shortage of raw materials than with technology. Some factories have raw material supply which is less than 20% of their production capacity.

5.2.3 Technology Acquisition

The source of technology for food processing in Thailand is Taiwan which is a country endowed with both industrial and agricultural experience. There is an integrated production starting from culturing to manufacturing of food materials. Also food processing machinery and cost of technology when compared to that of the same in western countries, are much lower. This is because Taiwan has the capability to copy foreign technology by reverse engineering.

The food processing industry first started in Thailand because Taiwanese entrepreneurs moved their production bases to Thailand with an aim to gain export quota. The conditions of the climate and labor cost are such as to enable them to compete. As Thai entrepreneurs saw the profitability of food processing activities, they followed Taiwanese entrepreneurs to invest in this area by acquiring technology and experienced technicians from Taiwan. This phenomenon coincided with the fact that food processing activities in Taiwan were starting to decline due to a rise in labor cost and currency appreciation. Thus, Thai entrepreneurs were able to purchase used machines at a low price and there were a large number of skilled technicians to be hired. Apart from helping Thai entrepreneurs in setting up a production system during the initial period, these experienced technicians are the channel through which Thailand acquired research and development data from Taiwan. Previously, the

Taiwanese Government had spent much on the universities for the development in this area. Some factories even sent their relatives to study at Taiwanese universities because the technical documents on this subject were all written in Chinese.

While small Thai firms would hire experienced technicians from Taiwan to start production, small firms in provincial areas such as Chiang Mai, which have less capital and information, will have to rely on advice provided by a local university. After the factory has been set up and activities started, they would hire machinery factories inside the country to copy machines or to carry out reverse engineer. At present, a cyclone evaporator for producing concentrated tomato juice has already been copied by Thai technicians, but its production quality is not yet clear. As for big international companies, they get access to technology by acquisition and merger licensing the needed technology.

With regard to frozen food technology, foreign companies tend to use expensive and high quality machinery from Japan and Europe. Joint-venture companies would use the European cooling system and Taiwanese processing machines. Since foreign companies have big capital and their investment is being promoted, they could afford to use commercially proven machines. As for Thai companies which have low capital, they have to risk developing their own technology. With the cooperation of the Faculty of Engineering, Chiang Mai University, a Thai firm adapted the existing technology, that is the air blast system working jointly with IQF by adding another belt to the air blast chamber.

In conclusion, in the food industry, the technology market is relatively open. There is no problem in technology access, except in the case of packaging by Tetra Pak which would not sell technology but would hire out machines instead. However, there are other rival companies in the world and thus this technology is not altogether monopolized.

5.2.4 Problems and Obstacles Seen by Entrepreneurs

Entrepreneurs in the canned food industry are not so much concerned about technology. When they were asked to enumerate important problems, they stated the following as their major problems. These are raw materials, labor cost, lack of support from the Government to bargain with foreign countries and problems concerning containers. Of all the problems, they see raw material problem as the most important and much more critical than others. Only the raw material problem will be discussed here.

Food processing, especially canned food and frozen food, requires raw materials which are high value crops and this must be considered as new crops in Thailand. Though Thailand has been producing agricultural crops for a long time, farmers are experienced only in growing low value field crops. Therefore growing high value crop would need substantial technical advice. Also, the existing farming characteristics are that production are in small farms. As a result, when a private firm opens a factory, it would have to purchase raw materials from a large number of farmers. It becomes necessary to create a system of contract farming to guarantee that a factory would have sufficient raw materials. However, it has turned out that many factories lack the capability to promote contract farming. They also lack the understanding and effort to create institutional arrangement which would benefit both farmers and the factories. As a consequence, most of the factories surveyed do not have enough raw materials and do not get the materials which possess the quality they require. Some of them exercise only 20% of their production capacity. Canning of some food has to rely on imported raw materials. For instance, dried beans are imported from New Zealand; mushrooms stored in concentrated salt water are imported from China for canning because there is a very low quantity of the raw material within the country and its quality is uncertain. Problems of institutional arrangement between farmers and factories are those outside the scope of this study and thus the details in this matter are omitted here.

As regards raw materials which are used for breeding prawns, technology from Taiwan has been transferred to Thailand to the extent that Thailand can now produce in a mass. However, the system of production is not so efficient and is without sustainability. The situation now is farmers produce separately. Mangrove forests which are breeding grounds for aquatic animals are being destroyed and farmers drain polluted water to others' fresh water ground. A good example is the case of producers in Samutsakorn who have to give up their business because of polluted water.

While Taiwan has a more changeable climate than Thailand, it has been able to maintain the sustainability of prawn breeding for over ten years. Thailand may not be able to keep sustainability for that long if the production system is not properly managed. At present, the methods used to expand production are to struggle for unoccupied land and to use that as breeding grounds for only a few production seasons before moving on to another piece of land. Therefore the present production system is without sustainability. Eventually, entrepreneurs will lose their business, the country will lose this industry faster than it should do and the people will lose the mangrove forest permanently in only a few years to come.

As far as raw materials from fishing are concerned, the Thai waters do not have enough raw materials for the industry. Although the Thai fishing fleet is the seventh biggest in the world, it has to go increasingly further away in order to fish. However there are fishing boats which do not have modern cooling devices to maintain the freshness of raw materials. When they arrive on shore, there are not enough refrigerators. Improper methods used to maintain freshness of raw materials make them injurious to health. For fishing boat, it is not worth investing in modernizing their boats because the high risks of being captured by neighboring countries. Raw materials from the sea are of either not the right specification or not up to the quality required.

The private sector sees these problems as being serious and most urgent in the food processing industry. They are problems which the private sector cannot solve alone. The State will have a more important role in managing raw material problems than in acquisition of technology. The capability to compete in the world market depends on not only production efficiency at the factory level but also the capability or efficiency at the national level to acquire, develop and bargain for raw materials.

5.2.5 Problems and Obstacles in the Acquisition of Industry Specific Technology

Three major principles in food processing are freshness, sanitation and sterilization. With regard to technology to maintain freshness which concerns planting methods or nurturing, harvesting and transportation, these are outside the scope of this study. Here we will discuss problems and obstacles relating to the improvement of the production process.

(a) Problem of Lacking Basic Knowledge and Production Experience

Although Thailand has been exporting food for a long time, it is mainly cereal type of food which has relatively few problems concerning shelf-life when compared to vegetables and fruits. Since Thai raw materials are tropical raw materials, there is no source of information and technology readily available in the world which can be brought to use as in cases of scientific knowledge and other technology. Therefore, Thailand needs to develop its own technology. At the present time, however, knowledge concerning chemical and physical properties of agricultural produce possessed by Thai governmental agencies is still limited to field crops, especially rice.

The situation now is that most Thai entrepreneurs produce with little basic knowledge, using trials and errors to find out means which would reduce production cost. Since they only know how and do not know why, causes are often not found except only by chance. Refrigeration is done without knowledge concerning a freezing curve of each raw material. Besides production activities are conducted without reference standard. Thus experiments are not systematic. For most vegetables and fruits, there has not been yet a systematic study of their properties, such as acidity, solid content classified by species, time and place of cultivation. When customers wish to order new products, such as ground onion, producers are unable to serve their needs because they are not certain whether the species they possess have sufficient solid content. With regard to exported fresh fruits, producers lack knowledge concerning heat of respiration. As a result, they are unable to develop appropriate post-harvest and packaging, including a transportation system which would prolong the life and preserve freshness.

Export of high value added crops which need to be processed is a new activity in Thailand. The expansion of this business occurred before an investment was made to create basic information. The Thai Government has invested very successfully in research and development work concerning cereals and field crops. It is time they turned to create basic information concerning horticulture crops as a base for improving crop species and processing in the future.

For sanitation in a production process, there must be knowledge and understanding in managing systems of public utility. This starts from constructing a building which is free from insects, rats and birds. Building materials for the floor must absorb least water and types of water used during various processes must be carefully selected. Most entrepreneurs do not understand that in the food industry, there are various types of water which must be selected for use in order to minimize cost and to maximize safety. For instance, the first type of water is the lowest quality water, which is taken from canals or wells and is primarily filtered. This is used to heat cans without contacting with the food.

However, there are producers who use this type of water to reduce cans' heat at the time when the seams reach maximum expansion. As a result germs existing in the water may leak through the seams and grow in the food. The second type of water is potable water. This kind of water would cause water marks on a can if it is used to reduce heat and this make the product unattractive for buyers. The water used to clean chopping boards and conveyor belts through which must be sterilized water with a higher proportion of chlorine than usual. For boilers and heat exchangers, softened water must be used in order to avoid calces.

With regard to sterilization, Thai producers adopt techniques from abroad without adaptation. For instance, in using an F zero system which is a graph capable of information about temperature and length of time which ensures 100% sterilization, there would be a fluctuation value, for example, at the temperature of 120°C requiring 60 minutes plus a fluctuation value of 4 minutes. Whereas fluctuation values would vary according to the environment and climate, Thai producers have adopted the system without carrying out experiments to find out appropriate fluctuation values and adjust them according to Thai conditions.

In conclusion, although Thailand has a large food processing industry, it is an industry which has moved its base from Taiwan without a true foundation inside the country. Personnel involved in important technology are foreigners. Some factories which have subcontracted production from foreign companies would receive technical assistance to meet customers' individual standard. But Thai industries lack basic knowledge to create an international standard system of production in order to serve customers in general. The present production is carried out without logical understanding on the part of entrepreneurs. The government lacks personnel and its research work is concentrated on nutrition rather than on research of goods for export.

Obstacles in technology acquisition on the part of the private sector are as follows. First, entrepreneurs lack formal education and knowledge and this deprives them of understanding and interest to invest in technology acquisition. Second, Thai entrepreneurs are used

to buying hardware technology such as machines and devices. They are not accustomed to purchasing and investing in software technology such as know-how which would require accumulation of knowledge and experiences of a working team. They often view acquisition and development of software technology as being costly while there are other easier ways, such as hiring Taiwanese technicians who are patient, capable of doing everything and adjusting them well with Thai conditions. Thus, they are not enthusiastic to acquire this type of technology. They fail to understand the fact that for a business to progress continuously, there is a need to accumulate technology systematically within the organization and it is not enough to depend on any particular individual alone.

Technology promoting activities of STDB, such as D/RDS may be able to encourage entrepreneurs to give more attention to improving software technology. Also, expansion of STQC activities in low acid canning to the industrial circle would help to solve problems concerning lack of technology and improve basic knowledge on the part of the private sector.

(b) Supporting Industries such as Machinery and Metal-working Industries are weak.

The Metal-working industry is incapable of producing good components and parts. Imported metal components and parts are subject to a duty of 30-35%. Imported rubber parts are still subject to a high rate of duty in order to protect the local rubber industry despite the fact that there are no parts which are domestically produced.

The fact that the Metal-working industry is weak provides an opportunity for sellers of components and parts in Thailand to set high prices for their goods. Some components and parts cost more than exactly the same products in Singapore.

With regard to agricultural processing machinery, Thailand has a high level of capability in producing rice milling machines, Tapioca pellets machines and some machines for sugar factories. Production of rice milling machines has reached the point of exporting such machines and Thailand is capable of carrying out reverse engineering of machines from Europe. This has made machinery importing companies refrain from importing machines for sale in Thailand.

But when it comes to other agricultural processing machinery, except cereals, tapioca and sugar, domestic production capability of machines and equipment is relatively low. This is because there is little opportunity to acquire experience in this regard. A certain number of food processing machines and factory equipment have been produced in Thailand by copying imported machines, mostly Taiwanese machines technology of which is not so complex. However, the fact that they copy Taiwanese machines which have no specifications, Thai machines become even less systematic. They can be operated but their efficiency rate cannot be specified.

5.2.6 Problems and Obstacles in Acquisition of Generic Technology

Generic technology in the food industry comprises energy saving technology and waste management technology. As far as energy saving technology is concerned, most entrepreneurs do not know-how to save energy. They do not know the industrial standard of energy consumption and the proportion of energy cost to cost structure. Since there is no reference criteria, they would not know whether their existing practices are good or bad. As a result, there cannot be an acquisition and improvement of energy saving technology.

With regard to waste management technology in the food industry whose raw materials are fruits and vegetables, the waste in most cases is sold as animal feed and thus there is no management problem. As for fruit skins such as rambutans and longans this kind of waste is disposed of or burned. In medium sized and small sized

factories, the quantity of daily waste is not big enough to be further processed. Also, for local raw materials, there is no ready-made technology from abroad to put the waste into use. Therefore, there is a role for the public sector in developing waste management technology. As for canned fish factories which have a large production capacity, water used for cleaning fish can be processed to obtain a new product such as cooking sauces. This is made possible by purchasing the technology from Japan. However this process still leaves a large amount of waste in the draining water. For private firms, gains from developing wastes into product are not worth the cost.

It can be concluded that the food processing industry under this study has grown rapidly without a solid technological foundation. Private organizations lack S&T information, knowledge, understanding and hence interest to further acquire software technology. This will prove to be an obstacle to the development of this industry in the long run.

5.3 THE GEM AND JEWELRY INDUSTRY

In 1989, the export value of the gem and jewelry industry[5] was as high as 28,421.9 million baht. It ranked third, being next from rice and garments. Therefore it is considered to be very important for the Thai economy. The major export markets for Thai gems are Japan, the United States and Belgium. Most of the exported gems are rubies with blue sapphires and followed by diamonds. As for jewelry, the major markets are the United States, Japan and the European Community (West Germany, France, the United Kingdom and Italy). The jewelry exported comprises gold, silver and other valuable jewelry.

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[5] These figures are quoted from the report entitled The Identification of Key Technologies for Industrial Development, TDRI, 1991.

Production of ready-made gems and jewelry has created substantial employment and this industry need a large pool of skilled labor with experience, care and delicacy. Machines cannot replace workers' skill and experience. In 1987, the number of workers employed totalled 1,223,500.

The gem industry consists of two groups of firms. The first group comprises big factories. There are about 15 factories in this group and they share as high as 60% of the export market. This group has relatively high production technology and thus they hardly have technological problems. The second group comprises small factories employing from 2-3 workers to 40-50 workers. These factories number around a thousand in all. Most of them produce to supply domestic markets and some export through trading firms. These firms have relatively low technology. Of all the two groups of firms, there are about 103 firms which have received investment promotion.

The gem industry consists of three main processes, namely heat treatment, cutting, making gem bezels and setting of gems. A summary of the state of technology in this industry will be given in the following.

5.3.1 The Status of Technology

(a) Heat treatment

Heat treatment is a traditional technology. It is a part of the production process in a gem cutting factory. Heat treatment is carried out by gems in a furnace with refractory lining. Heat may be generated by gas, oil mixed with alcohol or electricity depending on the required temperature. Small factories would treat gems in an oil barrel. Most factories do not have temperature measuring and controlling devices. Instead, they would rely on the skill and experience to determine at what temperature and for how long gems from a particular source should be treated. The gem structure should also be taken into account in its

treatment. Gem treatment may take hours or days. The art of gem treatment has so far remained a personal or family secret, not to be transferred to outsiders. In general, gem treatment has a characteristic of alchemy rather than being a scientific process.

Nowadays, big gem businesses use computer to control temperature and to record data for analysis so that factories would be able to treat gems according to the required quality. However, this knowledge is still a trade secret.

(b) Cutting

Most cutting is performed by using domestic tools. Workers are usually assigned different tasks. Thai workers have great skill in gem cutting but they still have little experience in lapping diamonds. Labor for cutting usually comes from the provincial areas. Most of the firms interviewed do not have problems concerning employment and training. It takes only a few months to train workers.

At present De Bier's Company which holds a monopoly in international diamond trade has started to subcontract the work of diamond cutting to Thai firms.

(c) Making Gem Bezels and Gem Setting

Most Thai firms have no knowledge about alloy and properties of metals which are used to solder valuable metal bezels. Most goldsmiths are skilled workers who were trained when they were young without sufficient background in scientific knowledge, especially metallurgy. Therefore, small sized factories are not capable of making bezels according to the precise standard set by foreign customers.

In future, there is a tendency that the gem and jewelry industry will use more manmade stones in order to supply the artificial jewelry markets. Also, there is a big possibility that De Bier's Company will further expand its diamond cutting base to Thailand. Jewelry production in the future may also need more complicated casting technology, for example the multiple melting point casting to obtain various types of valuable metal bezels without blending the metals.

5.3.2 Acquisition of Technology

Small entrepreneurs acquire technology by inheritance from ancestors and training in other factories. Nowadays, some private institutions have organized a short training course in gemology to interested persons in general. This would provide an opportunity for small entrepreneurs to learn more about gem technology.

With regard to export firms, they acquire technology by procuring machines such as casting machines from Japan. Also, they rely on technical advice given by sellers of alloy. Many entrepreneurs send their descendants to study gemology in the United States.

Although Thai entrepreneurs are able to acquire technology without much difficulty from various sources at the present time, Thailand is becoming one of the world's jewelry centres and this means that there will be less and less opportunity to buy technology. Thus, there is a need to develop more technology on its own. Otherwise, Thai firms will have to merge with or acquire foreign firms.

Thai entrepreneurs who have received technological service are of the opinion that casting technology provided by the government is still at a low level. Research on gem treatment conducted by the Thailand Institute of Scientific and Technological Research lacks continuity and has not brought applicable results.

5.3.3 Problems and Obstacles in Acquisition of Main Technology

(a) Gemology

There are few people who have scientific knowledge about gems. Most of them are skilled workers with experiences in observing colored gems from sources within the country and in neighboring countries. But as domestic raw materials are depleting, there is a need to import raw materials in which Thai entrepreneurs have no experience. If Thai producers have some knowledge about gemological theories and are capable of experimenting with refractive index and light dispersion, they will be able to develop skills in setting and cutting raw materials more rapidly and more cost effectively.

Basic knowledge about gems can be acquired from private institutes both in and outside the country. In addition, the private sector concerned has sufficient economic power to acquire it. The present obstacle has to do with time. In this regard, there are more obstacles on the side of the government than on the side of the private sector. Its personnel still lack the knowledge and capability in this field. Moreover since gem materials have high value, the government cannot invest in research and development in this area.

(b) Metallurgy

As mentioned above, there is still little knowledge about casting general metals in Thailand. Thus knowledge about precious metals is even less adequate. The lack of knowledge exists both in the public and the private sectors. People in general believe advertisements made by gold stores that gold jewelry on sale contains 100% gold even though as a matter of fact, most of it would contain pure gold substance not exceeding 97% at the maximum. Some local gem and jewelry exporting firmware now capable of extracting gold to contain as high as 99.99% in substance and the cost involved is still not commercially feasible.

Therefore at present, they would aim at the rate of 99.9. The ability to extract to reach a high level of purity would enable producers to produce 14K and 18K gold more accurately and at a lower cost.

In producing gold jewelry, there is still a large amount of gold loss because most factories do not establish proper practice. For instance, production is carried out in a room with open windows and thus gold particles get blown away. There is no establishment of suction piping to or suction of dust for filtering in order to retrieve gold dust or filter attached to air conditioners. All these cause production cost to be higher than necessary.

The important obstacles are that small firms do not know the proper control of gold loss. For very small firms, though they appreciate the fact that there is gold loss during production, the amount lost is too small to be worth building up a retrieval system. Instead they often choose to sell dust and waste to large sized factories which have the capacity to extract gold.

With regard to generic technology, such as computer-aided design (CAD), this has not been brought into use because labor cost in Thailand is still low. Besides, gem cutting still requires skilled workers to set the gem in order to produce fire and lustre while CAD could only help to save mineral substance whereas these former factors have more value than saving mineral substance.

As for management technology, this has received much attention from big businesses because of the valuable raw materials which are involved. Therefore, there is a strict system management.

Most entrepreneurs, big and small, do not consider hard-ware technology to be an important problem. Big entrepreneurs believe that their business has a higher level of technological capability than the government while small businesses have no knowledge and are not interested in searching for such knowledge because tax evasion helps to reduce cost and thus, the necessity to improve efficiency.

5.4 THE PLASTICS INDUSTRY

At present, there are not less than 3,000 commodity plastic factories, most of which being situated in small shophouses. From statistics of registered factories with the Ministry of Industry, in 1989, out of 1,536 factories registered, 77% were in Bangkok. From 1986 to 1989, the average expansion rate of the industry was 30% a year. Plastic commodities which bear a high proportion of export to production are plastic flowers and plants and toys. The proportions of export to production of these commodities in 1987, 1988 and 1989 are 87, 77 and 65%, respectively. Major export markets for Thailand are the ASEAN countries, the European Community and the United States, accounting for 38.4, 35.6 and 8.7% of Thailand's total plastic commodity export value, respectively.[6]

5.4.1 The General Status

The plastic industry in this study means commodity plastics and engineering plastic, the first category consisting of 80-90% of the total number of factories. At present, it is estimated that there are about 3,000 factories. Most of the plastics used in production are PP, PE, PS, PVC and ABS etc.. The second category comprises about 10% of plastic factories. They produce plastic parts and components for the automotive and electronic industries.

Here, the plastic industry will be classified according to levels of production technology into 4 groups as follows:

(a) Small Subcontractors

This group consists of small sized factories employing 20-30 workers. They subcontract according to designs by customers. These factories would have 2-3 machines, namely injecting, blowing and

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[6] These figures are quoted from the Report on Determination of Target Technology for Industrial Development, TDRI 1991.

extruding machines. Most of the machines are second-hand machines from by big factories or second-hand machines from Japan or Hong Kong. In addition, some machines are manufactured in Thailand by copying foreign models. Commodities produced by this group are mostly of low quality and prices. Therefore, plastics used for most production are low-grade plastics by melting rejects plastic waste from big factories to manufacture new products. Molds and dies used in production are simple types which do not require much precision, that is only millimetre scale of precision is required. Therefore, small machining factories are hired to manufacture molds and dies. Most firms in the group do not posses much technological knowledge. Their technology is acquired through work experience, trials and errors, sellers of machines and plastics etc..

(b) Subcontractors and Commodity Producers

This group has similar characteristics as the first group but they are also commodity producers themselves. They develop their capability by joining trade exhibitions which generates idea for product imitation. Since the manufacturers in this group frequently join the machinery exhibitions, some of their machinery and equipment are fairly new, especially plastic injection machines. The most popular ones are from Japan. Second in popularity are machines from Hong Kong. Machines from Germany are known to be good but as they are expensive, and hence not so popular. As for Taiwanese machines, these are viewed as inefficient. As far as extruding and plastic blowing machines are concerned, Thailand has been capable of manufacturing them. Since this group have more modern and better machinery than the first group, they sometimes obtain contracts to produce higher quality products. As a result, mold and die manufacturers must be able of to produce more sophisticated work and need more precision equipment. These are problems remain to be solved.

(c) Medium Sized Factories Which are Capable of Making Molds and Dies

This group of firms have a higher capability than the first two groups. They are capable of making their own molds and dies. This capability has come about as the firms expand with greater diversity of products to be manufactured. Also, they may contract to perform work which requires greater delicacy. For all these reasons, hiring of other machining factories may become a bigger problem. It is difficult to find machining factories with great skill. Also, the fact that molds and dies need to be readapted all the time and there is a necessity to make molds and dies ready in time have prompted this group of entrepreneurs to make their own molds and dies in order to make their business flow. This is done by attracting experienced technicians into their firms to make molds and dies. Therefore the firms' capability to make molds and dies depends on the ability of technicians they hire. Most technicians are skilled because they have accumulated long experience in making molds and dies. The methods used and the capability to produce molds and dies are thus quite limited. Products manufactured by this group of entrepreneurs are of higher quality than the first two groups. Apart from producing commodity plastics in general, this group of firms produce parts and components for engineering plastics. These are electronic and automotive parts and components. Some of these products are manufactured by acquiring molds and dies from principals. Plastic resins used for production are mostly good grade plastics with compounding.

In a survey conducted by the Department of Industry Promotion (Pranee Opasanon et al 1990) concerning the technological state of 49 medium sized and small size plastic factories, it was found that 53% of them had been established for less than 10 years. The majority of the factories (67%) supply 90% of their total product sale to domestic markets. Also most of them have no production development due to the following reasons; lack of capital (50%), no foreseeable new markets (33%). With regard to factories which have actually carried out product development, it is found that when new products were accomplished, the demand for

them were lower than that had been expected and production cost arising from development effort proved to be too high. This phenomenon helps to confirm that a change in production process without changing marketing cannot be successful.

Most product quality control is set according to the firms' own standard. Products which do not meet the firms' and customers' standard are estimated to be 6.8%. The majority of factories (67%) would maintain and repair machines only when they break down. On average for each machine, the time lost due to breakdown is about 4.6% of the total time. Details concerning the state of the industry are presented in Appendix 5.

(d) Large Sized Factories Which Manufacture Their Own Products and Joint-venture Firms

This group of firms acquire technology by becoming a joint-venture with foreign firms. Therefore they would receive both technological assistance and molds and dies from their respective joint-venture firms. Most entrepreneurs in this group would manufacture their own products and put the products on the market. They seldom subcontract to produce. Most of the products manufactured are of high quality. There is more manufacturing of engineering parts and components. Therefore this group of entrepreneurs have fewest technological problems. The only knowledge they lack is about plastic compounding which is at present an area being researched and developed. As this is normally a trade secret, it is not generally revealed.

5.4.2 Problems of Technology Acquisition from the Views of Entrepreneurs

Each group of entrepreneurs have the following problems concerning technology acquisition:

(a) Medium Sized and Small Sized Factories

These are classified into the first and the second group. Entrepreneurs in these groups do not appreciate the importance of searching for technology. This is because most of the goods produced are for supplying lower levels of markets. Prices of products are therefore more important than quality. Entrepreneurs would try to reduce cost by using low-grade plastics and employing unskilled labor at low pay. They would also try to reduce the weight of their products in order to bring down the cost. This is done by altering or adapting the molds. However entrepreneurs in the second group may have some problems in finding machining factories to produce good molds and dies in cases when they are contracted to do piece-work which demands higher quality.

(b) Medium Sized Factories

Entrepreneurs in this group appreciate most the importance of technology. They know that acquisition of good technology would enable them to increase productivity and raise quality of products. However they lack information to search for technology. They do not know where to find joint-venture and consultancy. They lack knowledge concerning technology to be applied. As a result, they experience problems in their choice of plastic resins, making of high precision molds (less than 10 microns), including adjustment of injecting machines to suit each type of products. Therefore this group of firms cannot reduce much production cost and this limits their capability in market competition.

(c) Large Sized Factories Which Become a Joint-venture with Foreign Firms

This group of firms have no problems in acquiring technology because technology would be transferred from their respective joint-venture firms. However, as most products manufactured by this group are plastic parts and components to supply the automotive and electronic industries, they need better knowledge in engineering plastic

5.4.3 Obstacles in Technology Acquisition

The major technologies designated by the Determination of Target Technology for Industry Development Project to be crucial for the plastic industry are compounding technology, mold and die designing and management. The existing obstacles for technology acquisition are as follows:

(a) Compounding Technology

Technology in this area is still being extensively researched and developed because there are none who truly possess the knowledge. Besides, it is normally treated as a trade secret. Big firms have to buy know-how from foreign countries and thus they would possess only the compounding technology which has been bought. To improve the capability in this area requires both research and development.

(b) Mold and Die Designing

This is the area where medium sized and small sized firms would encounter most problems. This is due to a lack of basic knowledge in making molds and dies systematically, starting from mold and die designing, drawing, interpreting of designs to making molds and dies and trying them. The reason for this lack of knowledge is the fact that there has not been systematic accumulation of knowledge in the Thai industries. The capability possessed by most technicians in making molds and dies is purely a result of their skill and experience. In addition, machinery for making molds and dies is expensive. For instance, in the case of a copy milling machine, eventhough reduction of import duty for machinery has lowered its price from 10 million baht to 7 million baht, it is still too expensive for medium sized and small sized firms.

(c) Management Technology

About 70% of the commodity plastics industry are small sized factories. Another 15% are medium sized factories and the rest are large sized factories. Most small sized factories have management problems because entrepreneurs lack knowledge and capital. Most factories are situated in row apartments. They are established because entrepreneurs concerned see business opportunities and procure machines to produce contracted piece-work. Their businesses are of simple types without considering a need for production management.

5.4.4 Opportunities for the Plastic Industry

For Thailand, the plastic industry has potential in the following areas:

(a) Product Designing

Since plastics are diverse raw materials which can be adapted to manufacture new products all the time, development of designing capability will promote the industry to have a long future. Therefore more attention should be given to development in this area. At present, this industry still copies foreign products.

(b) Labor for Plastic Injection

Since the labor cost in Thailand is low when compared to that of developed countries, Thailand has an advantage in contracting to perform plastic injection. For instance, one factory which has been contracted to produce electronic parts and components manufactures the products by using semi-automatic injection machines. It has been found that the production cost is lower than that of a Japanese factory which uses fully automatic machines to manufacture the same type of products of equal quality. This has helped the Thai factory in getting selected by a Japanese electronic product firm to be the contractor producing electronic parts and components.

(c) Mold and Die Making

Molds and dies are crucial for producing commodity plastics. R&D in raise the standard of small and medium sized factories. They would enable entrepreneurs to produce goods of better quality. Also, the knowledge in this area would increase the capability in product designing.

5.5 CONCLUSION

A study of technology acquisition in the food, textile, gem and jewelry and plastic industries indicates that in general entrepreneurs who possess capital could acquire technology without obstacles. This is due to the structure of the technology market. Important obstacles exist with regard to State's measures and resource restrictions within entrepreneurs' organizations. The study also shows that conditions relating to marketing and market size have significant effect on entrepreneurs' choice of technology.

It is also found in this study that even consumer product industries, such as the food, textile, gem and jewelry and plastic industries, which have evolved for decades and have brought in vast amount of foreign currencies, still lack a solid technological foundation. Although entrepreneurs are able to acquire technology, they lack profound knowledge of the core of technology. Thus when problems occurred, they are incapable of solving problems and sustaining their efficiency.

CHAPTER 6: STUDY CONCLUSIONS ON GUIDELINES, MEASURES AND MECHANISMS

6.1 STUDY CONCLUSIONS

6.1.1 Technology Acquisition

The most popular technology acquisition method among small and medium enterprises which constitute a major part of the Thai industry is the imports of machinery. The second most important method is technical assistance from raw material suppliers. Technology transfer through subcontracting from customers which are large hi-tech firms is not widely practiced because large firms usually prefer in-house production or production by their subsidiaries.

Foreign investment has played a much more important role in technology transfer over the past 3 years, and has served as a channel to rapidly acquire technology and to efficiently apply technology within a short period of time. However, these foreign firms usually rely on the technology of parent firms, resulting in lack of in-house design and R&D activities. The hope to have foreign firms investing in Thailand acquire or transfer technology to small and medium Thai enterprises has not been fulfilled. Foreign firms prefer backward integration to subcontracting to small and medium Thai enterprises with insufficient technological capability.

Apart from imports of machinery, large Thai firms enter into technology purchase and licensing contracts to acquire software technology derived from production experience to enhance the efficiency of machinery utilization.

Since most technologies applied in the Thai industry are not very sophisticated and most production still mainly depends on labor and natural resources, the technology market where Thai enterprises are buyers is competitive. Thus, technology can be easily acquired. In other words, the structure of the technology market does not impose obstacles to the technology acquisition of the Thai private sector.

Technology acquisition through in-house development is barely practiced in small and medium industries. Even in both Thai and foreign large enterprises, R&D activities are still insignificant because imports of technology and dependence on parent firms provide more commercially reliable and less time-consuming technology acquisition methods.

Nevertheless, some enterprises start to pay more attention to R&D activities due to more intense competition in the local market. In case of electronic products, some enterprises realize the benefits of replacing foreign designs with Thai designs. Thus, design development has been initiated.

Technology acquisition through the government incentive system such as the patent system can be considered unsuccessful. Since 1979, a total of 526 invention patents have been registered. Only 63 inventions were created by Thai nationals and all of these 63 inventors were individuals, not legal entities. The number of patent applicants that were legal entities amounted to only 11 from 63.

Questionnaires were distributed to the 57 Thai inventors listed at the Commercial Registration Department, only 13 questionnaires were returned. According to this survey, there was only one inventor who received a government research grant whereas another inventor acquired financial assistance from a private firm. About half of the inventors who were willing to disclose the volume of financial resources used in their research had total research expenditures not exceeding 100,000 baht. Four inventions have been commercialized, and inventors themselves implemented the commercialization in most cases. There exist several major obstacles of commercialization. Firstly, the lack of technological infrastructure leads to hindrances in the important process linking the laboratory work or concepts with practical application. Secondly, inventions are simply concepts from which inventors have not developed or have sufficient resources to develop the prototype. Thirdly, the public agency concerned has never implemented any public relations for local patents. The Patent Registration Office simply records the addresses of inventors when the

registration takes place. The database has never been updated. Moreover, inventors themselves possess limited public relations capability.

The 44 firms which were interviewed by the research team do not possess any patents. The major reason is that they have not adequately developed their technology to apply for patents and they do not want to reveal their secrets containing commercial value.

Technology acquisition by the public sector still remains a very new activity. In general, there exist two methods, namely, acquisition through public R&D activities and technology extension and improvement of the existing acquisition methods in the private sector. In conclusion, technology and services provided by the public sector still remain limited in terms of scope and capability, and sometimes cannot respond to the demand and trends of industrial technological changes.

6.1.2 Conditions Related to Markets, Entrepreneurial Resources and Technology Selection Decision

It is usually believed that Thai enterprises use obsolete machinery and technology and produce low quality goods due to their lack of knowledge and attitudes which are not favorable to technology development. This study indicates that most enterprises select technology according to the market conditions that they are facing. Since the markets for small and medium enterprises are mainly domestic and border markets which have low purchasing power, limited demand, and prefer low-cost products, the application of high technology in manufacturing these products is not cost-effective. Thus, the possibilities to upgrade the technological capability of these enterprises vary from one to another. Those enterprises with appropriate resources such as educational background, interests to expand connections as well as new market and technology opportunities will be more willing to take risks, leading to potentials to change target markets and marketing culture. Thus, these enterprises will be given more opportunities to upgrade their technology.

Public agencies and private organizations involved in promoting technology acquisition and application need to understand such conditions concerning markets and resources of enterprises, in order to identify appropriate target groups with adequate development potentials.

6.1.3 Obstacles of Industrial Technology Acquisition and Development

This study indicates the following obstacles of industrial technology acquisition and development.

(a) Lack of Science and Technology Infrastructure for Investment in Industrial Technology Acquisition and Development

The infrastructure consists of three major components, namely, organizations, personnel and supporting industries.

(1) Organization

As mentioned earlier, Thai private firms depend heavily on foreign sources regarding technology acquisition because the relative costs of imports are lower than in-house development. However, most of these firms possess merely utilization knowledge. They do not understand factors underlying utilization conditions. During the time of rapid economic expansion, utilization knowledge yields high commercial returns within a short period of time. During the economic slowdown, enterprises will need in-house knowledge to reduce costs and to introduce new products to respond to the market changes. In addition, most private businesses, particularly small and medium enterprises, do not sufficiently invest in acquiring and developing science and technology skills.

Public agencies involved in creating, acquiring and promoting industrial technology are currently encountering problems arising from regulations which do not facilitate the implementation requiring rapid response and interaction. The public organizational structure and regulations have inevitably become a part of the existing obstacles.

(2) Lack of Human Resources with Knowledge, Skills and Experience Related to Industrial Technology

The knowledge referred to here includes 1) basic science and technology knowledge i.e. knowledge on chemical and physical properties of raw materials and 2) knowledge on trends of industrial technology development and market opportunities derived from technological improvement.

The study reveals that the two types of knowledge remain low among Thai enterprises. Skilled personnel lack appropriate scientific knowledge. In other words, a large number of skilled personnel are deprived of systematic science and technology knowledge. Most of the production of small and medium enterprises is semi-industrial and is not accustomed to mass production. In case of only one or two pieces, they can manufacture high quality products, but the quality becomes variable when the production involves a large volume. This is due to the short history of the Thai industry. Technology personnel thus possess inadequate basic knowledge. Engineers lack industrial experience whereas entrepreneurs do not possess sufficient knowledge and experience concerning production technology.

At present, the problem of human resource shortage exists at almost every level. The demand for human resources at each level depends on industry types. For instance, the synthetic fiber industry which is the upstream industry of the textiles industry lacks human resources with bachelor's degree while the yarn spinning and weaving industries need more personnel at the vocational level. Regarding production experience, enterprises have to depend on bringing in foreign experts as in the food industry.

The human resource shortage problem does not exist in the private sector alone. It also imposes a major problem in public agencies responsible for promoting technology, and the problem is even greater than that encountered by private firms which can bring in foreign experts if promoted by the Board of Investment. Public agencies such as

the Technology Transfer Center and universities lack adequate recruitment budgets. The Technology Transfer Center cannot recruit foreign experts. The universities can acquire foreign experts but do not have sufficient budget.

(3) Weak Supporting Industries

Major supporting industries include Metal-working and electronics industries due to their role as the technological base for Thailand's current major export industries i.e. food and garments. These two industries are considered the centerpiece of the Thai industry.

Supporting industries mainly consist of small and medium enterprises. The economic problem lies in the lack of high standard product market, and entrepreneurs have to acquire loans with high interest rates. The technological problem is the lack of design and production skills. Moreover, these enterprises are industrial units neglected by the government. Some enterprises try to avoid taxes. Thus, they do not wish to receive services provided by the government.

With weak supporting industries, the Thai industry shows an unbalanced development pattern. At present, imports of technology are indispensable and very crucial, particularly at the technological level that Thailand still lacks capability. However, if supporting industries are not progressively developed, the Thai industrial development will be similar to constructing a skyscraper without laying a solid foundation.

Most importantly, small and medium enterprises do not possess knowledge and information, and do not realize the benefits of software technology which is not usually embodied in machinery. Most Thai enterprises are accustomed to the application of technology in the form of hardware such as machinery and equipment. They do not have information or knowledge on the importance of software for profit generation.

(b) High Technology Costs (Costs referred to here include machinery, testing equipment and interests)

Most machinery utilized in the Thai industry is imported from Japan. The yen appreciation after 1985 resulted in much higher costs of imported machinery. Since the reduction of import duty imposed on machinery classified under tariff codes 84 and 85 to 5%, the most important obstacle to technology acquisition has been alleviated to a large extent. Nevertheless, many of production equipment including computers, metrological devices and testing instruments are not classified under these two tariff codes. For these equipment, heavy tax burdens still remain.

The costs of acquiring software technology are a part of technology costs. A developing country like Thailand lacks an efficient information system. Thus the costs of acquiring software technology are rather high due to inadequate information. Some entrepreneurs need to search for information abroad. The STAMP Program (See Chapter 2) of STDB which helps reduce the acquisition costs still encounters some constraints. Apart from acquisition costs, software technology is rarely appreciated by local entrepreneurs. So they tend to feel that its benefit does not warrant the cost. Besides, some hidden costs are incurred in the form of restrictive market conditions.

Moreover, enterprises have to shoulder rather high interest costs while their competitors in other countries such as Taiwan and Singapore receive subsidized loans with low interest rates.

(c) Obstacles Arising from Government Measures

Government measures having a strong impact on industrial technology development include the tax structure (at the macro level) and production capacity control (at the industry level).

(1) Tax Structure

It is widely known that Thailand's complicated tax structure has caused economic distortions and resource misallocation. This study also indicates that Thailand's tax structure does not encourage the creation of design skills and instead imposes hindrances to technology improvement and development.

- At the time of the survey, spare parts bear higher import duties than complete knockdown units (CKD), resulting in disincentives to implement local assembly. Various and uneven tariff rates create need to assess taxes on imported parts and equipment, leading to delays in exports and higher costs. This situation imposes obstacles to the development of certain industries such as electronics and automotive industries as the world's contract manufacturing center.

- Business taxes encourage enterprises to manufacture every part themselves in order to reduce costs incurred by business taxes. Thus business taxes are hindrances to the development of supporting industries.

- The taxes imposed on raw materials, measuring and testing instruments remain high.

- Public personnel in charge of import tax collection lack knowledge and understanding related to technology equipment and instruments, resulting in the inability to collect taxes according to the objectives of the harmonized tariff system. Thus, enterprises have to bear more tax burdens than they should.

- The use of tariff barriers to protect a number of firms or industries which cannot manufacture semi-finished products according to the quality and range required by the local industries has caused obstacles to technological and skill development as seen in the case of conflicts between dyestuff manufacturers and the dyeing and finishing industries.

(2) Production Control Measures

The Ministry of Industry has issued measures for controlling capacity expansion with the objective to induce economies of scale. However, this public mechanism cannot efficiently respond to the changes in demand. Moreover, production capacity control reduces competition and thus imposes disincentives to technological development.

6.2 GUIDELINES AND MEASURES

The guidelines and measures recommended here can be applied to the industry in general. The specific guidelines for the six target industries are also presented after the general guidelines.

6.2.1 To Improve the Organizational Structure and Infrastructure for Industrial Technology Development Investment

(a) To Formulate the National Industrial and Technological Development Guideline

Demand for technology is derived demand. No one wants technology per se, but requires technology to further apply it in product manufacturing. Industrial growth is a major technology inducing factor. Thus, technological development planning needs to be well co-ordinated with industrial growth trends.

Besides, technology differs from science in the sense that technology is related to commercial application. Major components of industrial technology are also industry-specific. If technology development is to be planned technological development directions should be in accordance with the industrial development directions. If industrial development directions are uncertain, it will be difficult to induce continued technological development.

At present, there exist many organizations and boards supervising industrial and technological promotion. These bodies independently operate or are not well co-ordinated. Planning in the past did not place an emphasis on the selection of target industries. When target industries are identified, a clear technology plan can then emerge.

An important point to be noted is that during the time when science and technology change very rapidly, monitoring and acquiring technology require a flexible mechanism and an extensive database which can be linked to the market demand information. Thus, policy planning should incorporate the linkages between the policy planners of both public and private sectors.

Therefore, in order to formulate the national industrial and technology development guidelines, The National Committee for the Development of Industries and Technologies should be established and chaired by the Prime Minister or the Deputy Prime Minister. Board members include the Ministers of Industry; Commerce; Science, Technology and Energy; Agriculture and Co-operatives; Education; University Affairs; Interior; Secretaries-General of the National Economic and Social Development Board; the Office of the Board of Investment; the National Environment Board; Director of the Bureau of the Budget representatives from the Thai Chamber of Commerce; the Federation of Thai Industries; and representatives of small and medium enterprises. This Board will be responsible for determining industrial and technology development guidelines, improving conflicting laws and regulations related to industrial promotion and considering approaches to eliminate the problems faced by small and medium enterprises, particularly determining fund-raising methods and fund allocation for industrial technology development. Since these guidelines are long-term plans (10 years), the Office of the National Economic and Social Development Board should be the secretariat.

(b) To Use the Joint Public-private Fund System to Replace the General Public Administration in Developing Industrial Technology

In general, the government has three alternatives in selecting organizational structures to implement policies, namely, general government, state enterprises and trust funds. The current technological service creation and provision rely on the first alternative. According to this study, this organizational structure cannot efficiently respond to rapid technological changes. Therefore, a new organizational structure should be applied, that is a trust fund which is appropriate for activities with distinct targets and interest groups. Moreover, this organization will have management and financial systems different from those of the general public administration to maintain more flexibility.

As the Thai industry is still at the initial stage, and most Thai enterprises are small and medium scale and deprived of accurate information, there is a need for a special agency involved in providing services and monitoring investment in long-term industrial technology development. Thus, resources allocated to technology development may be below the appropriate level. The resources for technology development should then be reallocated through the establishment of the Industrial Technology Development Fund Act to determine the fund and organization in charge of managing investment in industrial technology development.

The objectives of the trust fund include the development of technology for industry with an emphasis on the acquisition, upgrading and improvement of technology, and training rather than research work which STDB already stresses and will be supported by a separate Act. Those who are eligible for financial resources from the fund will be private businesses, non-government organizations and technological service and promotion agencies. If public agencies wish to promote technology by using financial resources from this fund, the projects must be jointly implemented with the private sector.

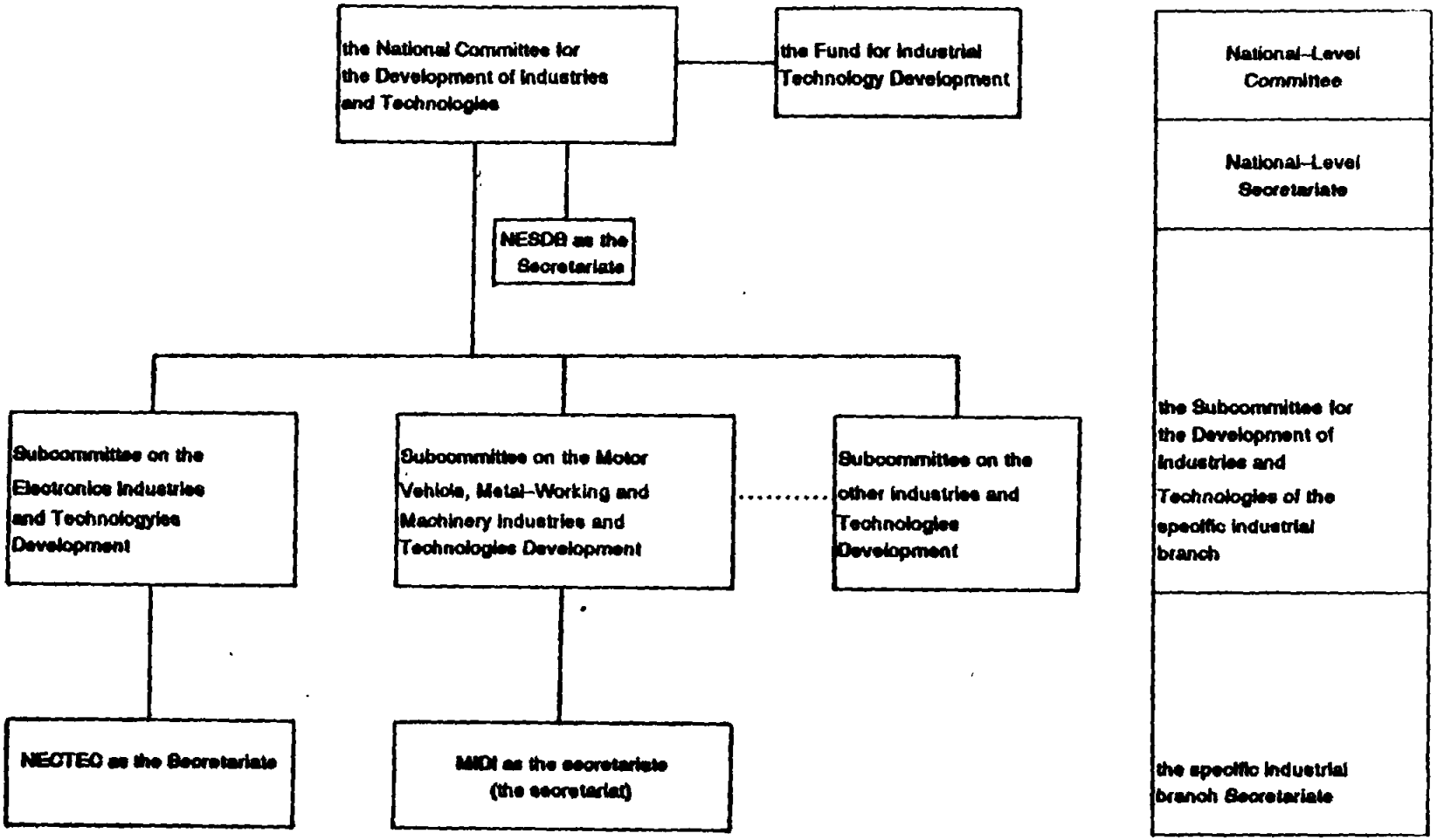
The trust fund will rely on the following financial sources:

- corporate income taxes of firms eligible for using financial resources of the fund and
- export and import taxes related to those who benefit from the fund

The National Industrial and Technology Development Board will (1) determine the fund-raising methods and the size of fund for each industry group, (2) allocate fund to target industries according to the national industrial and technology plans (3 or 5 years), and (3) appoint industry-specific subcommittees to manage industry-specific funds. Regarding industries other than the targeted ones, the Subcommittee for Small and Medium Enterprises will be in charge of fund management. The industry-specific subcommittee will be chaired by a member of the National Industrial and Technology Policy Board. Subcommittee members will include representatives from the Federation of Thai Industries, the Thai Chamber of Commerce experts from specific industrial sectors and professional associations, representatives from high education and technology institutions related to specific industries. The representative from a public agency involved in each industry will be the secretariat (See Figure 6.1).

Private firms, public agencies and state enterprises involved in providing technological services, private organizations such as foundations, professional associations are eligible for applying financial assistance for acquiring and developing industrial technology if the beneficiaries of the projects are industrial businesses. Projects submitted by public agencies may be general training projects (i.e. the development of skills in acquiring industrial technology) or industry-specific projects. This trust fund will be an important financial source of IDS (Industrial Development Support) activities of the STDB.

Figure 6.1 : Structure of the National Fund for Industrial Technology Development



(c) To Improve Financial Regulations to Enable Public Agencies Involved in Technology Service Promotion and Provision to Maintain More Flexibility and More Efficient Management

Most public agencies in charge of technology service and promotion are usually quasi-academic bodies which directly service the private sector. The government administration may cause some red tape and does not timely respond to the changes in demand in the private sector. Some problems may arise from budget regulations and remittances to the treasury. For example according to the government financial regulations, public agencies expend the government's financial resources. In other words, the government is the spender. At present a special law is needed for a government agency to receive money from the non-public sector. For instance, when a public agency organizes a training program, it cannot keep the profits for hardware purchase. Moreover, public agencies cannot request for a budget for the manufacture of a prototype.

Public technology service agencies may require human resources in the areas where there is some shortage. Moreover the public compensation system with low pay scales cannot attract people with expertise and experience to regularly join the public sector.

Thus, it is necessary to improve the organizational structure and financial regulations of the public agencies involved in technology services such as MIDI, the Textile Industries Division and the Technology Transfer Center to enable these agencies to maintain more flexibility and efficient financial management. For instance, public agencies should be allowed to earn some revenues to further finance their services to enter into foreign technology acquisition contracts for further dissemination to local enterprises, to hire both local and foreign experts to transfer technology to local enterprises, to determine compensation rates, per diem, accommodation allowances of resource persons without having to comply with regular government regulations.

(d) To Upgrade Technology of Supporting Industries

To accelerate the growth of supporting industries which are mainly small and medium enterprises the following measures should be taken.

(1) To accelerate the enforcement of the Value Added Tax.

(2) To increase the size of loans provided to private firms in supporting industries to

- replace old machinery with new machinery or technology,
- purchase measuring instruments and precision equipment,
- provide loans through Technology Transfer Center and IFCT to supporting industries to relocate factories to industrial estates or technoparks.

(3) To encourage industrial estates to establish joint facilities for equipment pool such as testing equipment, design computers for small and medium supporting industries, industrial estates may receive loans with low interest rates or exemption of corporate income taxes on the revenues generated from the activities provided to supporting industries. Relocating small and medium industries in the industrial estates would encourage linkages between modern large scale and small and medium supporting industries.

6.2.2 To Promote the Efficiency of Market Mechanisms and Technology Transfer from Abroad

(a) To Abolish Control on Production Capacity

The industrial expansion and competition are major conditions leading to technology development. The production capacity control on the other hand slow down the process of technology acquisition and development. Japan is a good example i.e. although local industries are protected, competition remains intense. In order to enable the market mechanism to function more effectively, the production capacity control measures administered by the Ministry of Industry should be abolished i.e. factory establishment and expansion control for industries where economies of scale are not a major factor. The Board of Investment should cancel protection measures provided to promoted activities which reduce local competition. If some protection measures are deemed necessary, a time frame should be clearly specified and should not exceed 5 years.

(b) To Promote Information-related Measures

(1) The budget and capability of public agencies should be increased to improve the information system on industrial investment (i.e. product types; production capacity in horse power, raw materials and output; volume, types of machinery; energy and water consumed; and labor) to enable investors to make appropriate decisions. Many public agencies such as the Department of Industrial Works and the Office of the Board of Investment already collect these data, but a systematic arrangement and dissemination is necessary. The information related to industries which have specific service agencies such as the Textile Industries Division and the Metal-working and Machinery Industrial Development Institute (MIDI) should remain under the responsibility of these specific agencies whereas information of other industries should be monitored by the Industrial Economics & Planning Division.

(2) The financial and human resource capability of the Office of the Science and Technology Development Board, Technology Transfer Center and specialized institutes should be enhanced to expand the scope of work concerning S&T information.

(3) The Technology transfer Center should establish a directory of Thai patents and should identify private firms interested in commercializing these Thai patents.

(4) Public agencies usually have a large scale investment project such as the Mass Communication Organization of Thailand, the Telephone Organization of Thailand and the Electricity Generating Authority of Thailand. These agencies should prepare a long-term action plan and inform the private sector of the future market expansion trend, including broad technical specifications of major equipment and products so that the private sector can be prepared to develop technology and investment plans in advance.

(5) The Office of the Board of Investment should play an increasing role in promoting Thailand as an international subcontracting center by creating a database on local and foreign vendors, subcontractors and contractors and should facilitate the matching between demand and supply.

(6) The Office of the Board of Investment (BOI) should establish a special program of technology dissemination from existing foreign subsidiaries and joint-ventures in Thailand since BOI is reasonably well equipped with technical human resources and technology information, including data on technical personnel of foreign firms. For example, BOI could co-operate with other public agencies to more systematically induce the transfer of technology from promoted foreign subsidiaries to Thai firms through seminars, short training courses and study tours. In the same, BOI officers may have an opportunity to enhance their knowledge and experience and can be resource persons themselves at a later stage.

(c) To Improve the Existing Tax Structure which is an Obstacle to the Imports of Machinery and Testing Equipment i.e.

- to render the import duty rates on parts lower than those imposed on complete knockdown sets,
- to equalize the import duty rates on spare parts and machinery,
- to render the taxes on laboratory equipment, testing instruments, metrological apparatus and manufacturing-aided computers equal to those imposed on machinery,
- to exempt taxes on machinery and equipment, including chemicals used in waste water treatment,
- to train customs officers to have a better understanding on production technology equipment by recruiting experts from technology service agencies such as MIDI and the Textile Industries Division as well as the private sector so that the tax collection can be properly conducted according to the objectives of the harmonized tariff system.

6.2.3 To Encourage Non-government Organization (NGOs) Both in Thailand and Overseas to Play a More Active Role in Technology Extension

(a) The government should encourage the establishment of vocational associations or professional forum, non-profit seeking foundations to render technology promotion channels more flexible and efficient. These NGOs may be allowed to use the government premises during their initial stage.

(b) Financial support from the government's budget or the Fund mentioned earlier should be directly given to technical NGOs for the purpose of technology promotion.

In Japan most agencies involved in technology creation and promotion are non-government organizations (NGOs) subsidized by the government and the private sector because these agencies maintain greater flexibility and can quickly access business units. If this option is exercised in Thailand small enterprises will feel more at ease with these agencies will inspect their tax payment status. Moreover, private organizations possess more flexibility regarding expert fees, budgeting and hardware acquisition.

In Thailand, there exist only a few private organizations involved in technology promotion. The agency widely known among private firms is the Technological Promotion Association (Thai-Japan), which produces some well-accepted outputs. Their operations are currently financed by the Japanese government. If such organizations are eligible to receive financial support directly from the government or can apply for support from the Industrial Technology Development Fund, technology promotion activities in Thailand will grow more rapidly. Additional training channels will be opened up whereas technology gap can be filled.

6.2.4 To Accelerate the Production of Qualified Technical Human Resources

(a) Computer-aided design and computer-aided manufacturing (CAD/CAM) skills should be developed. The National Electronics and Computer Technology Center (NECTEC) should emphasize CAD training while the Metal-working and Machinery Industrial Development Institute (MIDI) should be the leader in training related to CAM and modern equipment application.

(b) Budget increases should be given to public technology service agencies to organize series of seminars or short training courses for the private sector by placing an emphasis on production management and quality control technology, energy conservation technology and waste management technology. These training programs may be organized by Thailand Management Development and Productivity Center, the Metal-working

and Machinery Industrial Development Institute in co-operation with the Federation of Thai Industries, industrial associations, vocational associations and other private organizations involved in technology promotion such as the Technological Promotion Association (Thai-Japan) by recruiting resource persons with both theoretical and practical expertise. Industry-specific service agencies could increase more specific technology training programs and prepare specific machinery application manuals.

(c) The S&T education system should be improved by

- revising the current curriculum through a stronger emphasis on logics and engineering designs at the university level,
- expanding the dual system which is the provision of basic S&T and theoretical education by Department of Vocational Education,
- increasing the time required for students to have practical training,
- supporting the Factory-in-School system at the vocational level by providing more materials and opportunities for students to actually implement some contract work to increase industrial experience, and the School-in-Factory system where formal education is given in factories. These efforts need to be jointly conducted by the private sector, education institutes under the Department of Vocational Education and public technology service agencies i.e. the Textile Industries Division and MIDI.

(d) The Office of the Board of Investment could play a more pro-active role in attracting local and foreign firms to establish university level technical institutions by offering the following incentives:

- exemption of import duties and business taxes on machinery and equipment used in education,
- 8-year corporate income tax exemption, and
- permission to bring in foreign lecturers and experts when necessary.

Moreover, associations and foundations with licenses to set up universities should be eligible for applying for promotion.

Education and training institutes usually have lower returns than other businesses. Moreover, land costs in Bangkok and metropolitan areas are very high, but institutes need to be located in easily accessible areas to be able to provide services during the day and night. Therefore, the Ministry of Finance could provide promoted projects with public-owned land for long-term lease (not less than 30 years).

(e) The Ministry of Education and Ministry of University Affairs should allow education institutes to import educational machinery and equipment from every country, including those which are not UNESCO members.

(f) The Metal-working and Machinery Industrial Development Institute, in co-operation with the Engineering Association of Thailand, should establish the technical examination to enable technicians and skilled workers to develop their career in the long term. Moreover, the Civil Service Commission should increase compensation for technicians who succeed in these technical examinations at every level.

6.2.5 To Implement Measures and Projects Focussing on Target Products and Technologies

Businesses in each industry possess different levels of technology absorptive capabilities. Technology promotion measures do not necessarily upgrade the technological capability of every enterprise, but only those with high potentials should be selected to participate in promotion programs.

Target groups may be developed through the following measures:

(1) Target manufacturers should be selected for further group-specific promotion and development of technology (i.e. enterprises mainly supplying hi-tech products to public agencies). Studies may be conducted on the standards of these products and capabilities of Thai manufacturers.

(2) Products with major technology and skill content i.e. design skills which the government wishes to disseminated should be selected probably by choosing target products, and a number of public agencies could co-ordinate with the private sector in the projects related to these products by providing one or more of the following subsidies or support:

- to provide target product manufacturers with loans with low interest rates,
- to allow accelerated depreciation over 3 years,
- to grant exemption of taxes on revenues derived from target products,
- to grant exemption or reduction of business taxes and exemption of import duties on machinery,
- to provide technical and R&D assistance,

- to support the acquisition of know-how from overseas i.e. exemption of withholding tax on technology acquisition through contracts such as licensing agreements and technical assistance,
- to create markets through government procurement.

As far as this study is concerned, the key technologies proposed as targets for promotion during the Seventh National Plan include metalworking and electronics technologies due to their contribution to the productivity enhancement of every industry. Technology targets should be as follows:

1. To develop the production technology of every field of Metal-working, particularly casting, drilling, forging and plating to reach international standards,

2. To develop the design technology of electronic product, especially personal computers, small PABXs, mobile telephones, facsimiles, specialized integrated circuits and machinery control sets so that these products can be exported.

The technical details will be presented in the section on industry-specific measures.

6.3 INDUSTRY-SPECIFIC GUIDELINES AND MEASURES

The development guidelines and measures aforementioned can be applied to the technology promotion of every industry in general. Nevertheless, as regards the six key technologies, the researcher team wish to recommend the following development guidelines.

6.3.1 Machinery, Automotive and Metal-working Industries

(1) Targets

(a) To develop process technology of every type of Metal-working, particularly casting to reach the ASTM standard (Reference No. A536 or ISO 1083-76 or equivalent), drilling to reach the repeatable accuracy at 10 micron, and forging to achieve the tensile strength 60 kgf-mm,

(b) To accumulate and disseminate design technology and product-specific technology of parts and components for small pick-up trucks, agricultural machinery and machine tools to achieve the design capability of manufacturing metal parts for engines, transmission, rear axles, and steering systems.

(2) Guidelines and Measures

(a) To Raise Funds for Organization and Infrastructure Improvement

(i) The National Industrial and Technological Development Board to be established as recommended in the section on general measures should allocate financial resources from the Industrial Technology Development Fund to motor vehicle, Metal-working and machinery industries. Also it should appoint the Subcommittee on motor vehicle, Metal-working and machinery Industry and Technology Development, the secretariat of which should be The Metal-working and Machinery Industrial (MIDI). This subcommittee will be in charge of allocating funds to private and public agencies applying for financial support to their training programs, R&D activities related to Development Institute.

(ii) The Budget Bureau should increase budgets allocated to MIDI to expand the following activities:

- to organize training programs on process technology to foster technical capability of the aforementioned supporting industries
- to establish the product testing and equipment calibration center (in accordance with major trade partners' safety standards) to support the production of the supporting industry for auto parts and machinery industries.
- to set up an internal R&D laboratory to support technology promotion activities

(iii) The Ministry of Finance should amend financial regulations to allow MIDI to use their revenues in procuring new or replacing out-date machinery and equipment with efficient and modern ones at all times. This is to be the center which provides information, training and services related to the production of metal works as well as machinery and auto parts. Moreover, regulation changes need to be made to allow MIDI to pay supplementary benefits to their officials and staff members.

(iv) MIDI should be permitted to recruit personnel without having to comply to the 2% growth constraint.

(b) <u>To Promote the Market Mechanism and Eliminate Technology Acquisition Obstacles and to Increase the Efficiency of Technology Transfer from Overseas</u>

(i) The Ministry of Finance should grant tax exemption on raw materials used in producing metal works and reduce taxes on measuring and testing equipment required for metal work production to 5% as shown in Table 6.1 to encourage Metal-working production in Thailand, leading to higher quality and lower cost of production. This is further technology development.

Table 6.1 : Metrological instruments and laboratory equipment reduce tax to 5%

Harmonize	Description	Rate of Import Duties (%)
9017.3	Micrometers, callipers and gauges	20
9017.8	Other instruments	30
9017.9	Parts and accessories except articles of 9017.10 and 9017.20	20
9024.1	Machines and appliances for testing metals	20
9024.8	Other machines and appliances	20
9024.9	Parts and accessories	20
9027.1	Gas or smoke analysis apparatus	20
9027.2	Chromatographs and electrophoresis instruments	20
9027.3	Spectrometers, spectrophotometers and spectrographs using optical radiations (UV, visible, IR)	20
9027.5	Other instruments and apparatus using optical radiations (UV, visible, IR)	20
9027.8	Other instruments and apparatus	20
9027.9	Microtomes; parts and accessories	20

(ii) The Customs Department should levy import taxes on machinery, equipment, and instruments according to the usage, not the physical features, particularly those made from ceramic and rubber parts subject to import prohibition and high tax. To attain this objective, MIDI should organize training programs for Customs officers to enable them to have a better understanding on machinery and machine tools.

(iii) The Office of the Board of Investment should implement a program on transferring technology from foreign firms to Thai companies by following the measure recommended in the section on general measures (items (5) and (6) of 6.2.2 (b)).

(c) To Accelerate the Development of Human Resources Related to Machinery and Metal-working Technology

Implement the general measures in 6.2.4.

Furthermore, the National Center for Metal and Material Technology should encourage universities and higher education institution to develop themselves to become the center of excellence in each area related to Metal-working and parts and components for pick-up trucks. This is to accumulate the industry-specific technology of their permanent staff and to produce human resources with specialized expertise.

MIDI should organize industrial technology training programs through audio-visual system by covering the following issues:

- process technology development for supporting industry,
- process technology development to increase production efficiency,
- human resource development in design and process technologies.

(d) To Encourage the Private Sector to be Involved in Technology Promotion

(i) The Office of the Board of Investment should promote technical service enterprises by granting 8-year corporate income tax exemption and exemption of import taxes on materials.

(ii) MIDI should have some financial resources available to support independent organizations responsible for technology promotion such as casting, machining and mold and die machining. These professional associations should be allowed to share budgets, premises and personnel with public agencies at the initial stage.

(e) To Initiate a Project on Technology Development for Targeted Products

(i) The Subcommittee on Motor vehicle, Metal-working and Machinery Technology Development should organize development programs for the following targeted products: automotive parts and components i.e. transmission, axles, and steering system for small trucks and agricultural machinery. The objectives of these programs will be consistent with the industry objectives specified earlier. These projects should be jointly implemented by private enterprises, universities/higher education institution, and other public agencies. This should comply with appropriate measures listed in the section 6.2.5.

6.3.2 The Electronics Industry

(1) Targets

(a) To develop design technology and product-specific technology of the following targeted products: personal computers, private automatic branch exchanges, specialized integrated circuits, mobile telephones, facsimiles, and application specific integrated circuits.

(b) To develop process technology relating to computers, telecommunications and office automation both at the assembly, subassembly and part & component levels.

(2) Guidelines and Measures

(a) To Mobilize Financial Resources to Improve Organizations for Industrial Technology Development

(i) The National Industrial and Technology Development Board should allocate technology development funds to the electronics industry. The National Electronics and Computer Technology Center (NECTEC) should be the secretariat of the Industrial and Technological Development Subcommittee (for the electronics technology and industry), which consists of representatives from both public and private sectors. This subcommittee will allocate funds to public and private agencies (apart from regular budgets) applying for financial support to R&D and engineering activities relating to computers, telecommunication and office automation.

(ii) The Budget Bureau should provide NECTEC with special financial support to accelerate the following aspects of the electronic technology development relating to computers, telecommunications and office automation:

- process technology development to foster the supporting industry-relating to electronics,
- human resource development, particularly concerning with design, product-specific, process, and production-management technologies,
- establishment of the product testing and equipment Calibration Center,
- establishment of an in-house R&D laboratory to support the activities aforementioned.

(iii) The Ministry of Finance should amend the financial regulations to allow NECTEC to use the revenues derived from their activities to maintain machinery, equipment and instruments as efficient and modern as those of large enterprises. This is to enable NECTEC to become the information and training centers and to provide services relating to the designing and manufacturing of electronic products, and their parts and components.

(iv) The Civil Service Commission should modify the recruitment regulations to allow NECTEC to recruit personnel without the maximum 2% growth condition, and to be able to provide its staff with supplementary benefits.

(b) To Eliminate the Obstacles of Technology Acquisition and Market Mechanism Promotion

(i) The Ministry of Finance should exempt taxes on electronic parts (as shown in Table 6.2) and reduce taxes on metrological instruments and laboratory equipment to 5% for the following reasons.

- To make the electronic raw materials, parts, and components locally available and inexpensive, and hence stimulating enterprises to initiate R&D activities and increase their adaptive capability.
- To encourage local companies to be able to conduct their own sourcing, leading to cost reduction and acquisitive capability enhancement.
- To increase flexibility in mobilizing electronic raw materials, parts, and components. This will boost supporting industry and enhance operative capability.

(ii) The Office of the Board of Investment should play a co-ordinating role and implement other functions relating to marketing and technology transfer as well as those measures mentioned in items (5) and (6) of 6.2.2 (b).

Table 6.2 : Description of exemption tax on electronic parts

Harmonize	Description	Rate of Import Duties (%)	Rate of Business Tax (%)
853210	Fixed Capacitor	35	9
853221	Tantalum Capacitor	35	9
853222	Aluminium Electrolytic Capacitor	35	9
853223	Ceramic Capacitor Single Layer	35	9
853224	Ceramic Capacitor Multilayer	35	9
853225	Paper or Plastic Capacitor	35	9
853229	Other Capacitor	35	9
853230	Variable Capacitor	35	9
853290	Part of Capacitor	35	9
853329	Other fixed Resistor	35	9
853331	Wirewound Variable Resistor 20 W	35	9
853339	Other Wirewound Variable Resistor	35	9
853340	Other Variable Resistor	35	9
853390	Parts of Resistor	35	9
853310	Fixed Resistor	35	9
853321	Other Fixed Resistor < 20 W	35	9
8541.10	Diode	10	9
8541.21	Transistor	10	9
8541.29	Transistor	10	9
8541.30	Thyristor	35	9
8541.40	Photosensitive Semiconductor Devices & LED	35	9
8541.50	Other Semiconductor Devices	35	9
8541.60	Mounted Piezo-electric Crystals	35	9
8541.90	Parts	35	9
8542.11	Digital IC	10	9
8542.19	Other IC	10	9
8542.20	Hybrid IC	10	9
8542.80	Other IC	10	9

(c) To Encourage the Private Sector to Participate in Technology Services and Promotion

(i) The private sector should be encouraged to conduct services related to consulting, product testing and certification, training and disseminating the use of product standards and industrial process standards.

(ii) Free trade zones for electronic products, including raw material, parts and components should be established to facilitate the manufacturers in their selling and purchasing activities.

(d) To Accelerate the Production and Development of Human Resources for the Electronics Industry

(i) NECTEC should be a leading training at service center in computer-aided design and surface-mount technology to upgrade the design and operative capability of local companies.

(ii) NECTEC/STDB should encourage universities and higher education institution to develop themselves into the center of excellence in each electronic product area: computers, telecommunications, and office automation. This is to accumulate the industry-specific knowledge of their permanent staff members and to produce electronic personnel with specialized expertise, particularly graduate and postgraduate researchers.

(iii) The Office of the Board of Investment should encourage local and oversea private organizations to establish higher education institution in electronics at the bachelor's degree level or higher by granting various incentives such as 5-8 year corporate income tax exemption, exemption of import taxes on educational machinery, instruments and equipment and provision of long-term land leases at low costs.

(iv) The Ministry of Education should implement measures to encourage public and private vocational schools to offer electronic programs (on computers, telecommunications and office automation) at the bachelor's degree level by improving the education curriculum at diploma level to enable students to pursue their study at the bachelor's degree level.

(e) To Promote Technology Infrastructure

(i) NECTEC should set up the center of metrological equipment and product standard testing (in accordance with the safety standards of major trading partners i.e. UL and FCC) for computer, telecommunication and office automation products to increase production efficiency, support R&D activities.

(ii) The Office of the Prime Minister should issue new regulations requiring public agencies to purchase computer, telecommunication and office automation products. The purchasing procedure should be bidding. However, this should be limited to firms manufacturing their products from the prototypes jointly developed and accredited by the National Electronics and Computer Technology Center (at least 2 firms). The application of this special procedure will increase by 10%, starting from the fiscal year 1992.

(f) Measures and Mechanisms Related to Targeted Product Development Programs

(i) NECTEC should create development programs for the following products: personal computers, mobile telephones, facsimiles, application specific integrated circuits and private automatic branch exchanges. The objectives of these programs need to be consistent with those of the relevant industries discussed earlier. With supporting measures proposed in section 6.2.5, these programs should be jointly implemented by private companies, universities/high education institutes and other public agencies.

6.3.3 Textiles Industry

(1) Target

The textiles industry has to face intense competition in the international market. Thailand's most important competitor is Indonesia, which has lower labor costs. Thus, the development targets of the textiles industry should be arranged in the following order according to their importance:

- to promote high value-added products,
- to improve the entire industrial structure by promoting the growth of the dyeing and finishing industries,
- to increase the production capability and efficiency and create production flexibility to respond to market changes.

Technological targets are as follows:

(1) to develop and upgrade textile chemical technology, in particular, fabric dyeing and printing,
(2) to promote the application of waste water treatment technology.

(2) Guidelines and Measures

(a) To Mobilize Funds and Improve Organizational Structures to Develop Textile Technology

(i) The government should appoint a subcommittee on the textiles industry and technology development consisting of representatives from textile companies and public agencies. This subcommittee will be responsible for using the Industrial and Technology Development Fund in promotional activities by emphasizing skill creation and training.

(ii) The capability of the Textile Industries Division should be enhanced in terms of financial and human resources to better provide technology and information services. Moreover, some regulations should be amended so that the Division can offer flexible and efficient services consistent with the industrial evolution.

(b) To Promote Market Mechanisms and Eliminate the Obstacles of Technology Imports

(i) Production capacity control in the textiles industry should be abolished to let the market mechanism function so as to allow the industry to truly react to the market signals. This measure is crucial for a mature industry with high competition in the international market.

(ii) The information system on the following aspects of the textiles industry should be established:

- product types/capacity/volume and types of machinery/employment/use of raw materials, energy, water supplies and others,
- development of new technology,
- marketing information.

This information system will help companies make a correct decision and formulate proper production plans responsive to technological changes and product development in the international market.

(iii) measures on waste water control standards should be distinct and the standards should be quantifiable.

(iv) Import taxes on dyestuffs and chemicals used in dyeing should be reduced to 5%.

(v) Taxes on machinery components and spare parts should be levied at the same rate as machinery to encourage the local machinery improvement and assembly.

(vi) Every type of tax on raw materials, chemicals and machinery used in water treatment should be exempted.

(c) To Accelerate the Production of Technical Human Resources in Terms of Both Quantity and Quality

(i) The Vocational Education Department should expand the dual system for the textiles industry so that workers can have an opportunity to continuously develop their knowledge and skills.

(ii) The Textile Industries Division should increase short and medium term training courses as well as practical training provided to their vocational-level manpower.

(iii) Education institutes should produce more human resources at every level to respond to the demand of the following industrial subsectors:

- synthetic fiber industry: to increase the number of university graduates,
- dyeing industry: to add courses and elective subjects on textile chemistry at the university level,
- other areas of the textiles industry: to stress the increase of diploma-level manpower.

(vi) The Textile Industries Division should produce audio-visual materials on production management, knowledge on new technology as well as training courses and learning via audio-visual media.

6.3.4 Food Industry

(1) Target

The major products of the present food processing industry include canned pineapple and canned seafood which maintain a very high share in the world market. Thus, growth potentials tend to lie in other products such as canned vegetables and fruits, of which the market has been dominated by Taiwan, and fresh and frozen vegetable and fruit production for exports.

Requirements for market penetration for new products include marketing, raw material management (which is not covered by the scope of this study). Technological development for new products and raw materials require Thailand's own knowledge and expertise (particularly if Thailand does not want to compete with China in the product lines where China has abundant raw materials). However, this new knowledge has not been sufficiently acquired and developed to be further commercialized.

Therefore, the proposed technology targets during the Seventh National Plan are as follows:

(1) to create and develop basic science and technology on local raw materials, particularly of new high value crops,
(2) to develop post-harvest technology,
(3) to develop and promote skills and industrial experience related to food production,
(4) to promote the development of industrial waste recycling technology.

(2) Guidelines and Measures

(a) To Mobilize Funds and Improve Organizations for Technology Development

(i) The Industrial and Technology Development Subcommittee on the Food Industry could be established with members from both public and private sector. The National Center for Genetic Engineering and Biotechnology should be the secretariat. This subcommittee will manage the Food Industry Technology Development Fund by placing an emphasis on researches on domestic raw materials post-harvest technology, industrial waste management, production management training and food quality control.

(ii) MIDI should set up a project for target groups or targets products to upgrade the capability of manufacturers of food processing machinery.

(b) To Promote R&D Activities and to Improve the Technological Base and Production Efficiency of the Food Industry in the Following Aspects:

(i) The National Center for Genetic Engineering and Biotechnology could encourage universities especially those in regions with major raw materials to conduct researches on basic knowledge on local raw materials.

(ii) Researches on waste management could be supported by granting subsidies to large private enterprises or specialized consulting firms under the condition that these technologies will belong to the government and will be further disseminated to the business in general.

(c) To Promote the Dissemination of Knowledge and Training on Sanitation, Quality Control and Production Management

(i) The Office of the Science and Technology Development Board, Thailand Management Development and Productivity Center and Technology Transfer Center should organize series of seminars to transfer knowledge to the private sector by relying on resource persons from high standard companies and foreign experts.

(ii) The Technology Transfer Center (TTC) could prepare, in co-operation with resource persons from the private sector, manuals on sanitation, quality control and production management. To achieve this end, the preparation can be made through a special project in which both local and foreign resource personals will participate to systematically transfer technology from foreign firms and experts. The TTC should be able to hire local resource person to edit the manual.

6.3.5 Gems and Jewelry Industry

(1) Target

The Thai jewelry industry has developed to the point where Thailand is becoming the world's leader in colour stones and jewelry due to several advantages. These are relatively low labor costs, a large pool of craftsmanship, an ample supply of blue sapphires in Kanchanaburi. Moreover Thailand is located among other major sources of colour stones such as Indochina, Sri Lanka and Australia. Thus, it is most likely that Thailand will become the world's center of colour stones.

If De Beers Company, which controls most of the world's diamond mines could locate their diamond cutting center in Thailand, Thailand could certainly become Asia's diamond cutting and trading.

With availability of colour stones and diamonds, Thailand has a great tendency to the world's center of jewelry. However, it is felt that the value-added tax which will also be applied to this industry will eliminate all the possibilities because the world jewelry center should be a tax heaven.

The target of the development of the gems and jewelry industry is to render Thailand the world's center of colour stones, East Asia's diamond cutting and trading and world's jewelry center. To achieve this target, may all taxes except corporate income taxes are requested to be exempted. Nevertheless, this issue is beyond the scope of this study.

As regards technology promotion, companies interviewed are not very interested in technology promotion by the government because the potential of the government in this direction is rather low for many reasons. Firstly, public agencies do not possess the relevant knowledge, personnel or R&D resources. Secondly, R&D investment requires extensive capital due to high raw material costs. Thus, government should play a supporting role rather than a leading role. Thus, the technology targets in the Seventh National Plan are as follows:

(1) to promote the gemstone industry to reach the international standard,
(2) to encourage the private sector to upgrade precious metal casting to the international level, and
(3) to promote the transfer of knowledge on gemology to Thai companies.

(2) Guidelines and Measures

The recommended measures are as follows:

(a) To Establish the Colour Standards

The growth of the gemstone industry depends on creditability. At present each factory currently uses its individual standard. No common standards have been established. The colour standards will help facilitate gemstone trading and will become reference standards to be used in improving gems heating technology in the future.

It should be understood that colour standards are not quality standards, but are simply colour codes used as references. At present, there are only two industries which use colour standards: paint and printing ink industries.

The next instrument that is needed a standard lamp to allow customers to correctly inspect the colour standard because colour when reflected under different light intensity will give different shade. However, a research need to be conducted on the types of light from various sources to derive the type of light that will make gemstones look most natural and the right distance between the source of light and the gemstone.

These measures should not be compulsory. Instead, these standards will help the products of the members of the Thai Gem and Jewelry Traders Association gain more creditability. The measures could be jointly established by the Gems Institute, which will be set up by the Ministry of Industry, and the Thai Gem and Jewelry Traders Association. The Association will issue certificates to firms conforming to the standards.

(b) To Encourage the Private Education Institutes to Set Up Gemology Institutes

The subsidies that could be provided are:
- exemption of import taxes on machinery, equipment and testing instruments,
- 8-year corporate income tax exemption, and
- long-term land lease by the government.

(c) To Transfer Knowledge on Gemology to Thai Companies

The Gemology Institute (to be established by the Ministry of Industry) or the Technology transfer Center should implement technology transfer by inviting experts from overseas to provide knowledge on gemology and precious metal casting through seminars, training and factory visits to give advice on general management.

6.3.6 Plastics Industry

(1) Target

(a) to upgrade the technology of plastic products to reach the repeatable accuracy below 100 micron,
(b) to enhance accumulate, disseminate, and the capability the application of computer-aided design in the plastics industry, and
(c) to increase the local capability in the engineering plastic product manufacture.

(2) Guidelines and Measures

(a) To Accelerate the Production of Technical Manpower

(i) The Vocational Education Department should add courses on molds and dies to the diploma-level curriculum. At present, these courses, to be offered in 1992, are available only at Samutprakarn Technical College and can be attended by about 40 students.

(ii) Basic courses on plastic materials should be introduced at the university and vocational levels. No institutes currently offer these courses.

(iii) Courses on industrial design for plastic products and materials should be offered at the Faculty of Engineering of every university and high education institutes by placing a stress on the integration of knowledge on designs, application, tool designs and production processes.

(iv) NECTEC should be the center of information and training related to the application of computers in plastic product design.

(b) To Establish Target Product Projects

In order to enable companies to gain the capability to produce plastic molds and engineering plastic products according to the targets set forth in (a) by enforcing the following supporting measures:

(i) MIDI should upgrade the level of mold design technology to derive quality products by organizing training activities on mold designs and mold engineering processes, disseminating knowledge on properties of plastic materials and other materials used in making molds as well as promoting the creation and accumulation of skills required in adapting machinery to achieve the most efficient plastic injection. These training activities will require:

- local and foreign production experts and
- NECTEC personnel involved in study and research projects on plastic molds

(ii) The Technology Transfer Center could prepare the manuals on the application of machinery used in the plastic product industry, and procure video tapes on plastic engineering technology from abroad to be further disseminated among Thai companies.

(iii) The Technology Transfer Center could receive additional loans with low interest rates to be offered to small and medium enterprises participating in this program to improve their machinery and technology because efficient injection machinery will save both raw materials and energy.

(c) <u>To Promote the Transfer of Technology from Foreign Companies</u>

The Office of the Board of Investment could initiate a technology transfer program under which technology from foreign firms will be transferred to engineering part manufacturers as mentioned in the section on general measures in items (5) and (6) of 6.2.2.

ABBREVIATION

AIST	Agency of Industrial Science and Technology
CAD	Computer-Aided Design
CAE	Computer-Aided Engineering
CAM	Computer-Aided Manufacturing
CAT	Computer-Aided Testing
CKD	Completely-Knocked Down
CPM	Critical Path Method
DIP	Dual In-line Package
D/RDS	Diagnostic/Research Design Service
IDS	Industrial Development Support
IFCT	The Industrial Finance Coorperation of Thailand
IQF	Individual Quick Freezing
JIT	Just-In-Time
JITA	Japan Industrial Technology Association
MIDI	The Metal-working and Machinery Industrial Development Institute
MITI	Ministry of International Trade and Industry
MRP II	Manufacturing Resource Planning
NECTEC	The National Electronics and Computer Technology Center
OE	Original Equipment
OE	Open-end Spinning
PABXs	Private Automatic Branch Exchanges
PCB	Printed Circuit Board
PROM	Programmable Read Only Memory
P-V-CH	Vocational Certificate Level
P-V-S	Higher Vocational Diploma Level (For student who graduate from Vocational Certificate Level)
P-V-T	Higher Vocational Diploma Level (For student who graduate from secondary school)
QCC	Quality Control Circle
RE	Replacement Equipment
R&D	Research and Development
SKD	Semi-Knocked Down
SMP	Surface Mounted Package
SPC	Statistical Process Control
STAMP	Support for Technology Assessment and Mastery Program
STDB	The Science and Technology Development Board
STQC	Standard, Testing and Quality Control

TDRI	Thailand Development Research Institute
TIAC	Technical Information Access Center
TISTR	Thailand Institute of Scientific and Technological Research
TPM	Total Productive Maintenance
TQC	Total Quality Control
UNIDO	United Nations Industrial Development Organization
USAID	United States Agency for International Development

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APPENDIXES 1

1.1 List of Persons and Organizations Interviewed

Date	Interviewee (position)	Place
Private Companies		
1) Thr.11 Oct.90	Khun Somchai Songsakdecha (Managing Director)	Thanulux Co.,Ltd. 129/1 Chongnonsi Road, Yannawa, Bangkok 10120 Tel. 284-0162-6
2) Thr.11 Oct.90	Khun Supawit Wuthi-Udomlert (Managing Director)	GSS Electronics (Thailand) Ltd. 733/3-6 Phahonyothin Road, Lumlookar, Pathumthani 12130 Tel. 531-3786-9
3) Mon.15 Oct.90	Dr.Jiravut Santabut Khun Kanch Limbut	Unicord Co.,Ltd. 606-608 Luang Road, Phomprab, Bangkok 10100 Tel. 225-0025, 225-2093-6
4) Tue.16 Oct.90	Khun Suradech Sunpituksaree (Assistant Director)	Union Textile Ind. Corp.,Ltd. 205 Moo 4 Bangpoo Mai, Muang, Samutprakan 10280 Tel. 323-9282-3
5) Tue.16 Oct.90	Khun Supong Chayutsahakij (Director Deputy General, Manager Administration)	Teijin Polyester (Thailand) Ltd. 14th Floor, Central Chidlom Tower, 22 Soi Somkid, Ploenchit Road, Bangkok 10500 Tel. 254-7161

Date	Interviewee (position)	Place
6) Wed.17 Oct.90	Khun Kamol Tuntivanich (Manager)	Thai Textile Manufacturing Association 454-460 Sukhumvit Road, Bangkok 10110 Tel. 258-2044, 258-2023
7) Fri.19 Oct.90	Khun Adisorn Thumaprudti (Managing Director)	Ayutthaya Metal Co.,Ltd. 33 Group 3, K.m.11 Rojana Rd., Bang Pa-In, Ayuttaya Tel. 239-4774
8) Wed.24 Oct.90	Khun Alongkot Chutinan (Managing Director)	Thai Engineering Products Co.,Ltd. 1 Siam Cement Road, Bangsue, Bangkok 10800 Tel. 586-3333, 586-3468-71
9) Sat.27 Oct.90	Mr.Paul S. Wong (Managing Director)	Oversea Gems Import&Export Co.,Ltd. 18 Soi Phumijit 46 Sukhumvit Road, Prakanong Bangkok 10110
10) Mon.29 Oct.90	Khun Narathip Likitnun (Accounting Manager & Assistant Managing Director)	Jong Stit Co.,Ltd. 33 Moo 1 Bangkhuntaien Road, Bangkok 10500 Tel. 415-0081, 415-4510
11) Mon.29 Oct.90	Khun Ninnart Chaithirapinyo (Associate Director)	Toyota Motor Thailand Co.,Ltd. 82/1 Moo 11 Old railway Road, Samrong Tai, Phra Pradaeng, Samut Prakarn 10130 Tel. 386-1000, 386-1056

Date	Interviewee (position)	Place
12) Tue.30 Oct.90	Khun Pongphan Tunyagijja (Graduate Gemologist,GIA)	Julies Gems Co.,Ltd. 47/1-2 Phayathai Road, Bangkok 10400 Tel. 245-2115, 245-4393
13) Wed.31 Oct.90	Khun Waranun Otarachit (Administration & Personnel Manager) Khun Sumitr Nemitrmansuk (Plant Manager)	Bangchan General Assembly Company Limited 99 Sukhapiban 2 Road, Kannayao, Bangkapi, Bangkok Tel. 517-0022-7, 518-1483-7
14) Fri.2 Nov.90	Khun Sudaranee Chivapuntusri (Executive Director)	Q&Q Holding Co.,Ltd. 44 Moo 7 Ladkrabang Industrial Estate, Chalong Krung Road, Ladkrabang, Bangkok 10520 Tel. 326-9755-8
15) Tue.6 Nov.90	Khun Archrin Sarasart (Vice President Manufacturing)	Siam Motors Co.,Ltd. 891/1 Rama I Road, Pathumwan, Bangkok 10500 Tel. 215-0830-50
16) Wed.7 Nov.90	Khun Nikon Buachaiyo (Assistant Factory Manager & Personal Manager)	Tanin Condenser Co.,Ltd. 14/28 Srinakarin Road, Phrakhanong, Bangkok Tel. 398-5333-7

Date	Interviewee (position)	Place
17) Fri.9 Nov.90	Khun Wiwat Laichuthai (Assistant Manager Purchasing Section) Khun Werachai Loganuwong (Assistant Manager Import-Export Section)	Sharp Appliances (Thailand) Ltd. 64 Moo 5 Tambol Bangsamuk, Amphur Bangpakong, Chachoengsao Tel. (038) 531-663-70
18) Mon.12 Nov.90	Khun Viwat Praepriwngam (Director)	Sa-nga Dumrongka Ind. Ltd.Part. 243 Settakit village Road, Pasicharoen, Bangkok Tel. 421-1030-2, 421-0026-7
19) Wed.14 Nov.90	Dr.Rochana Kosiyanon (Director)	Thai Business Consultants Co.,Ltd. 19th Floor, B.B.Building, 54 Asoke Road, Sukhumvit 21, Bangkok 10110 Tel. 260-7313-21
20) Wed.14 Nov.90	Khun Gowit Jira (Vice President Marketing)	Unimesa Co.,Ltd. 2540 Sukhumvit Avenue, Bangna, Bangkok 10260 Tel. 398-6952-4, 398-6955-6
21) Wed.14 Nov.90	Khun Sombat Premprabha (Legal & Privilege control Manager)	Minebea (Thai) Ltd. 1 Moo 7 Phahonyothin Road, K.m.51 Tambol Chiang Rak-Noi, Bang Pa-In, Ayuttaya 13180 Tel. (035) 361-439

Date	Interviewee (position)	Place
22) Fri.16 Nov.90	Khun Siripong Rungrodkitiyot (President)	P.C.S.Industrial 3627/3-5 Mittraphap Road, Muang, Nakhonratchasima Tel. (044) 242-230, 243-152, 254-034-6
23) Fri.16 Nov.90	Khun Jira Jiriyasin (Managing Director)	Tavon Computer Co.,Ltd. 316/2-3 Sukhumvit Soi 22, Sukhumvit Road, Bangkok 10110 Tel. 258-9863, 258-3282, 258-1099
24) Tue.20 Nov.90	Khun Khemadhat Sukondhasingha (Chief Executive Office)	CM Industry, Thai Kawasaki 203 Moo 10 Samrong Tai, Samutprakarn Tel. 387-2437, 287-1330-2
25) Thr.29 Nov.90	Khun Chatporn Thepvanangkul (Director) Khun Prapat Pimprapoat (Owner)	V.P.C.Chemical Co.,Ltd. 142/31 Soi Suksa Vithaya North Sathorn Road, Bangrug, Bangkok 10500 Tel. 237-6617-8
	Mr. Masaharu Ohtsuji (General Manager)	Daika (Japan) Ltd.
26) Thr.29 Nov.90	Dr. Somsak Vivatpanachat (General Manager)	Siam Machinery and Equipment Co.,Ltd. 58 Group 11 Papermill Road, Bang Pa-In, Ayuttaya 13160 Tel. (035) 261-051, 261-061

Date	Interviewee (position)	Place
27) Fri.30 Nov.90	Khun Tayuth Sriyuksiri (Managing Director)	K.Cotton & Gauze Co.,Ltd. 95 Suapa, 3 Floor, International Commercial Bank of China Building, Bangkok 10100 Tel. 225-0060
28) Fri.7 Dec.90	Khun Vorathep Tiyachareansri (Special Assistant Department Manager)	Thai Petrochemical Industry Co.,Ltd. 299 Sukhumvit Road, Amphor Muang, Rayong 21000 Tel. (038) 611-333, 613-571
29) Wed.12 Dec.90	Khun Sangchai Prachayanukul (Factory Manager)	Sampran Printing Co.,Ltd. 18/3-4 Moo 2 Sampran, Nakorn Pathom
30) Sat.15 Dec.90	Khun Naris Sittimongkolchai (Managing Director)	Chiang Mai Frozen Food Co.,Ltd. 92 Moo 3 Amphor Sansai Chiang Mai
31) Sat.15 Dec.90	Khun Somsri Buddhanon (Manufacturing Manager)	Santipap (Chiang Mai 1988) Co.Ltd 88 Moo 5 Amphor Sansai, Chiang Mai
32) Tue.18 Dec.90	Khun Ong-Art Kittikunchai (Managing Director)	K.C.Northern Product Co.,Ltd. 191 Moo 1 Sanpatong Road, Chiang Mai Tel. (053) 311-589

Date	Interviewee (position)	Place
33) Tue.18 Dec.90	Khun Kosol Mingampan (Manager)	Leamthongkitcharoen cold Cold Storage Sansai Prao Road, Chiang Mai
34) Thr.24 Jan.91	Khun Suthas Wimalai (Business Development Manager)	Union Plastic Limited Bangchan Industrial Estate, Minburi, Bangkok Tel. 517-0109-13
35) Fri.25 Jan.91	Khun Tanit Ruenobcheoy (Assistant Personnel Manager)	Srithai Superware 355 Suksawad Road, Soi 36 Raj Burana, Bangkok 10140 Tel. 427-0200-4
36) Fri.25 Jan.91	Khun Santi Stanley Ho (Managing Director)	Bijouxdamour S.A. 32 Surasak Road, Silom, Bangrug, Bangkok 10500 Tel. 236-7048, 236-7042
37) Tue.29 Jan.91	Khun Pichai Tinsantisook (Marketing Manager)	T.M.C.Industrial Co.,Ltd. 29 Pichai Road, Dusit, Bangkok 10300 Tel. 243-6215-7
38) Wed.30 Jan.91	Khun Songkram Cheevapra-watdomrong (Marketing Manager)	Jong Stit Co.,Ltd. 26 Moo 7 Suksawadi Road, Phrapradaeng, Samutprakarn 10130 Tel. 463-4001-4

Date	Interviewee (position)	Place
39) Wed.6 Feb.91 a	Assc.Prof.Suchada Jatikavanich (Project Manager)	Thai Engineering Analysis Co.,Ltd. 222/1 Rama IX Road, Huay Khawng, Bangkok 10310 Tel. 247-7920
40) Mon.11 Feb.91	Dr. Wiboonkiet Moleeratanond (Director of R&D)	Premier Global Co.,Ltd. 1 Soi Premier Srinakarin Rd., Praves, Bangkok 10260 Tel. 398-0029
41) Mon.11 Feb.91	Asst.Prof.Prayoon Shiowattana (General Manager)	Technological Promotion Association (Thai-Japan) 5-7 Sukhumvit Road, Soi 29 Prakanong, Bangkok 10110
42) Wed.13 Feb.91	Khun Chatchai Boonyarat	Thai Fruit Canning Corp. 518/5 Ploenchit Road, Maneeya Center 15th Floor, Bangkok 10330 Tel. 254-8178-81
43) Wed.13 Feb.91	Dr. Siwa Bhjongbhibhat (Managing Director)	Siwa Testing Inspection& Consulting Co.,Ltd. 17/1 St.Louis Soi 3, South Sathorn Road, Yannawa, Bangkok 10120 Tel. 286-9402-4
44) Fri.8 Mar.91	Khun Prida Tiasuwan (Managing Director)	Pranda Jewellery Co.,Ltd. 333 Bangna-Trad Road, K.m.2, Soi Rungsang, Prakanong, Bangkok 10260 Tel. 393-8428, 393-8779

Date	Interviewee (position)	Place
Public Companies		
1. Fri.12 Oct.90	Dr. Nantaya Yanumeth (Senior Scientist)	Textile Industry Division Department of Industrial Promotion Tel. 392-0540-2
2. Mon.15 Oct.90	Khun Satit Sirirangka-manont	Textile Industry Division Department of Industrial Promotion Tel. 392-0540-2
3. Thr.25 Oct.90	Khun Suchart Intarachote	Textile Industry Division Departmnet of Industrial Promotion Tel. 392-0540-2
4. Thr.8 Nov.90	Dr. Pichet Piriyachitra	Faculty of Pharmacy Chiang Mai University Tel. (053) 221-699
5. Thr.8 Nov.90	Dr. Pimjai Apavacharut	Faculty of Agriculture Chiang Mai University Tel. (053) 221-699
6. Wed.14 Nov.90	Dr.Sirijutaratana Cova-visaruch	Department of Chemical Engineering Faculty of Engineering Chulalongkorn University Bangkok 10330 Tel. 252-5001-9
7. Fri.14 Dec.90	Khun Ratnaporn Kanarak-santi (Scientist)	Textile Industry Division Department of Industrial Promotion Tel. 392-0540-2

Date	Interviewee (position)	Place
8. Fri.14 Dec.90	Khun Pichai Pongvirat	Textile Industry Division Department of Industrial Promotion Tel. 392-0540-2
9. Fri.25 Jan.91	Dr. Damri Sukhotanang (Director)	Metal-Working and Machinery Industries Development Institute Department of Industrial Promotion Tel. 381-1051-6
10) Tue.29 Jan.91	Khun Narong Rattana (Director)	Technology Transfer Centre Ministry of Science, Technology and Energy Rama IV Road, Phayathai, Bangkok 10400 Tel. 245-9032
11) Wed.30 Jan.91	Khun Pranee Obhasanond (Director)	Textile Industry Division Department of Industrial Promotion Tel. 390-0687
12. Sat.9 Feb.91 Sun.10 Feb.91	Khun Orapin Werawut (Director)	Industrial Economics & Planning Division Ministry of Industry Tel. 245-9829
13. Sat.9 Feb.91	Asst.Prof.Kovit Satavuti	Department of Industrial Engineering Faculty of Engineering Chulalongkorn University Tel. 252-5001-9

Date	Interviewee (position)	Place
14. Mon.25 Feb.91	Khun Chackchai Panichapat (Assistant Secretary General)	Office of the Board of Investment 400 Phaholyothin Road, Bangkok 10400 Tel. 270-1400
15. Tue.5 Mar.91	Prof.Dr.Pairash Thajcha-yapong (Director)	National Electronics and Computer Technology Centre Ministry of Science, Technology and Energy Rama IV Road, Phayathai, Bangkok 10400 Tel. 247-1482
16. Thr.7 Mar.91	Dr. Wirojana Tantraporn (Technician Advisor)	Office of The Science and Technology Development Board (STDB) Charan Insurance Building 6th floor, room 401 Ratchadapisak Road, Bangkok 10310 Tel. 276-1314-7
17. Feb.-Mar.91	Khun Ratana Attabhanyo	Department of Food Science and Technology Faculty of Agriculture Chiang Mai University Tel. (053) 221-669

1.2 List of participants in the brainstorming section for the textile industry at Conference Room, 15th Floor, TDRI on Febuary 26, 1991

1.	Khun Akradet	Pathuengsit	Asia Fiber Co.,Ltd.
2.	Khun Supong	Chayutsahakij	Teijin Polyester Co.,Ltd.
3.	Khun Surasak	Chaikulngamdee	Ngamdee Co.,Ltd.
4.	Khun Vira	Sirikietsoong	Thai Industries Development Co.,Ltd.
5.	Khun Prapat	Pimprapoat	V.P.C.Chemical Co.,Ltd.
6.	Khun Suradech	Sunpituksaree	Union Textile Industry Co.,Ltd.
7.	Khun Chavalit	Nimla-or	Oriental Garment Ltd.
8.	Khun Suchart	Chantaranakaracha	Thai Rung Textile Co.,Ltd.
9.	Khun Satit	Sirirangkamanont	Textile Industry Division
10.	Khun Artit	Vitikaro	Textile Industry Division
11.	Khun Chatchaval	Pinthanon	Bambi House Ltd.Part
12.	Khun Sopon	Wichitrakorn	Hantex Corp.,Ltd.
13.	Khun Pranee	Obhasanond	Textile Industry Division
14.	Khun Supranee	Srisuta	National Economic and Social Development Board
15.	Khun Amorn	Mongkolwongroj	V.P.C.Chemical Co.,Ltd.
16.	Khun Phongsak	Assakul	Bangkok weaving mills Ltd.
17.	Khun Vinai	Virojanavat	Thai Li Printing Co., Ltd.

Science and Technology Development Program (TDRI)

18.	Dr. Chatri	Sripaipan	Project Director
19.	Dr. Mingsarn	Kaosa-ard	Project Leader
20.	Dr. Anupap	Tiralap	Researcher
21.	Khun Amornrat	Apinunmahakul	Research Assistant

1.3 List of participants in the brainstorming section for the motor vehicle, metal-working and machinery industries at Empress Hotel, Chaieng Mai on February 9-10, 1991

1. Khun Orapin Werawut	Industrial Economics & Planning Division
2. Khun Khemadhat Sukondhasingha	CM Industry, Thai KAWASAKI
3. Khun Gowit Jira	Unimesa
4. Dr. Damri Sukhotanang	Metal-Working and Machinery Industries Development Institute

Science and Technology Development (TDRI)

5. Dr. Mingsarn Kaosa-ard	Researcher
6. Dr. Anupap Tiralap	Researcher

APPENDIX 2: INDUSTRIAL POLICY

Implications of government policy for technology acquisition at the firm level are found as follows:

a) The recent tax reduction on machinery and equipment has had positive impacts for technology acquisition among Thai firms. However, this has not yet covered the measuring and laboratory equipment and tools.

b) Although the cost of Thai labour remains low compared with other more industrialized countries, The continuous rise of minimum wages owing to government policy has a tendency to bring out the substitution for labour-saving technology among large-scale business. This is due to the higher labour cost compared to Thailand's main competitor (Indonesian labour).

With regard to tariff policy, the rate of protection effective which has been reported is still very aggregate to make an assessment at the product level, thereby business impacts.

1. TRADE POLICIES

Although changes have taken place in the economic incentive and regulatory environment over the years, Thailand's industrial sector is still protected. Also, despite the recent rapid growth of exports, based in large part on the activities of foreign and joint ventures, most of the industrial sector is still domestic-market oriented.

1.1 Tariffs

The tariff structure in Thailand has tended to give higher nominal protection to finished goods than to inputs. The 1974-80 period was characterized by high and variable nominal rates of protection, increased use of non-tariff barriers, price controls and domestic content requirements.

In the 1980s several changes were introduced into the tariff regime, including the introduction of special taxes and surcharges mainly due to revenue considerations. The only significant reforms are the setting of the maximum tariff at 60% and the reduction of the dispersion in the effective protection rates (World Bank 1990).

According to World Bank (1990), overall averages as well as the sector differences in effective protection remained relatively unchanged between 1985 and 1988. Hence, Thailand's trade regime remains basically inward-oriented and has not been adequately reformed to ensure greater competitiveness by domestic industry nor to reduce the built-in anti-export bias.

TDRI (1990) (Trade and Industry Sub-project 3) also found that average tariff rates and average effective rates of protection in the late 1980s were almost twice as high as those of the early 1980s.

In September 1990, the Ministry of Finance reduced tariff rates from 20% to 5% for machinery and equipment used in manufacturing activities, principally those items covered under Sections 84 and 85 of the Customs Code. The BOI was required to cease granting exemption or reduction of import duties on these machinery and equipment. For machinery and equipment not covered in the tariff reduction list, the BOI can grant 50% reduction of tariff rates. Such moves should help reduce costs of imported machinery for non-promoted firms. However, testing and laboratory equipment are not included in the tariff reduction list.

1.2 Board of Investment (BOI) Surcharges

The BOI is empowered to impose surcharges on imports which were similar to those produced by promoted firms for a period of not more than one year, although they can be extended for longer periods. The maximum surcharge is 50% of the c.i.f. price of the imported product. Surcharges are imposed when the BOI believes there is evidence of dumping or unfair tariff structure.

There were 90 or so products or product groups on which surcharges were levied during 1978-87. However, in response to criticism that BOI surcharges provided protection to promoted firms that were unable to operate without them and they might never become competitive, the BOI became strict in granting surcharges in the late 1980s. By 1990, no project has been granted surcharges.

1.3 Quantitative Restrictions

The BOI is empowered to impose import bans to protect promoted firms. However, it rarely uses this measure. The Ministry of Commerce (MOC) can impose import bans or require special import licenses for certain products in order to protect or to promote domestic production, or to save foreign exchange. Although the general policy guidelines of the ministry indicate that the role of these measures should be limited and reduced where possible, application through the MOC remains discretionary and not very transparent.

1.4 Domestic Content Requirements

Local content requirements have been imposed on certain products by the BOI and the Ministry of Industry (MOI), with the objective of promoting domestic production of inputs for those products. The most important domestic content regulations exist in the automotive sector.

Although the local content requirements tend to encourage subcontracting in their respective industries, the small size of the domestic market may not allow for economies of scale in production. High production costs of parts and components may lead to higher prices for final products, which may hinder their competitiveness in both domestic and international markets. International subcontracting in certain areas is becoming a more evident way of achieving these economies of scale but is not yet prevalent. Furthermore, the control by foreign firms of both assembly and parts supply has meant that Thai firms have had difficult time beading into these sectors as subcontractors (World Bank, 1990).

The BOI has recently set up a special unit called the BOI Unit for Industrial Linkage Development (BUILD) to promote local subcontracting through the provision of information and technical assistance. Foreign firms in particular will be encouraged to assist local subcontractors in improving product quality, reliability, and timeliness.

1.5 Export Promotion Schemes

Export promotion schemes have existed since the 1960s. They include: BOI's tax exemptions on intermediate inputs used in the production of exports; tax drawbacks from the Customs Department; tax rebates from the Fiscal Policy Office; bonded factories; and export processing zones. The main problem remaining in implementing the export promotion schemes is the difficult access for indirect exporters, which results in discrimination against small and medium sized enterprises.

2. INVESTMENT POLICIES

2.1 BOI Incentives

Investment incentives are provided primarily by the BOI. Projects to be given special consideration by the Board include those which: significantly strengthen the balance of payments position especially through production for export; support the development of domestic resources; substantially increase employment; locate operations in the provinces; conserve energy or replace imported energy supplies; and develop basic industries.

Under the current Investment Promotion Act 1977, the BOI may grant tax privileges such as exemption from or reduction of import duties and business taxes on imported machinery and raw materials, and exemption from corporate income taxes for three to eight years. Additional tax incentives are provided to export oriented projects and those which locate in the BOI designated Investment Promotion Zones (IPZs). Non-tax incentives include guarantees against nationalization, competition from new state enterprises,

state monopolization, competing imports by government agencies and price controls; and permission to own land, to bring in foreign technicians, to remit abroad foreign currency, and to export.

Criticism of the past policy of the BOI focused on its preference for large projects and the discretionary element in its decisions. The revised criteria of 1987 reduced the minimum requirement for export projects to 1 million baht, thus making smaller firms eligible for promotion. BOI's measures to promote export oriented activities also help reduce bias of tariff structure against export industries.

Industrial decentralization has become BOI's major policy in the 1980s. In 1983 the BOI announced new criteria for granting tax incentives. The location became a criterion in the granting of major tax incentives. Projects located in Bangkok and Samut Prakan would receive no tax exemption on machinery unless at least 80% of their output were exported, and they would only receive a 50% reduction for expansion in the same compound. In addition, the income tax holiday would be extended for one year for projects located in industrial estates or outside Bangkok and five neighboring provinces. In 1985 a more attractive package was offered to projects locating in industrial estates, especially those in Chiang Mai and Lamphun.

A major change in BOI's spatial policy occurred in September 1987 following a surge in the number of applications. Location became a major criterion in granting tax incentives. The country was divided into three zones: Zone 1 including Bangkok and Samut Prakan; Zone 2 including four neighboring provinces and industrial estates in Zone 1; and Zone 3 including other 67 provinces which were designated as IPZs. Promoted projects located in Zone 1 would receive the least benefits while those in Zone 3 receive the most. Now for the first time, projects located in Zone 1 receive no corporate tax holiday unless they meet export or employment targets.

As the number of applications continued to increase, the BOI further modified the criteria for granting tax incentives in January 1989. The change involved the expansion of Zone 1 to include Bangkok and five neighboring provinces (former Zones 1 and 2), and Zone 2 to include 10

provinces in the Central area, and Zone 3 to shrink to 57 provinces and the Laem Chanbang Industrial Estate. Zone 1 continued to enjoy the fewest benefits and Zone 3 the most.

In October 1990, the criteria for granting tax privileges were simplified, although the zones were not changed. The BOI also extended the list of products eligible for promotion in Zone 3 without export requirements and with a minimum capital requirement of 500,000 baht and minimum Thai ownership of 51% of registered capital. The objective of the latter measure is to reduce barrier to entry for small and medium firms in provincial areas.

2.2 Foreign Investment Policies

The Thai government has long appreciated the crucial role to played by foreign investment in the development process. In general, one could say that the Thai government has pursued an open door policy towards inward FDI over the past three decades. There are no restrictive screening mechanisms for FDI or technology transfers by foreign companies except for projects applying for Board of Investment (BOI) promotion status.

The very rapid increase in FDI in recent years has generated public concern regarding foreign economic dominance and foreign competition in infrastructure and manpower usage and in the domestic market. There is also concern that foreign firms will exploit Thailand's export quota and GSPs; hence competing with Thai exporters. This has raised questions concerning the future policy stance towards foreign investors.

The most serious complaint about FDI concerns the role of foreign investment in transferring technology. It is recognized that foreign companies transfer technology to their overseas subsidiaries and that such subsidiaries in Thailand make it possible for Thailand to compete in world markets. But complaints are that foreign firms in Thailand do not do as much as they could to transfer technology to local firms or to develop local linkages. They have not been as active as expected in developing local subcontractors or giving technical assistance to suppliers. It is claimed

that Japanese firms, in particulars, tend to bring in other Japanese firms as their suppliers. While American and European firms are generally believed to be more open to local Thai participation in their management, the complaint is that they also tend to buy mostly from other locally based foreign firms. Data from BOI investment approvals also indicate that most foreign firms import the majority of their material inputs and components.

With regard to the general approach to FDI, there is no doubt that the Thai government will continue to recognize the contribution of such investment in accelerating the country's economic development. As senior Board of Investment officials often reiterate, the Thai economy must achieve higher levels of growth and progress in order to reach the objective of becoming an advanced, developed nation. A great deal of resources and opportunities in industrial diversification are waiting to be tapped. Therefore, efforts will continue to be made to encourage more foreign participation in the drive toward development and prosperity.

The Thai government has offered various incentive measures to promote FDI and at the same time has exhibited a certain degree of nationalism through a number of restrictions. These incentive and restrictive measures towards FDI are discussed below.

2.2.1 Incentive Measures

BOI Incentives

Among the measures adopted by the government to promote FDI are incentives offered by the BOI.

Recently, the BOI has played an active role in facilitating FDI operations in Thailand. Since the second half of 1989, several new measures have been initiated to attract and assist foreign investors. In addition to granting temporary permits for foreign investors, technicians and experts, to work on promoted projects, the BOI can now offer them permanent residence permits. Moreover, apart from allowing foreign firms

to own land to set up factories, the BOI now permits them to own land outside their factories to build residential facilities for both Thai and foreign employees. It is also coordinating with the Ministry of Education to allow for new international schools to be established. In addition, the BOI has set up a working group to explore laws and regulations which are

obsolete and constrain private business. Such laws and regulations will be amended or eliminated completely.

Other incentives

Apart from the BOI incentives mentioned above, other major measures which are currently offered to foreign investors include:

(1) the Bank of Thailand's facility to enable the easy remittance of foreign capital and incomes generated from FDI;
(2) the liberalization of foreign exchange controls following Thailand's compliance with the International Monetary Fund's obligations since 22 May, 1990;
(3) a wide range of international agreements on investment protection (with 14 countries) and the avoidance of double taxation (with 22 countries);
(4) the protection of intellectual property rights through patent, trademark, and copyright laws;
(5) the Industrial Estate Authority of Thailand's incentives to activities located in IEAT industrial estates such as permissions to bring in foreign experts, to own land, and to take or remit abroad foreign currency. Factories located in export processing zones are also granted tax exemption on imported machinery and raw materials;
(6) the law allowing foreigners to own condominium units is to be passed by the parliament in the near future.

2.2.2 Restrictive Measures

The major restrictions on FDI involve the limitations on foreign ownership, on the employment of foreign nationals, and on the use of land by foreign firms. There is also a plan to prevent foreign suppliers of technology from imposing restrictive or unfair terms in technology contracts.

(1) Foreign Ownership

The Investment Promotion Act of 1977 empowers the BOI to stipulate a condition restricting foreign ownership in promoted firms. The BOI's Announcement No.1/1983 lays out joint venture criteria as follows: Thai nationals must hold at least 60% of registered capital in investment projects in agriculture, husbandry, fishery, mineral exploration and mining, and services, and at least 51% in the production for domestic distribution; while foreign investors may hold majority ownership when at least 50% of the output is to be exported and hold 100% when 100% of the output is to be exported. It should be mentioned that the BOI sometimes allows 100% foreign owned firms to sell up to 20% of their total sales in the domestic market. However, if these firms use simple production technique or their products are widely produced by local firms, they will be required to export totally in order to avoid impact on Thai firms.

The Alien Business Law of 1972, administered by the Ministry of Commerce, prohibits aliens or foreign majority owned firms from participating in certain businesses. However, the effectiveness of this law is undermined by a number of exemptions and exceptions. For instance, American firms and BOI promoted firms are exempted from the law and most manufacturing activities in which inward FDI tends to be concentrated are not included in the list of restricted activities.

(2) Finance, Securities and Credit Foncier Companies Act

Moreover, the Finance, Securities and Credit Foncier companies Act of 1979, administered by the Ministry of Finance, restricts foreign ownership in finance and credit foncier companies to a 25% limit.

(3) Employment of Foreign Nationals

The Alien Employment Act of 1978, administered by the Labor Department, requires all alien to obtain a work permit prior to commencing their employment. It also prohibits foreign nationals from practicing certain types of occupations. However, BOI promoted firms and those locating in IEAT industrial estates tend to face less restrictions in bringing in foreign experts and technicians.

(4) Land Ownership

The Land Code of 1954 prohibits aliens, including companies of which over 49% of the equity share is owned by aliens, form owning land in Thailand. However, foreign firms which are promoted by the BOI or are located in IEAT industrial estates are allowed to own land. Due to the high incidence of land being bought for speculation by foreigners, the Land Department has recently started to scrutinize land transactions by firms with less than 49% of equity owned by foreigners.

(5) Technology Transfer

The Sixth Development Plan called for a national committee on technology transfer to issue laws and procedures to ensure that technology transfer would benefit the development of local technology. Subsequently, in mid-1989 the BOI submitted a proposal to the Joint Public private Sector Coordinating Committee (JPPCC) to formalize technology transfer procedures and to empower the BOI in removing restrictive clauses and unfair terms from technology transfer agreements. The reluctance of the private sector has promoted the BOI to shelve the project.

3. TAX POLICIES

Within tax policy, the major problem has been the application of a business tax levied on a gross basis for sales receipts at each transaction. The cumulative effect of the business tax has been to discriminate against subcontracting, which has hampered development of linkages between larger and smaller enterprises. The introduction of the Value Added Tax system should help solve this problem.

4. INDUSTRIAL REGULATION

There is a wide range of regulations and instruments that can control entry and exit. The Factory Act of 1960 empowers the MOI to restrict the construction or expansion of factories it considers that there is excess capacity, or when the domestic industry experiences difficulties and explicitly asks the Ministry to prevent entry of new competitors. Also, at the request of the BOI, the MOI may impose controls on activities that currently are not promoted. Regarding exit, it is extremely rare for large firms to go bankrupt in Thailand, suggesting that there may be significant barriers to exit, operating perhaps through the financial system.

It is not known to what extent the regulatory constraints are actually applied in practice and how binding they are. For example, the general perception is that although the BOI has considerable scope for reducing competition, it has not been exercising its prerogatives in the last few years because of its current focus on export oriented investment. To some extent it would appear that the regulatory structure, much of which is a holdover from earlier times when there was a greater propensity for government regulation, may be somewhat antiquated.

5. ENERGY PRICING POLICIES

5.1 Oil Pricing Policy

Before the cabinet's approval of oil price formula on 7 August, 1990, retail oil prices had been controlled by the government, with an oil fund and excise taxes being used as measures to stabilize oil prices. For instance, as world oil prices rose in 1989, the government cut excise tax rates twice to slow down outflows of the oil fund and avoiding increases in retail prices. Excise tax rates were cut again in early 1990. As a result, the government lost excise tax revenues totalling 22 billion baht.

In August 1990, the government introduced oil price mechanism in order to separate price adjustments from politics. A committee was set up to oversee oil price adjustments. The oil price formula would allow retail prices to be adjusted automatically within a certain range following changes in world prices. However, the new system was not meant to float oil prices or to abolish government control of retail prices. In fact, it is quite similar to the present foreign exchange rate mechanism.

Under the formula, the oil fund will be administered within a range of 300 million baht (floor) and 1,500 million baht (ceiling). The government also set minimum and maximum rates of excise taxes and the Ministry of Finance can change the rates within this range without cabinet approvals. When the oil fund reaches a level of 1,500 million baht, excise tax rates will be adjusted upward to increase tax revenues to the government. Once the maximum tax rates are reached, retail prices will be reduced to stop the fund to exceed the ceiling. When the oil fund drops to 300 million baht, excise tax rates will be reduced to avoid price rise. Once the minimum tax rates are reached, retail prices will be raised to prevent the fund from falling below the floor.

Since the introduction of the formula, the committee has increased retail prices of oil and gas twice on 13 September and 26 September 1990, resulting in an average increase in oil prices by 1.90 baht per litre.

5.2 Electricity Pricing Policy

In order to assist exporters, the government has offered electricity rebates for export products. However, this measure has been criticized for creating bias in the structure of electricity charges and causing some countries to impose countervailing duties on Thai exports. Consequently, the National Energy Policy Committee has abolished this measure from 1 January 1990.

6. WAGE POLICIES

Wages in the private sector are determined by demand and supply in the labor market. However, wages of unskilled labor tend to be less elastic than those of skilled labor. This caused the government to intervene in the labor market by setting up the minimum wage rate system in 1973. Under the system, a tripartite committee, (comprising representatives of employers, workers, and the government) appointed by the Minister of Interior, is empowered to consider changes in minimum wage rates and recommend the changes to the minister. Factors used in fixing minimum wage rates include: trends of economic growth, consumer price index, pressure from labor and strategies of both employers and workers; capability of employees to pay; income structure of the whole country including both public and private sectors as well as agricultural and manufacturing sectors; and impact of the wage increase.

Minimum wage rates went up quite rapidly in the 1970s. However, due to more balance in political pressure from workers and employees and low inflation rates in the 1980s, minimum wage rates rose much more slowly. In 1990, minimum wage rates jumped by more than 10 percent following rapid economic expansion.

Appendixes 3

Appendix 3.1 Number of patents applied for and approval classified by sector

	Science & Technology		Product Designs		Total	
	Applied	Granted	Applied	Granted	Applied	Granted
1979	22	0	25	0	47	0
1980	215	0	61	0	276	0
1981	332	0	89	25	421	25
1982	371	4	187	45	558	49
1983	560	21	272	38	832	59
1984	668	20	311	44	979	64
1985	707	45	282	93	989	138
1986	694	52	341	73	1,035	125
1987	882	71	383	321	1,265	392
1988	1,119	86	429	208	1,548	294
1989	1,424	164	667	302	2,091	466
1990 (Jan.–June)	962	60	308	155	1,270	215
Total	7,956	523	3,355	1,304	11,311	1,827

Source : Ministry of Commerce

Note : Science & Technology patents include engineering

Appendix 3.2 Number of patent applications and approvals

Year	Engineering				Chemistry				Product Design				Total			
	Thailand		Foreign		Thailand		Foreign		Thailand		Foreign		Thailand		Foreign	
	Applied	Granted	Applied	Granted	Applied	Granted	Applied	Granted	Applied	Granted	Applied	Granted	Applied	Granted	Applied	Granted
1979	4	0	6	0	3	0	9	0	25	0	0	0	32	0	15	0
1980	8	0	61	0	5	0	121	0	9	0	52	0	22	0	254	0
1981	25	0	128	0	1	0	178	0	24	4	65	21	50	4	371	21
1982	36	1	124	2	4	0	207	1	87	5	100	40	127	6	431	43
1983	35	7	191	3	13	1	321	10	152	20	120	18	200	28	632	31
1984	36	5	227	6	13	3	392	6	182	23	129	21	231	31	748	33
1985	46	5	237	12	9	0	415	28	131	79	151	14	186	84	803	54
1986	44	12	205	10	16	4	429	26	182	46	159	27	242	62	793	63
1987	57	6	303	18	11	6	511	41	193	62	190	259	261	74	1,004	318
1988	67	0	451	10	11	1	590	75	111	45	318	163	189	46	1,359	248
1989	41	16	609	57	2	3	772	88	172	114	496	188	215	133	1,876	333
1990 (Jan.–June)	31	2	421	11	10	2	500	45	96	38	212	117	137	42	1,133	173
Total	430	54	2,983	129	96	20	4,445	320	1,364	436	1,991	868	1,892	510	9,419	1,317

Source : Ministry of Commerce

APPENDIX 4: SCIENCE AND TECHNOLOGY SERVICE INSTITUTES

1. MINISTRY OF AGRICULTURE AND COOPERATIVES (MOAC)

Background

MOAC was first established on April 1, 1935.

Organization

There are 21 departments in MOAC, including governmental organizations and state enterprises. They are:

Governmental Organizations

- Office of the Secretary to the Minister
- Office of the Permanent Secretary Ministry of Agriculture and Cooperative
- The Royal Irrigation Department
- Department of Cooperative Auditing
- Department of Agricultural Extension
- The Cooperatives Promotion Department
- Land Development Department
- Department of Livestock Development
- Department of Fisheries
- The Royal Forest Department
- Office of Agricultural Economics
- Agricultural Land Reform Office
- Department of Agriculture

State Enterprises

- Dairy Farming Promotion Organization of Thailand
- Fish Marketing Organization
- The Forest Industry Organization
- The Government Cold Storage Organization

- The Marketing Organization for Farmers
- Rubber Estate Organization
- Office of the Rubber Replanting Aid Fund
- The Thai Plywood Company Limited

Selected Organizations in MOAC

1.1 Department of Agricultural Extension

Background

Thais are well aware that agriculture is the backbone of Thailand and the most important sector of the country's economy since the establishment of the Kingdom. However, the level of mechanization and use of modern technology in farming is not much different from that of ancient times, particularly in some regions, where most farmers are still poor and have economic and social problems which the Royal thai Government is trying to reduce.

To help the poor and to increase the gross national product, The Ministry of Agriculture and Cooperatives had instructed the Departments to carry out agricultural extension services throughout the country by introducing the latest innovations and new technology to farmers and training them to use new methods of cultivation. In 1968, these activities were consolidated to form the Department of Agricultural Extension.

Organization

This Department consisted of 16 divisions:
- Office of the Secretary
- Personnel Division
- Agricultural Communication Division
- Seed Division
- Finance Division

- Plant Protection Service Division
- Planning and Special Projects Division
- Training Division
- Agricultural Administrative Development Division
- Crop Promotion Division
- Northern Regional Agricultural Extension Office, Chiangmai Province
- Northeastern Regional Agricultural Extension Office, Khon Kaen Province
- Western Regional Agricultural Extension Office, Ratchaburi Province
- Central Regional Agricultural Extension Office, Chai Nat Province
- Eastern Regional Agricultural Extension Office, Rayong Province
- Southern Regional Agricultural Extension Office, Songkhla Province

Function

To accelerate the increase of the national agricultural products and to train farmers and the rural youth to develop their skill and knowledge as agricultural professionals, the Department of Agricultural Extension has been charged with the following responsibilities.

- To promote the production of food crops to cope with local and national consumption, and to provide substitution of certain foods that need to be imported.

- To promote the production of industrial crops to serve internal consumption quantitatively and qualitatively. Such crops are jute, cotton, sugar cane, pineapple, groundnuts, soybean and kapok.

- To promote crop production and other agricultural commodities for export. Besides rice and rubber, the key crops are corn, cassava, jute, beans, cotton, kapok, castor-oil plant, sesame, mangosteen and sapodilla plum.

- To advise and help farmers concerning their future plans for increasing products aimed at gaining the maximum output per rai and also attaining a rising income as high as possible.

- To support the organization of farmers, because such groups can be an essential force in expanding production by cooperatively providing needed supplies and marketing services.

- Participate in and coordinate the tasks of both government and non-government institutions dealing with rural and community development as well as other development programs in relation to agriculture: irrigation, roads, soil conservation, and the management of forested lands and water resources.

Activities

The Department has successfully implemented its agricultural service programs by using many functions and methods which are briefly indicated as follows:

- To disseminate technical knowledge and farming skills to farmers.

- To train farmers and rural youth towards leadership in agricultural development in order to have self-sufficiency and the ability to help each other.

- To work jointly with other technical institutions in finding solutions to problems facing farm people.

- To organize pre-service and in-service training programs in such fields as: the role of administrative personnel, techniques of coordination, and effective ways to deal face to face with local people.

- To work in cooperation with other governmental and non-governmental agencies in support of rural community development, cooperatives, agri-industry, education, health, sanitation, etc..

1.2 The Department of Fisheries

Background

The Department of Fisheries was established in 1901 under Revenue Act R.S. 120 (1902) as the Fishery Revenue Division of the Revenue Department responsible for collection of fishery revenues. Because of the decline in fish production and the development of fish conservation concepts, a fishery administration staff was created in the Ministry of Agriculture as a division in 1921. In 1926 a Royal Decree establishing the Department of Fisheries was proclaimed.

Organization

There are 12 divisions in this department:

- Office of the Secretary
- Finance Division
- Fishery Policy And Planning
- Personnel Division
- Fishery Conservation and Extention Division
- Fishery Extension Division
- Freshwater Fisheries Division
- National Inland Fisheries Division
- Brackish-Water Fisheries Division
- Marine Fisheries Division
- Fishery Technological Development Division
- Exploration Fishing Division

Function

The Department of fisheries is responsible for all activities in the fields of fishery promotion, development, administration and control, conservation of aquatic natural resources, aquaculture, processing and preservation, training of fishermen and extension services.

1.3 The Department of Agriculture

Background

The Department of Agriculture is one of the 13 departments within the Ministry of Agriculture and Cooperatives. It was established in 1972 by merging the former Agriculture and the Rice departments together.

Organization

This department consists of 18 divisions:

- Personnel Division
- Finance Division
- Planning and Technical Division
- Agricultural Regulatory Division
- Agricultural Chemistry Division
- Agricultural Engineering Division
- Plant Pathology & Microbiology Division
- Entomology & Zoology Division
- Soil Science Division
- Botany and Weed Science Division
- Agricultural Toxic Division
- Rice Research Institute
- Field Crops Research Institute
- Horticulture Research Institute
- Sericulture Research Institute
- Rubber Research Institute
- Farming Systems Research Institute

Function

Its responsibilities are as follows:

- Doing research and development activities on crops, sericulture and farming systems. This aims to benefit farmers through yield increases and efficiency.

- Providing services of analyzing samples of soils, fertilizers, plants and agricultural chemical material for the public.

- Doing agri-developmental work in areas which possess economic and security problems.

- Producing foundation seeds for the Department of Agricultural Extension and farmers.

- Disseminating information and providing training for government officers and the public.

- Providing regulatory services according to certain agricultural laws.

2. MINISTRY OF INDUSTRY (MOI)

Background

Under its mandate, the Ministry of Industry is concerned with two broadly defined areas. First, it is concerned with the exploration and development of mineral, energy and underground water resources. Second, it is concerned with the promotion and development of the manufacturing industry.

Functions

The Ministry's roles are both regulatory and promotional, and its activities of most interest to potential investors are as follows:

1. Natural Resources Development

The Department of Mineral Resources is responsible for the administration, promotion and development of the country's mineral industry. It conducts geological surveys; exploration for mineral resources; technical research on mining technology, mineral utilization and metallurgy; exploration and development of ground water and exploration analysis; and research of mineral fuels. On the legal side

of its function, it grants prospecting licenses and mining leases and enforces mining laws and regulations. It also has the duty of collecting royalties on minerals produced in the country.

To ensure that the utilization of valuable energy and off-shore mineral resources is in the best interests of the country, two state enterprises -- namely, the Petroleum Authority of Thailand (PTT) and the Off-shore Mining Organization (OMO) -- act as the Ministry's production and trading arms, and are the state enterprises through which subcontracts may be given to the private investor under the Ministry's general guidance.

2. Pre-Investment Information

The Industrial Economics and Planning Division (IEPD) of the Office of the Permanent Secretary is the core of an information network that can provide comprehensive pre-investment information in the form of trade and production statistics, status reports on selected subsectors, and current sectoral policy and regulations.

3. Training and counseling

Technical training in various fields of entrepreneurship, management and technology is regularly provided for the benefit of new and existing entrepreneurs, managers and industrial workers, by the Department of Industrial Promotion (DIP). Particularly, the Metal-Working and Machinery Industries Development Institute (MIDI) plays a significant role in the development of the small- and medium-sized machinery and metal-working factories (See details later). Special in-house training can also be arranged upon request. In addition, investment and technical counseling services are provided by the Ministry's own staff, who can also help obtain specialized external counsel if needed. The Industrial Development Centre (IDC) of DIP assists foreign investors seeking Thai partners and vice versa.

4. Concessional Finance for Small Industries

To assist small industries whose fixed assets do not exceed 10 million baht, the Small Industry Finance Office (SIFO) of the Department of Industrial Promotion provides low-interest, long-term credit facilities. SIFO works in close cooperation with the Krung Thai Bank and offers a maximum loan limit of 3 million baht at an interest rate of 11% per annual for a period of three to seven years, with a grace period of six to twelve months. In addition, SIFO offers smaller loans up to 500,000 baht at an interest rate of 10% per annual through its own resources.

The industries served by SIFO include manufacturing, engineering service, handicrafts and home industries.

5. Machine Registration Service

The Department of Industrial Works, through the Central Machine Registration Office, offers assessment and legal advice on registration of machinery for finance and credit purposes. The certificate of registration, in addition to the machinery itself, can be used as collateral for loans from commercial banks or other financial institutions.

6. Industrial Estates and Export Processing Zones

In response to the investor's need for infrastructural support and to the government's policy of rural and export industries development, fully serviced industrial estates have been developed and are managed by the Industrial Estate Authority of Thailand (five on the outskirts of Bangkok and one located in Lamphun Province). These industrial estates are serviced by major highways that give easy access to sea, air and rail transport facilities.

Export Processing Zones with comprehensive facilities are also being set up in Bangkok and at the site of the Laem Chabang Deep-Sea Port.

The Eastern Seaboard projects aim to create interrelated infrastructural facilities along Thailand's east coast to support a well-coordinated industrial development program that encompasses heavy industries as well as light manufacturing industries. They include deep-sea ports; roads, rails and modern telecommunications; water supply; electricity and other utilities; industrial estates; Export Processing Zones; and residential housing.

In addition to all convenient facilities, industries located in these industrial estates are also entitled to preferential privileges under the Industrial Estate Act and the Investment Promotion Act.

7. Industrial Hazardous Wastes Treatment

For the prospect of a better quality of life, the Department of Industrial Works has taken a step forward in handling industrial toxic and hazardous waste problems by implementing an industrial hazardous wastes treatment complex at Samae Dum, Bangkhuntien District -- a 22-million-baht pilot project that is the first of its kind in Thailand. The complex is capable of treating industrial liquid, sludge or solid toxic wastes. After the completion of the construction work, the center will be leased to a private contractor for operation and management. The approved service fees will be paid directly to the contractor by polluters. The Department of Industrial Works has also planned to construct this type of facility in other industrial areas in the future, such as in the Bangkok suburbs of Paknam and Rungsit.

8. Industrial Standards and Product Certification Service

As a measure to win acceptance for Thai products, the Ministry of Industry provides a product certification service through the Thai Industrial Standards Institute (TISI), which is the national standards body for Thailand. By virtue of the Industrial Product Standards Act B.E. 2511 (1968), TISI prepares and publishes national standards and

grants the use of TIS marks. It also represents the country in the International Organization for Standardization (ISO) and the Joint FAO/WHO Food Standards Program (Codex).

Where a national standard exists for a type of product, the manufacturer can apply for a license to carry the TIS mark on his product. License is awarded for the product that conforms with the relevant standard, following stringent inspection and testing by TISI and accredited laboratories. The presence of the TIS mark on a product is an assurance of quality, reliability and safety.

9. One-stop Registration/License Service

For those industries that also require special operating licenses under the jurisdiction of other ministries -- such as in food, drugs or wood products manufacturing -- the Ministry of Industry offers a one-stop service to simplify and expedite this tedious procedure. Investors need only apply for licenses at any provincial industry office (or alternatively at the Bangkok office of the Department of Industrial Works); the Ministry will then apply to the other ministries concerned on the investors' behalf and obtain the necessary licenses within 90 days.

Selected Organizations in MOI

2.1 Textile Industry Division (TID)

Background

TID is a governmental organization in the Department of Industrial Promotion, Ministry of Industry. It was established in 1972 with the assistance of UNDP. It is the only textile technical center that has the responsibility of promoting the textile industry by means of providing technical training, technical and management consultancy services, and quality testing services, as well as carrying out research and experiments in textile fields.

Functions

- Provide training at all levels to meet the demands of the local textile industry.
- Give technical services to the local textile industries by means of technical consultancy, demonstration on modern equipment and techniques with a view to improve productivity.
- Advise and assist on textile mill management techniques.
- Give textile testing services to industry and the general public.
- Promote and develop new design, quality improvement standards and the popularity of locally produced textile products.
- Collect and disseminate statistical, commercial and technical information concerning the textile industry.
- Carry out research and experiments in the field of textiles.
- Promote and develop the textile industry in remote rural areas.

Activities & Services:

(a) Training Activities

- Textile Mill Management Techniques: The courses are designed to upgrade supervisors, foremen, etc. Some special courses in textile mill management will be formulated with the Thailand Management Development and Productivity Center.

- Entrepreneur Training: Training programs in modern machinery, seminars, and lecture series are arranged on request.

- Textile Technology Training: Technical training will be provided in the fields of spinning, yarn preparation, weaving, knitting, silk reeling, dyeing & bleaching, finishing and printing, as well as testing and quality control.

- Training of Worker or Machine Operator: The further training of existing workers is to upgrade their skills, improve efficiency, and increase opportunities of their future prospects within the textile industry.

- In-Plant and Instructor Training.

- Overseas Technical Training Course: TID organizes the regional training program for participants from nearby countries on request.

(b) Textile Industry Policy Committee

The Textile Industry Division also acts as the secretariat to the Textile Industry Policy Committee. The committee, which was appointed by the Cabinet, is chaired by the Minister of Industry. Its members include the director general of the Department of Industrial Promotion and the director of the Textile Industry Division, who act as the committee's secretary and assisting secretary, respectively. The Textile Industry Policy Committee has appointed subcommittees to solve the textile industrial problems; the first textile industrial policy was announced by the committee on March 10, 1978.

The activities that TID conducts for the committee are as follows:

- Survey and analyze the movement of the textile industry situation both inside and outside Thailand.

- Analyze statistical data for recommendation to the committee.

- Study and find out solutions to solve the problems the industry faces.

- Work out both short-term and long-term plans for the promotion and development of the textile industry in the country.

(c) Textile Fabric Design

TID has skillful designers who advise and assist the textile industry on textile designs. Courses and programs are also provided, aiming at improving style and modernizing textile products upon their structural and surface designs.

(d) Information Services

TID's library provides all textile information services: Textbooks, journals and magazines are available; statistical, commercial and technical information concerning the textile industry is also included.

(e) Textile Quality Testing Services

TID provides textile testing services to the industry and the general public by means of laboratory services for all textile products. It emphasizes quality control in the textile factory in order to improve fabric and yarn quality. Short courses are designed to train company staff who wish to set up small laboratories of their own.

(f) Research and Development

TID carries out research and development programs in order to improve and develop new textile technology. The aim is to increase the productivity and efficiency of machinery and human resources.

(g) Technical Services

The scientific and technical staffs of the division supply technical advice and information on a wide range of topics, such as textile material, the textile process, the technological method, and quality control. Moreover, surveys and analyses of the textile industry in Thailand and foreign countries are conducted in order to solve textile industrial problems.

(h) Rural Activities

On request, the division also organizes the textile training activities, such as handloom weaving, rug making, etc., for the participants in remote rural areas. Staffs for extension duty will conduct these courses by selecting village locations all over the country.

2.2 The Metal-working and Machinery Industries Development Institute

Background

MIDI is an institute that was set up within the Department of Industrial Promotion, Ministry of Industry, in accordance with a Cabinet decree dated December 3, 1985. The institute has received financial and technical aid from the Japanese Government while the Thai Government has provided personnel, operating expenses and other facilities. MIDI's main role is to be responsible for the development and improvement of small- and medium-sized industrial machinery and metal working factories, including the transfer of modern technology to these establishments. The objective is to increase their efficiency and improve their manufacturing standards so that eventually, they will be able to substitute imported machinery and even be exported. MIDI's secondary role is the development of personnel in order to build up a pool of skilled labor ready to meet the needs of foreign investors as well as to form the basis for the country's industrial and economic development.

Objectives

The institute's objectives can be divided into two parts:

1. The institute's aim is to raise the technological level of seven metalworking processes:

- Casting
- Welding and Sheet Metal Working
- Machining
- Heat Treatment
- Automation
- Electroplating
- Presswork

2. The institute's aim is to develop industrial and Metal-working products in seven areas:

- Agricultural machinery
- Molds and dies
- Gears
- Pumps and valves
- Tools
- Machinery
- Automotive and industrial machinery parts

Duties and Responsibilities

To meet its objectives in both areas, the institute has been assigned the following duties and responsibilities:

1. Provide technical training to the proprietors of small-size and medium-sized machinery and Metal-working factories in Bangkok and the provinces to increase efficiency of production.

2. Send technical experts to provide advice on a firm-by-firm basis; provide general technical advice and advice on quality control and production planning control.

3. Provide testing and examination of various metal products, testing of metallurgical properties, analysis and examination of metal structures and non-destructive testing.

4. Conduct economic and technical research to determine the technological level of each branch of the machinery and Metal-working industries to find out the problems facing them and how assistance can be provided; and to determine the extent and method of providing such assistance and technological transfers.

5. Research, experiment and construct prototype machinery as a service to factories; isolate firms willing to manufacture such machinery for the local market, thereby reducing the dependency on imports.

6. Provide information and news of developments in metalworking technology, of which there are seven main branches: metal casting; heat treatment; electroplating; welding and sheet metal working; machining; automation; and presswork. Make available other relevant news regarding engineering designs, production control, quality control, production planning, etc., through the provision of library services, questionnaires and monthly journals.

7. Serve as a coordination center for other agencies concerned with industrial machinery and metalworking in such areas as industrial development planning, human resource development, market research and development; integrated manufacturing and technological development.

3. MINISTRY OF SCIENCE, TECHNOLOGY AND ENERGY (MOSTE)

Background

The Ministry of Science, Technology and Energy was established on March 24, 1979 under an amendment to the Proclamation of Revolutionary Party No. 216, dated September 29, 1972. It was announced in Royal Gazette Vol. 96, dated March 23, 1979.

Before the establishment of the Ministry of Science, Technology and Energy, science and technology activities were independently carried out by many agencies, and their lack of coordination resulted in an overlapping of functions, operations and plans. Moreover, neither effective plans nor policies designed as proper guidelines for science and technology development existed. This, situation created many problems -- such as a lack of continuity in activities as well as a waste of human resources, budget allocations and equipment. Thus, the Ministry of Science, Techno-

logy and Energy was established through the recommendation of the National Research Council Meeting. Its objectives are to formulate, operate and develop science and technology activities.

Organization

The Ministry of Science, Technology and Energy is comprised of seven departments and one state enterprise as follows:

- Office of The Secretary to the Minister
- Office of the Permanent Secretary
- Department of Science Service
- The National Research Council of Thailand
- Office of The National Environment Board
- Office of Atomic Energy for Peace
- The National Energy Administration
- Thailand Institute of Scientific and Technological Research

Functions

- Formulating the policies, plans, schemes and projects related to science, technology, energy and the environment.
- Overseeing the management of all activities related to science, technology, energy and the environment to ensure that they will provide the highest socioeconomic benefit and will contribute to national stability.
- Creating a working plan that will evaluate the activities related to science, technology, energy and the environment.
- Improving the plans, schemes and projects concerned in order to ensure that they are appropriate and up-to-date.
- Developing appropriate technology within the country that will aid in production and marketing.
- Providing promote both internal and external technology transfers.
- Providing through research and analysis pertinent data for science, technology, energy and the environment.
- Collecting compiling and disseminating the results of research and development related to science, technology, energy and the environment.

Selected Science and Technology Institutions in MOSTE

3.1 Office of the Permanent Secretary

Background

In order to strengthen scientific and technological capabilities in some important areas, the Ministry of Science, Technology and Energy (MOSTE) has focused on scientific and technological expertise in three areas through the establishment of three national centers. They are the National Center for Genetic Engineering and Biotechnology, the National Center for Metal and Material Technology, and the National Electronics and Computer Technology Center.

In addition, the Ministry of Science, Technology and Energy has established a "Cooperation and Services Center for Private Sectors" to provide information and services to private sector firms.

Functions

- Responsibility for the general administration of the Ministry.
- Coordinating and rendering services concerning science and technology information and technology transfer.
- Formulating, conducting and following through on policies, plans and projects for the development of human resources, science, technology, energy and the environment according to the National Social and Economic Development Plan.
- Coordinating with foreign agencies on exchange of information in the areas of science, technology, energy and the environment and developing fund-raising strategies.
- Providing computerized services and performing data processing for obtaining scientific and technological information.
- Publicizing scientific and technological information, news and research activities thru public relations techniques such as press releases.

3.2 National Center for Genetic Engineering and Biotechnology (NCGEB)

Background

The National Center for Genetic Engineering and Biotechnology (NCGEB) was established in September 1983 under the Ministry of Science Technology and Energy to serve as the focal point for strengthening Thailand's capabilities in genetic engineering and biotechnology and for applying those capabilities to national economic and social development. In performing these functions,the NCGEB promotes research in a wide range of areas -- from gene and cell manipulation, to biomaterial processing, as well important areas of biochemical engineering and technology with a good potential for development in Thailand. The NCGEB also promotes industry-university links in relevant projects and activates selected programs by coordinating government and international support for the several institutes working in the field of genetic engineering and biotechnology.

Functions

The NCGEB plans and promotes research and development from the laboratory scale to the pilot scale, with an emphasis on the transfer and utilization of genetic engineering and biotechnology in the following major areas:

- Industrial applications
- Agricultural applications
- Public health, energy and environmental applications
- Strengthening of infrastructure in genetic engineering and biotechnology

Under these major areas, the following twelve specific fields were selected for emphasis:

- Production of selected enzymes
- Biotransformation of starch
- Production of selected nutritional biochemicals

- Improvement of small- and medium-scale bioindustries
- Development, design and construction of pilot plants
- Plant and animal tissue culture for the development of agriculture and agroindustry
- Production of improved rhizobium
- Organic fertilizer and mycorrhizae
- Development of natural rubber
- Production of improved bacterial larvicides
- Utilization of industrial wastes
- Strengthening of infrastructure in genetic engineering and biotechnology

The NCGEB funds research and development projects conducted by institutions within its network and is engaged in extensive collaboration with the private sector, particularly regarding the transfer of technology and information to private sector industries.

The Biotechnology Network

Organization

The NCGEB has promoted cooperation among research institutes in the country through the formulation of a Genetic Engineering and Biotechnology Network. Following, are the nine research and development institutes currently in this network:

- Chulalongkorn University
- Mahidol University
- Kasetsart University
- King Mongkut's Institute of Technology, Thonburi
- Chiang Mai University
- Khon Kaen University
- Prince of Songkhla University
- Srinakharinwirot University, Prasan Mit Campus
- Thailand Institute of Scientific and Technology Research

Functions

In addition to network activities, the NCGEB closely cooperates in research and development projects with the private sector and with the Ministry of Industry, the Ministry of Public Health and the Ministry of Agriculture and Cooperatives. Emphasis is on technology transfer from the laboratory to industry.

3.3 National Center for Metal and Material Technology (NCMMT)

Background

NCMMT was established to serve as the focal point for strengthening metal and material technology capabilities and for applying them to national social and economic development. NCMMT promotes research in metallurgy and materials science as well as in product design and processing for developing metal and material industries. Metal industries include transformation of minerals to metals, production of iron sheets, iron pipes and other iron shapes, production of non-ferrous metal, production of machinery parts, machineries and machine tools. Material industries include ceramics, polymers, fiber and textiles, rubber and composite materials industries.

Organization

NCMMT's Executive Board is comprised of eighteen members -- the minister of MOSTE serves as the chairman, with 12 experts from the public sector and 5 experts from the private sector serving on the board. The executive board will monitor and evaluate NCMMT's activities and consider its projects and budget. NCMMT's Policy Board will formulate policies and approaches and has appointed the Director to execute its policies. In addition, NCMMT has subcommittees appointed by the Executive Board, which are recruited from available experts in particular fields to evaluate in detail the projects supported by the NCMMT.

Functions

NCMMT's main objectives are as follows:

- Supplying relevant data and expertise in metallurgy and materials science as well as in production engineering and mechanical engineering to local industries in order to strengthen their capabilities and to standardize product qualities to increase their export competitiveness with other countries.

- Encouraging and activating local industries toward higher consumption of local abundant minerals and resources, or transforming these minerals and resources into other, more valuable forms.

- Providing and funding research and development projects carried out by institutions within the network, with extensive collaboration with the private sector to achieve and obtain the knowledge and capability necessary for enabling metal and material industries to meet both local and exporting demands.

- Functioning as a service center linking local certified, well equipped laboratorial organizations with the private sector to perform product testing, property analysis and quality control to comply with Universal Standards.

- Functioning as an information center to provide relevant data in metallurgy and materials science for commercial utilization.

- Analyzing compiled information about the benefits of using local minerals and resources, and about the basic industrial structure and status of metal and material industries serving as governmental guidelines (e.g., human resource development, tax restructuring, and so forth that will lead to Thailand's economic success and stability.

R&D Activities

Since its inception, the NCMMT has contributed to the following R&D projects:

1987 -- 2 projects with a 1.2 million baht budget
1988 -- 32 projects with a 10.9 million baht budget
1989 -- 46 projects with a 30.4 million baht budget

These projects were all implemented, in cooperation with the private sector, by public sector institutes such as the Department of Science Service, The Department of Industrial Promotion, and the Thailand Institute of Scientific and Technology Research, as well as public universities such as:

- Chulalongkorn University
- King Mongkut's Institute of Technology
- Chiang Mai University
- Khon Kaen University
- Prince of Songkla University
- Kasetsart University

3.4 National Electronics and Computer Technology Center (NECTEC)

Background

NECTEC was established to promote the electronics and computer industry for the import substitution and export market.

Functions

NECTEC's main objectives are as follows:

- Developing technological capabilities in the electronics and computer areas to support the country's electronics and computer industry.
- Accelerating computer applications in order to improve efficiency and productivity.
- Promoting research and development supporting the industrial promotion and international competitiveness of Thai products.
- Establishing R&D centers of excellence in selected areas.
- Creating core groups consisting of researchers in universities and companies for the development of industrial products and effective technology transfer.
- Establishing institutes and networks to provide technical and industrial information for electronics and the computer industry.
- Marketing industrial products development under NECTEC's program and to create technical entrepreneurs.

Operation Plan

There are two plans for operation:

Long-Term Plan

NECTEC has carried out a survey on the status of electronics and computer technology in Thailand in order to set up a long-term plan for technology and manpower development over the next 5-10 years. NECTEC plans to support technology intensive industries to substitute for labor intensive industries. The following areas have been identified and prioritized:

- Electronics Material Project
- IC and Electronics Project
- Hardware Computer Project
- Software Computer Project
- Industrial Electronics Project
- Consumer Electronics
- Telecommunications and Data Communications Project
- Sub-Fractional Motors Project

Short-Term Plan

In the short term, two types of projects have been identified:

Projects continuing from 1986, including:

- Designing Sub-Fractional Motors (under one horse power, using for electrical and electronic instruments) for the consumer electronic industry
- VLSI - Very Large Scale Integrated Circuit Design
- Machine Translation Project: translating Thai-Japanese documents

Projects contributing toward the goals of the Sixth National Development Plan (1987-1991), including:

- Artificial Intelligence to develop a computer language that is more user friendly
- Computer Network Project
- VLSI Design and Fabrication
- Biomedical Electronics and Instrumentation
- Technology Transfer and Human Resource Development
- Industrial Electronics and Instrumentation
- Development of Materials and Devices Technology
- Computer System Technology
- Computer Software Development
- Telecommunication Equipment Development
- Development of Sub-fractional Motors for Electrical and Electronic Appliances

3.5 Department of Science Service (DOSS)

Background

DOSS is a department in MOSTE that was moved from the Ministry of Industry when MOSTE was founded on March 24, 1979.

Organization

DOSS is divided into seven divisions:

- Office of the Secretary
- Research Division
- Analytical Chemistry Training Division
- Chemistry Division
- Physics & Engineering Division
- Biological Science Division
- Scientific and Technological Information Division

Functions

- Serving as the government's scientific and technological laboratories.

-Providing chemical, physical and biological analysis services to governmental and private organizations.

- Carrying out research works on the utilization of the nation's natural resources and industrial and agricultural wastes for economic benefit.

- Providing analysis and testing services in order to control and certify the quality of industrial products, food and beverages.

- Providing training for students of analytical chemistry of the various governmental and industrial laboratories.

- Providing scientific and technological information services.

Activities

DOSS activities can be classified as follows:

Testing Services

For sample goods or raw materials or for domestic industrial products that have not yet been provided with a standard by TISI.

Training Services

Depending on the customer's requirement, DOSS provides training in both the public and private sectors.

Consultant Services

DOSS provides this service to the firms that want to improve their production processes and product quality and cooperates with other government departments, such as the Department of Industrial Works, the Department of Public Welfare and the Bangkok Metropolitan Administration, to solve industrial problems.

Industrial Research

DOSS has its own research projects on both the agricultural and industrial sectors, including the pulp and paper industry, the food industry, the plastics industry, and others.

Information Services

DOSS has a library that has collected documents about science and technology, and patents and standards. In addition, DOSS publishes a journal every four months that reports on the progress of DOSS activities.

3.6 National Research Council of Thailand (NRCT)

Background

The National Research Council was originally established in 1956 in accordance with the National Research Council Act of B.E. 2499. The NRCT was initially divided into six scientific branches: the Physical Science and Mathematics Branch; the Medical Science Branch; the Chemical and Pharmaceutical Sciences Branch; the Biological Science Branch; the Agriculture and Forestry Branch; and the Engineering and Industrial Research Branch.

The National Research Council Act B.E. 2502 nominated the Prime Minister as the Chairman of the National Research Council, the Deputy Prime Minister as Vice Chairman, ministers as advisors, specialists in various branches of science as members, and the Secretary General and the Deputy Secretaries General for the Natural Sciences and the Social Sciences as committee member and secretary and committee members and assistant secretaries, respectively.

Organization

According to the Most recent legislation, the NRC is divided into ten scientific branches:

- the Physical Science and Mathematics Branch
- the Medical Science Branch
- the Chemical and Pharmaceutical Sciences Branch
- the Agriculture and Biology Branch
- the Engineering and Industrial Research Branch
- the Philosophy Branch
- the Law Branch
- the Political Science and Public Administration Branch
- the Economics Branch
- the Sociology Branch

The NRCT Executive Board is composed of chairmen of the ten scientific branches and not more than five people appointed by the Cabinet. The Secretary General of NRCT is a committee member and Secretary of the Executive Board, with the two Deputy Secretaries General as committee members and Assistant Secretaries. This Act also established the office of the NRCT, with the Secretary General and the Deputy Secretaries General as the executives and administrators.

Functions

- Adopting the national research policy by studying the present need of research as directed by the government, policies and plans of government agencies, the National Assembly's policy -- in harmony with the National Economic and Social Development Plan, and public requirements through the mass media -- in order that these objectives for research will focus to the same goal.

- Promoting and stimulating research work by providing funds to both the government and private sectors. These funds can be divided into research grants for junior researchers, senior researchers, experts, and university lecturers. In addition, some grants are available to

research workers to carry out certain projects that are considered to be of high priority. With a view toward promoting new inventions and research works, prizes with high remuneration are also awarded to outstanding inventors and researchers.

- Coordinating research work with international organizations through the exchange of research information and researchers in order to obtain knowledge that should be valuable for national development.

- Serving as a Research Documentary Center, where research works both in natural science and social science will be compiled and retrieved to all researchers. In addition, the center will serve as a clearing house for researchers in order to avoid duplication of efforts.

- Promoting and supporting the establishment of research institutes or professional societies as a means to group professionals in each field.

- In order that the country's research work can be carried out in the same direction as national development and to optimize the national expenditures in this regard, NRCT has appointed an investigation unit to examine the project proposals submitted for government financial support.

- Acting as a center for research coordination to provide support and to facilitate research opportunities for foreign researchers who carry out research work in Thailand.

- A training course for social scientists at a postgraduate level is organized twice a year to expand research community in this area and the subsequent manpower in various government agencies.

- Regarding the most important research projects or extensive projects that require considerable expense, NRCT can undertake the research projects itself, or it can coordinate with other concerned agencies. Some current projects under NRCT's coordination include the Aerospace Program, the Water Quality Assessment Project, the Mangrove Project, and the Narcotics Project.

- Continuing the exchange program of scientists and researchers and co-operation with other national organizations such as Japan Society for the Promotion of Science, the National Institute of Health, and the National Science Foundation of the United States on certain projects.

- Disseminating research results and information to the public.

- Carrying out translations of research documents and disseminating them to the public in order to increase knowledge and new technology in the community.

- NRCT operates Thailand LANDSAT ground receiving station, situated 40 km east of Bangkok in the Lad Krabang District. The station's reception area covers most countries in South and Southeast Asia, including the Philippines, Indonesia, Malaysia, Sri Lanka, Nepal and Bangladesh. The ground facilities are equipped with data processing and reproducing systems that enable the production of LANDSAT data. These LANDSAT data products are then distributed to domestic and foreign users upon request. The application of LANDSAT data to natural resources surveys in Thailand includes forestry, irrigation, land use, geology, water, and mineral resources.

3.7 Thailand Institute of Scientific and Technological Research (TISTR)

Functions

- Initiate and conduct research and provide scientific and technological services to state agencies and private enterprises for the country's economic and social development.

- Conduct scientific and technological research in order to promote the utilization of natural resources appropriate to the economic conditions, environment, health and welfare of the people.

- Improve productivity in accordance with government policies by propagating the results of scientific and technological research to benefit the country in agriculture, industry and commerce.

- Train scientific and technological researchers.

- Provide for testing and measuring services and other scientific and technological services.

Activities

TISTR obtains its funding largely from the government budget and government grants, with minor income obtained from contract and service fees.

For the budget year 1988, TISTR received government budget allocations and grants of 189.2 million baht; other income amounted to 12.3-million baht. The number of staff totaled 488.

Most of TISTR's research projects tend to be oriented toward the agroindustry. In 1988 TISTR had 24 in-house projects and 26 other research projects for outside institutes for both the public and private sectors. Analysis and testing services form a major part of TISTR's activities. In 1988 TISTR performed 33,126 service jobs. It also operates The Thai National Documentation Center, providing a great deal of reference publication services.

3.8 The Science and Technology Development Board (STDB)

Background

STDB was created in 1985 under the authority of the Thailand Institute of Scientific and Technological Research Act of 1979. It was established in order to carry out the objectives of the Science and Technology for Development Project, which is a joint project between the Royal Thai Government and the United States Government.

Objective

STDB's objective is to increase the effectiveness and extent of public- and private-sector applications of science and technology to Thailand's development.

It focuses on facilitating increased interaction between the public and private sectors in fostering national capability to identify, develop and produce the scientific and technological knowledge and technology required to assist industrial and agricultural development.

Budget Sources

The Science and Technology for Development Project has a duration of seven years (1985-1992) and a total budget of US$49.4 million. This amount consists of a US$26.5 million long-term soft loan and a US$8.9 million grant from USAID; a contribution of US$9.5 million from the Royal Thai Government; and US$4.5 million from the Thai private sector.

Main Activities

STDB's major functions are as follows:

1. Administering an RD&E Funding Support Program.

This critical component is needed to foster more opportunities for interaction between the users and the producers of research, development and engineering activities (RD&E) in order to focus existing Thai RD&E capabilities and resources on priority problems impeding Thai industrial growth and productivity and to enhance Thai RD&E competence in key subject areas. This program will finance RD&E activities in three priority technological areas: Bioscience and Biotechnology; Material Technology; and Applied Electronic and Computer Technology. It will include the following elements:

- A Designated RD&E Program, under which funding support will be awarded to specific institutions to enable them to develop their capabilities to be responsive to the science and technology research and information needs of particular industries on a continuing basis. Using

Designated RD&E funding support, it is intended that various institutions will become centers of excellence and expertise in various areas of significant industrial/agricultural concern.

- A Competitive RD&E Program, under which leading agriculturists, industrialists, technical professionals, industrial organizations, and trade groups will be invited to approach STDB with descriptions of problems that they believe are substantially hindering the profitability and/or expandability of specific industries or agricultural activities and might be subject to resolution or amelioration by the development of new scientific knowledge or new technologies. STDB will select those problems it considers to be the most serious and most amenable to amelioration, and it will invite proposals from the S&T community to undertake the RD&E efforts needed to address the problems. Institutions submitting the best thought-out proposals will be awarded funding support to carry out the research effort.

- A Company-Directed RD&E Program, under which STDB would provide funds to a private sector firm or organization to facilitate firm-specific RD&E efforts that it perceives to be in its best interests and which it also perceives to be of value to the nation as a whole.

2. Review of Science and Technology Policy and Practice.

This involves organizing and implementing a continuing systematic and comprehensive review of public policy as it affects (positively or negatively the extent and pace of scientific and technological development and the development of "high-tech" industries in Thailand. The following steps will be taken:

- Commission studies (to be undertaken by a variety of public- and private-sector organizations and individuals) on the impact of various policy constraints already identified.

- Finance technical assistance to key policy planning institutions to enable those institutions to better analyze and determine the impact of various present and proposed policies on S&T in Thailand.

- Organize and conduct a series of workshops and seminars focusing on particular policy issues.

3. Fellowship Support Program.

In conjunction with relevant RTG agencies, STDB is currently implementing a scholarship program in which individuals will receive training in Thai universities leading to master of science or doctoral degrees in priority technical areas. STDB will identify the areas on which to focus; identify the most appropriate Thai institutions for providing the training; and develop the criteria and procedures to be used in the selection of participants and programs.

4. Industrial Development Support Program.

This program's aim is to:

- Upgrade the capabilities and enhance the impact of key standards, testing and quality control or organizations in Thailand in order to increase the salability of Thai products.

- Oversee the establishment and monitoring the performance of a Technical Information Access Center (TIAC), which will provide high speed technical and scientific information to Thai decision makers in private and public sectors for a fee.

- Oversee the establishment and monitor the performance of a Diagnostic/Research Design Service, which will provide technical consulting services to private-sector firms in key industrial areas.

3.9 Technology Transfer Center (TTC)

Objectives

1. Recommend appropriate policies regarding technology transfer to the government.

2. Provide technology transfer services by arranging seminars and training activities and by providing consulting services.

3. Support technological development by providing financing to private firms through a revolving fund.

Organization

The TTC has the status of a division within the Office of the Permanent Secretary, MOSTE, and derives its policy directly from the Committee for Technology Development established by the Cabinet in 1982. The TTC provides promotional services related to technology transfer both at the international and local levels. It is also responsible for analyzing and evaluating new technologies and recommending priority areas and appropriate promotional measures to the government. It provides training services related to technology transfer in cooperation with TISTR.

The TTC consists of four divisions: the General Administrative Division; the Technology Status Division; the Contribution of Technological Development Division; and the Contribution of Technology Transfer Division. The TTC employs 29 staff: six with masters degrees, 16 with bachelors degrees, and seven clerks.

Activities

In the 1988 fiscal year, the TTC arranged seven technological exhibitions and six training and seminar courses, published 34,500 documents, provided video tape copying services worth 69,000 baht, and provided technology transfer in 13 rural areas.

In addition to these activities, the TTC supported five firms by providing funds from a revolving fund the support R&D (not more than 5 million baht at 4% interest) and efforts to increase productivity (not more than 10 million baht at 6% interest). The TTC also promotes energy saving and environment preservation by offering a tax reduction (mainly to non-BOI promoted firms) on imported machines for these purposes. About seven to eight applications are approved for this privilege each month.

4. MINISTRY OF UNIVERSITY AFFAIRS (MUA)

Overview of the S&T Activities in Some Universities

There are 16 state universities and 18 private universities in Thailand under the Ministry of University Affairs and the Rajamangala Institute of Technology under the Ministry of Education. Apart from granting academic degrees, many of the facilities of science and engineering also offer a number of S&T services. They may be special training courses; research in basic science, applied science, and engineering; consultancy and extension, testing of materials and products; and so on.

This section will briefly describe some of the universities offering these services. Further details on the S&T units may be found in Section II.

Selected Organizations in MUA.

4.1 Chiang Mai University

Chiang Mai University has 13 faculties and seven institutes or centers. Each of them provides its own services to the community. For example, the Faculty of Engineering has provided academic and technical services by:

1. giving lectures, training courses or organizing conferences and seminars to disseminate knowledge or research findings, as well as giving academic consulting services; and,
2. providing technical services such as analyses, tests or designs.

From October 1986 to September 1987, the faculty provided guest lecturers for other organizations on 14 occasions, accomplished 29 cases of technical services, and conducted six training courses.

The Faculty of Science provides community services with emphasis on the distribution of knowledge to the community at various levels in order to serve their needs and to help in solving their problems. Continuing education in the form of technical meetings, seminars, workshops and training courses is classified as one of the major categories of our services to the community. During the academic year 1987, the Faculty of Science and its six constituent departments organized a total of 13 activities of this kind, aiming at transferring knowledge to school and college teachers, scientists, industrialists and those involved in science and technology. Many of the activities have been organized consecutively in the last few years; for example, a workshop on ceramics, a geoscience workshop on field geology, and a training course on computer introduction for high school teachers.

Apart from the normal channel through faculties and institutes in disseminating research results, it is worth mentioning the new organization, UNISERV, which provides practical assistance to the small- and medium-sized private enterprises in northern Thailand through training and dissemination of research findings.

Faculty	Institute/Center
1. Associated Medical Science	1. Central Library
2. Dentistry	2. Computer Service Center
3. Nursing	3. Research Institute for Health Science
4. Medicine	4. Social Research Institute
5. Pharmacy	5. Multiple Cropping Project
6. Fine Arts	6. Institute for Science and Technology Research and Development
7. Agriculture	7. Uniserv
8. Humanities	
9. Science	
10. Engineering	
11. Education	
12. Social Science	
13. Graduate School	

4.2 Chulalongkorn University

Chulalongkorn University has 16 faculties covering the fields of social science, humanities, and science and technology. The Faculty of Science and the Faculty of Engineering are large faculties with more than ten departments each. Apart from performing academic duties, the departments also offer a number of S&T services to the public. These include testing of materials and products according to industrial or international standards, research, consultantcy and special training courses. The Scientific and Technological Research Equipment Center is well equipped with modern and sophisticated analytical equipment, and it has been providing a lot of testing services to both the public and private sectors. Recently, the university established Chula Unisearch to promote the utilization of knowledge and technology within the university to solve problems in commerce and industry. Its main function is to develop contacts with industry, government agencies and the community at large and to coordinate the resources universities need to meet their demand.

Faculty	Institute/Center
1. Architecture	1. Academic Resource Center
2. Arts	2. Computer Service Center
3. Commerce & Accountancy	3. Scientific and Technological Research Equipment Center
4. Communications Arts	4. Institute of Asian Studies
5. Dentistry	5. Instituted of Biotechnology and Genetic
6. Economics Engineering	6. Institute of Environmental Research
7. Education	7. Institute of Health Research
8. Engineering	8. Institute of Population Studies
9. Fine and Applied Arts	9. Institute of Social Research
10. Law	10. Language Institute
11. Medicine	11. Graduate Institute of Business Administration

12. Pharmaceutical Science
13. Political Science
14. Science
15. Veterinary Science
16. Graduate School

12. Chula Unisearch
13. Sichang Marine Science Research Station and Training Center
14. The Merchant Marine Institute
15. Institute of Middle East and Muslim World Studies
16. Public Enterprises Institute
17. Institute of Security and International Studies
18. The American Studies Program
19. Thai Studies Program
20. General Education Project
21. Continuing Education Program
22. The Petroleum and Petrochemical College

4.3 Kasetsart University

Kasetsart University concentrates on the field of agriculture. Apart from faculties and research institutes that undertake research activities, there are many more field stations and research centers for special programs, such as the Maize and Wheat Research Center, the Pig Research and Training Center, and the Highland Agricultural Program. The two organizations that are involved in promoting research and development and are also involved in the transfer of technology are the Research and Development Institute and the Office of Extension and Training. The former is the coordinating and facilitating body of the university for research activities; it is the funding and evaluating agency. This organization's role is the implementation of research results in the form of demonstrations and training. The Office of Extension and Training is equipped with facilities for training, including the production of audio visual media. Its major function is to provide training and dissemination of knowledge in agriculture -- for example, food preservation, farm machinery, breeding of animals, plant growing,

plant/animal diseases, fertilizer, etc. It is aimed at creating understanding and providing knowledge for rural people. Recently, the Faculty of Engineering's contribution has become more well known, particularly in the field of Thai language software.

The National Center for Agricultural Machinery, located at Kasetsart University's Kampaengsen Campus, offers information about the manufacturing process and the equipment of three technologies -- the work feeding machine, the mandarin sorting machine, and the incubator for "nin" fish eggs.

Institute of Food Research and Product Development

Institute of Food Research and Product Development was founded on September 30, 1988, the day that Kasetsart University incorporated the Department of Experimental and Researching Study of the Preserved Food Organization, the Ministry of Defence to Kasetsart University.

Objectives:

1. To conduct research in science and food technology to increase the efficiency of processing for food manufacturers in Thailand.
2. To advise in order to improve the quality of agricultural materials for food manufacturers.
3. To develop and improve the quality and quantity of food products for markets in both local and foreign countries.
4. To develop and assist entrepreneurs and interested persons in knowledge on food technology
5. To produce new kind of inexpensive and nutritious foods.
6. To support the development of food industry to increase income and generate employment for the people.
7. To coorperate with the other organizations in research on food science and technology.
8. To establish an information system on food science and technology.

Organization

To achieve the objective of the Institute. The Institute of Food Research and Product Development is divided into 6 departments and one office as follows:

- Office of the Secretary
- Department of Research
- Department of Product Development
- Department of Pilot Plant
- Department of Quality Control
- Department of Demonstration and Education
- Department of Plant Engineering

Responsibilities of Food Institute

1. Researching and Developing Food Products

- Plan research in food science and technology according to the National Economic and Social Development Plan which advocates "Integration as complete system" both in technology generation and marketing.

- To conduct research in prevention of the lost of agricultural products.

- To conduct research in chemical and physical sciences of agricultural products in order to develop existing methods or use new method of production to enhance agricultural product processing at industrial levels.

- To conduct research in the utilization of by products and wastes of agriculture.

- To conduct research on using biotechnology in the production of other food.

- To conduct research on quality testing and food safety including impurity and contamination.

- To conduct research and develop highly nutritious inexpensive foods and to improve them to suit for Thai consumption habits in order to solve the problem of malnutrition.

- To test run production to test the market and the need of consumers.

- To conduct research in quality and quantity of raw materials, the production process, the quality control both in microbiological and physical science of preserved food in accordance to the international standards.

- To study the type and shape of contains suitable to the product.

2. To advise, disseminate and transfer technology

- To advise on efficient and appropriate technologies to support the development of food industry.

- To advise and support the development of new agricultural products from by products of agriculture and agro-industry.

- To advise and support the production of nutritious and inexpensive foods.

- To advise and disseminate knowledge and technology of transportations, raw material storage, product processing, food preservation, quality control and factory sanitation to entrepreneurs.

- To advise and disseminate preserved food products in both local and foreign market.

- To cooperate with the government organizations and other institutions both local and foreign in exchanging information on food technology research.

3. Education, Demonstration and Training

- To cooperation with educational departments by giving training courses at various levels.

- To provide vocational training to the general public.

- To organize from time to time special training courses for factory personnel where considerable demand exists in the food industry such as food quality control.

- To provide food science and technology training course for foreigners.

4. Cooperations with Foreign Countries

- To seek from abroad, information, experts and funds to enhance effective transfer of technology and bring about better economic and technological development of local food production.

- To support an academic cooperation and interchange of experiences especially in agro-industry sectors with other developing countries in ASEAN and Asia.

- To improve information system in food, science and technology for exchange among ASEAN and other countries.

Project of Foreign Cooperation

The Institute of Food Research and Product Development has received numerous supports from foreign countries for years in terms of fundings, personnel development research and necessary equipment in conducting research and for pilot plants.

The Protein Food Project

The Institute of Food Research and Product Development conducted research and development to produce and supply protein rich foods for pre-school children in all regional nutrition centers. The institute has received support from USOM and USAID of U.S.A..

The Canada Plus One Project

The institute under the support from the Canadian Government has undertaken this project with an aim to diffuse new processing technologies as well as to provide services in chemical and microorganism testing of products and also training course for food manufacturers in Bangkok and Thonburi.

The Baby Food Project

By conducting research and development in search of suitable and affordable supplementary food for Thai children that could replace the use of for examples sweetened milk, and ground rice porridge which has little nutritions for babies. The project is supported by the Australian Government in terms of manpower, training, equipment and machinery.

The FAO Project

The project provides support in personnel development by giving scholarships for studying overseas as well as provides various laboratory equipment.

The ASEAN Protein Food Project

To tackle malnutritions among children caused by poverty and improper diets including those of mothers, this project provides funding for R&D equipment and chemicals, wages, training and other expenditures such as attending overseas conferences and workshops and conduction of experiments and research, etc..

The Post Harvest Information Exchange Project

The project aims to build and/or improve existing data bases to be linked into a regional network for information exchange regarding post-harvest management among ASEAN countries.

International Cooperation in Research, Study, and Training

This is a collaboration project in conjunction with research institutions of other countries with funds for training and exchange of research personnel provided for by various countries or institutions.

The Royal-Originated Projects

Various royal-originated projects to improve communication, educations, health care, nutrition value, and vocations have been instituted all with the objective to create better living standards for the Thai people.

The Green Isan Project

This is another royal-originated project specially aimed at improving the living standards of the Northeastern region of Thailand, the lowest among all the regions. The overall project has four main components: Research and Development, Implementation, Training, and Evaluation, among others.

The following are faculties, institutes or centers within:

- Faculty of Agriculture
- Faculty of Fishery
- Faculty of Humanities
- Faculty of Forestry
- Faculty of Science
- Faculty of Engineering
- Faculty of Education
- Faculty of Economics and Business Administration
- Faculty of Veterinary Medicine
- Faculty of Social Sciences
- Faculty of Agro-Industries
- KU Demonstration School
- Extension and Training Office
- Office of University Library
- Office of University Computer Services
- Institute of Food Research and Development
- Research and Development Institute

4.4 Khon Kaen University

Khon Kaen University is situated in Thailand's Northeast Region and thus has played a major role in the region's development. In cooperation with local government agencies, the university is involved in a bottom-up type of development program--starting with surveying the community to identify its problems and planning needs. Khon Kaen University's involvement in the self-help water resource development in rural Thailand is an example of the educational institute's participation in development by means of research. The government agencies are the implementers of villagers' participation. In order to transfer technology through the self-help approach, the training program is set up, and the university is involved in every stage of the process to ensure its effectiveness.

Faculty	Institute/Center
1. Agriculture	1. Research and Development
2. Engineering	2. Computer Service Center
3. Education	
4. Science	
5. Nursing	
6. Medicine	
7. Medical Technology	
8. Public Health	
9. Dentistry	
10. Pharmacy	
11. Humanities	
12. Graduate School	

4.5 Mahidol University

Mahidol University's contribution to the public is in the field of health science. The problem-oriented research is conducted in its various research institutes, i.e., the Institute of Population and Social Research Institute of Language and Culture for Rural Development, the Institute of Nutrition, and the Institute of Science and Technology for Development. Research and development activities are carried out by the last Institute in fields such as biotechnology, molecular genetics, genetic engineering, and thalassemic vaccine. This institute also disseminates knowledge about science and medical biological instruments. It offers a training program in the application and maintenance of biochemical equipment.

The Applied and Technical Research Center appears to be taking a more active and more commercially oriented role. The unit's manager has been able to conclude a relatively large number of apparently successful and well-negotiated deals with private companies for the university.

Faculty	Institute/Center
1. Medicine	1. Population and Social Research
2. Medical Technology	2. Nutrition
3. Nursing	3. Language and Culture for Rural Development
4. Science	4. Science and Technology for Development
5. Pharmacy	5. Biomedical Equipment R&D Center
6. Dentistry	6. ASEAN Training Center for Primary Health Care Development
7. Public Health	7. Applied and Technical Research Center
8. Tropical Medicine	
9. Social Science and Humanities	
10. Environment and Resource Studies	

4.6 Prince of Songkla University (PSU)

Prince of Songkla University has two campuses: Pattani and Hadyai. It was established in Thailand's Southern Region in order to decentralize university education, improve standards of regional living, promote social development, and transfer technology. The community college set up in Phuket provides a higher certificate of education. Southern Thailand is well known for its abundant natural resources. Thus, PSU serves the region well through the Faculty of Natural Resources. Research, training and invention activities that benefit the public through royal-initiated projects include the promotion of a small-scale palm oil industry, goat research and development, producer gas, artificial larynx, rubber research, and a southern business development program.

Faculty

Pattani

1. Education
2. Humanities
3. Social Science
4. Science and Technology

Hadyai

1. Engineering
2. Science
3. Medicine
4. Pharmacy
5. Nursing
6. Dentistry
7. Management Science
8. Natural Resources
9. Graduate School

4.7 King Mongkut's Institute of Technology-Thonburi (KMITT)

The institute was started in 1960 as the Thonburi Technical Institute, which served as a training institution for technicians. In 1971 it was combined with the Northern Bangkok Technical Institute and the Nonthaburi Telecommunication Institute to become the King Mongkut's Institute of Technology. In 1986 the three institutes were transformed into three universities under the Ministry of University Affairs.

In 1987 KMITT organized ten training courses and seven exhibitions. It also disseminated research findings through daily newspapers every month. The Continuing Education Center organized four seminars, three international conferences and published two documents. KMITT also actively participated in the royal project for foods by organizing training courses for project personnel and conducting research projects in food production and preservation.

The two organizations under the Faculties that play an important role in research and development and public services are:

- The Center of Operation for Research and Development under the Faculty of Engineering
- The Scientific Instrument Center for Standards and Industry under the Faculty of Science

The Center of Operation for Research and Development, which was established in 1981, acts as the contact point for technological services for the public. Its activities include: testing for the physical properties of metal, chemical analysis, problem solving regarding foundry works, improvement of productivity, design, fabrication and installation of machinery of processes, testing and calibration of mechanical and electrical instruments, custom-made castings from alloys as requested, etc.. Equipment built for other organizations includes an automatic palletizer, a natural gas liquid vaporizer and a liquid-liquid extractor. In 1987 the center conducted 20 research projects and tested 1,770 jobs.

The Scientific Instrument Center for Research and Development has disseminated research and development results and gives advice on laser application. It also provides analysis of water quality to the private sector. In 1987 it organized seven training courses.

Faculty	Institute/Center
1. Engineering	1. Center of Operation for Research and Development
2. Industrial Education	2. The Scientific Instrument Center for Science and Industry
3. School of Energy & Materials	3. Continuing Education Center
4. Science	4. Library and Documentation Center
	5. Computer Center
	6. Pilot Plant Training Institute

4.8 King Mongkut's Institute of Technology-Ladkrabang (KMITL)

Founded in 1961 as Nonthaburi Telecommunications Training Center, KMITL was upgraded three years later to become Nonthaburi Institute of Telecommunications. In 1971 KMITL became a part of King Mongkut's Institute of Technology. In 1986 the Thai government established KMITL as a separate university. KMITL has carried out several research and development projects, mainly in the Faculty of Engineering. Some recent identifiable research and development projects are: design and development of small motors for electric appliances, automatic pattern tracking for sheet metal cutting, animal feed production control by microcomputers, design and fabrication silicon rectifier for mass production, development of Thai printed character recognition for microcomputers, etc.. Some of the research achievements that have found applications in external organizations are: muzzle velocity measuring equipment, motor protection unit, automatic voltage regulator and automatic battery charger.

Faculty	Institute/Center
1. Engineering	1. Computer Research and Service Center
2. Architecture	2. Electronics Research Center
3. Industrial Education and Science	3. Engineering Service and Development Center
4. Agricultural Technology	

5. MINISTRY OF PUBLIC HEALTH

5.1 Food Control Division

Food Control Division is a division in The Food and Drug Administration, Ministry of Public Health. Its administrative organization consists of :

1. Food Registration and Licensing Section consists of Food Registration Licensing Unit and Label Permition Unit

2. Food Manufacture and Import Premise Control consists of Control Plant into Central Unit, Control Plant into Principal Unit and Developing Factory Unit

3. Food Standard Control Section consists of Food Standard Regulation Unit, Food Technical Service and Quality Assurance

The division's responsibility is to serve as a planing and implementing unit according to the following laws and regulations

- Set up and control the quality and standard of specifically-controlled food, quality/standard-controlled food, and all related food
- Authorize food manufacturing licence and approve importation of food
- Register food formulas and issue certificates
- Examine, change, and correct all new certificates

- Compile data and conduct research and study for setting up and controlling food quality and standard
- Conduct training and fact dissemination relating to food control and international food standard such as FAO, WHO, etc.
- Organize meetings for Food and Drug Administration Committee

In addition, the division is also responsible for Internal Program Chemical Safety according to the Cabinet, 13 November, 1984.

APPENDIX 5: DEVELOPMENT OF REGULATIONS FOR AUTOMOTIVE INDUSTRY

Date	Passenger Car	Small Truck Or Pick-up Truck*	Truck and Bus
1969	Tyres, battery, radiator and leaf spring should not be included in the CKD list	* including trucks with gross vehicle weight not over 3,000 Kgs., and wheel base not exceeding 3 metres.	
Jul.19, 1971	- Each manufacturer was allowed to produce not more than 3 models of passenger cars, and - not more than 1 model of cars of over 2000 cc. - A local content requirement of 25% of the total component value, effective from December 31,1973	- wheel base not exceeding 3 metres	- A maximum of 5 models for each manufacturer.
Feb.29, 1972	- Model restrictions by the announcement of Jul.19, 1971 were cancelled.		- Model restrictions by the announcement of Jul.19, 1971 was cancelled.
Nov.5, 1973			- A 15% local content requirement for chassis with engines, effective from Jan.1, 1975.
Feb. 1974			- A 20% local content requirement for chassis with windshield effective from Jan.1, 1975.
Jan.1, 1975	<------ Adoption of formula for local content calculation, ------> using C.I.F price and duties as bases.		

<table>
<tr><th>Date</th><th>Passenger Car</th><th>Small or
Pick-up truck</th><th>Truck and Bus</th></tr>
<tr><td>Aug.
1978</td><td>- Replacement of the formula with a standard table of fixed percentage values of car components.

- An increase in local content requirement from 25% to 50% within 5 years as follows: 35% in the first 2 years and 5% for each consecutive year up to Aug. 1983</td><td></td><td></td></tr>
<tr><td>Dec.
1979</td><td></td><td></td><td>- Replacement of the formula with a standard table of fixed percentage value of components.

- An increase in local content requirement of 5% per year up to the target rates specified for each type of trucks as follow:</td></tr>
<tr><td></td><td></td><td colspan="2">Chassis with cab: from 25% to 50%, Chassis with windshield: from 20% to 45%, Chassis with engines : from 15% to 40%</td></tr>
<tr><td>Dec.
1979</td><td colspan="3"><---- The local content rules were not required for ----> production of exports. However, specific local parts and components specified by the Committee on Automotive Industry Development must be used.</td></tr>
</table>

Date	Passenger Car	Small or Pick-up truck	Truck and bus
Dec.26, 1979			Approvals of establishment and expansion of a manufacturing facility were subjected to the following conditions for the manufacturers: 1. fulfilling the local content requirements. 2. submitting the project specification and details. 3. increasing local content for the existing production to the target rate.
Feb.-Apr. 1980			- Trucks weighing over 3.5 ton should have following local parts: radiator, exhaust pipe, battery, front and back leaf-springs, tyre and inner tube, safety glass and brake drums (front and back)
Mar.18, 1983	- The local content requirement was discontinued at 45%. - New models and new assembling patterns were prohibited.		
	<----- Expansion of the existing capacity of plants, but not establishment of new manufacturing facilities, was allowed. ----->		
Aug. 1984	- Not more than 45 series of domestic production of passenger cars was allowed. Each series should not have more than 2 models. (cont.')		

Date	Passenger Car	Small or Pick-up trucks	Lorry and bus
	And each model should consist of one type of body, one type of engine, and possibly two gearing systems. - In case the manufacturers failed to produce the approved series within one year, the right for production would be withdrawn. Other series than the approved ones were not allowed to resume the conceded right. This was enforced as from Jan.1, 1986		
Nov.20, 1983	- Renewal of manufacturing licenses required filling the following additional documents: 1. CKD price lists 2. Price lists of import parts 3. If procedure's infringed, the assembly's licence will be void.		
Dec.21, 1983	- The local content requirement increased from 45% to 50%, 60% and 70% of the total value of the complete set basing on the standard table;or, alternatively, from 67 items, to 109, and 196 items in 1986, 1987, 1988 respectively.	- The local content increased to 49%, 55%, and 65% of the total value of the complete set of parts, from 1987 to 1988 respectively.	- The local content requirement should be in the range of 40-50% of the total value of the complete set.

Date	Passenger Car	Small or pick-up truck	Truck and Bus
June 13, 1986	- Mandatory and optional lists of parts accounting for 54% were designed for local content program starting from 1987	- Reschedule of implementation of the local content earlier imposed to be 1986-1988	
July 1986		- Locally-made engines for pick-up trucks were included in the compulsory list of local parts, effective from July 1, 1989	
June 22, 1989	1. Expansion of the existing capacity was allowed, but not the establishment of a new plant. 2. The existing production should meet the minimum local content of 54%, in addition to other compulsory local parts required by the Ministry of Industry. 3. In case where implementation of above requirements was impossible, the manufacturers should seek recommendations from the Committee on Automotive Industry Development, endorsed by the Ministry of Industry 4. A Maximum of 42 series of passenger cars is allowed for the production for domestic market.		

Date	Passenger Car	Small or Pick-up Truck	Truck and Bus
	5. The requirements as in 2) and 4) were based on criteria and conditions specified by the Committee on Automotive Industry Development. Any appeals should be submitted to the Committee for consideration and approved by the Ministry of Industry.		

Note : Local Content means the requirements to use parts and components produced within the country.

The announcements of the Ministry of Industry relating to the motorcycle industry are as follows:

July 19, 1977 — A local content of 70% of the total value of the complete set of parts for establishment and expansion of assembly plants of motorcycle.

November 15, 1984
1. The manufacturers must use local parts and components specified by items, and on the schedule. (detailed as in the attachment to the announcement)
2. Relaxation, revision, or enforcement of the local content requirement for exceptional cases should be considered by the Committee on Automotive Industry Development and approved by the Minister of Industry.

January 13, 1987 — Except those conceded promotional status from the Office of the Board of Investment, applications of establishment and expansion of assembly plants of motorcycle of cylinder volume over 150 cc. would not be accepted.

December 25, 1986- November 8, 1989	Establishment and expansion of plants producing items of electrical parts and components for motorcycle (listed in the attachment to the announcement) were not allowed except those: 1. approved by ASEAN economic ministers, or 2. using other brand names than the one of projects approved by the ASEAN economic ministers, or 3. produced for exports to markets outside ASEAN not less than 75% of the total production.

Sources : 1. A Study on Automotive Industry by Industrial Finance Corporation of Thailand, September 1976.
2. Announcements and records of industrial policies of the Ministry of Industry effective on September 15, 1988, ordered by Thailand Standard Industrial Classification, Industrial Economics Division, Ministry of Industry.