Final Report

Development of the Machinery and the Equipment for Information Industries in Thailand

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The Research Team

EXECUTIVE SUMMARY

A. INTRODUCTION

The economy of Thailand has expanded at an impressive double-digit GDP rates in the last few years averaging 11.0 percent in real terms from 1987 to 1990. More significantly, the industrial sector has been surging at a much higher average growth rate in recent time to gain an increasingly large share of the GDP of over 25 percent since 1989. A recent World Bank study into the international competitiveness of Thailand has suggested that the country has appeared to undergo a structural change from labor-intensive to technology-intensive industries since it seems to begin developing some comparative advantage in the manufacture and export of differentiated goods.

In that respect, the development and enhancement of production and engineering capability necessary to support the manufacturing of differentiate products depend in no small part on an adequate machinery and information equipment industries, in particular on the machine tool, the mold and die, the computer and the telecommunications equipment sectors of the above industries. These industries while are important in their own right to meet the fast expanding world demand, their outputs also form essential production capital goods for most any industries, even more so for the production of technology-intensive goods.

It is therefore vital that Thailand should not neglect the development of these two industries, especially the four important sectors of machine tool, mold and die, computer, and telecommunications equipment.

B. THE THEORETICAL FRAMEWORK AND METHODOLOGY

The framework used in this study has two major components. The first is an economic analysis while the second a technological analysis. The former is essentially modeled along the concept of Michael Porter, while the second is based on a number of technological assessment frameworks from the works of Sharif, Wesphal and Thailand Development Research Institute's earlier works.

The economic analysis framework consists of four parts: demand conditions, supply conditions, market structure and firms's strategies and supporting industries. On demand conditions, home demand will be analyzed in terms of market segments and characteristics relating to product composition, technological requirements, price and other competitions, as well as role of government; export demand will focus on export value and share in production, growth and type of products, as well as international competitiveness. Supply conditions will cover factor requirements, sources of factor supply and input, factor market distortion. Market structure and firm's strategy concerns extent and nature of competition, barriers to entry, entrance and exit of producers, ownership and management style, market niches and product differentiation. Supporting industries will be analyzed with respect to availability and depth of supporting industries and services, extent of linkages, quality and capacity to meet demand, and price competitiveness, for examples.

The technological analysis framework seeks to integrate the concepts of technological embodiment, technological capability, and technological content. Technological embodiments describe a firm's technological resource endowments in manpower, machinery, information and organization each of which interacts with and influences one another dynamically. Technological contents describe a firm's basic production and technological base which resides in the four technological components of production-management technology, process technology, product-specific technology, and design technology. Technological capabilities give yet another perspective of a firm's technological and production base in terms of an ability to: develop and/or produce quality products at competitive prices (operative capability); acquire and absorb technology from without the firm (acquisitive capability); modify and improve products and/or production processes, or enhance the firm's technological resources from within the firm (adaptive capability); and lastly, introduce new applications of knowledge or experience that significantly change the firm's technological base and competitiveness (innovative capability). Technological contents essentially focus on the possession of technology embodied in a firm's technological resources while technological capabilities basically give a measure of how well a firm utilizes or enhances its technological resources.

Economic analysis and technological analysis according to the above theoretical framework are applied to each of the four sectors under study

based on secondary data sources from previous studies, published data and statistics in conjunction with primary data sources from interviews of firms, relevant agencies and expert opinions and knowledge. In all, 22 firms in the machinery and 21 firms in the information equipment industries were used, along with 10 government agencies in our field interview. In addition, expert opinion from 10 knowledgeable and authoritative persons within the relevant fields was sought.

C. THE MACHINE TOOL INDUSTRY

In the early 1970s, the production of machine tools began with simple machine tool manufacturing based on imports of critical parts and reverse engineering to supply the local needs. From some eight producers in 1973, the number increased to just 18 four years later.

The value-added generated by the industry's production in 1980 was a mere 113 million baht. Local production was only to serve many small repair shops. Therefore, most of the domestic demand for machine-tool capital goods was met by import which rose sharply from 132 to 791 million baht in 1970 and 1980 respectively. There was practically no export until about 1975 with some 7 million baht, rising to 36 million baht in 1980. The next half of the 1980s saw very little change. While production had risen to 324 million baht in 1985, import soared to over 2,100 amid a drop in export to just 16 million baht that year.

With a substantial new entry of foreign firms since the mid 1980s to take advantage of low labor and overhead costs, the industry has undergone significant changes. These foreign entries came mostly from Japan and Taiwan to manufacture CNC and high-end products for export. Production and exports rose therefore to 781 and 787 million baht, respectively, in 1990, while import continued to expand to over 11,300 million baht the same year.

Economic Analysis

a. Demand Conditions: The rapid growth in domestic demand has not stimulated similar growth in production, except for foreign subsidiaries aiming at the export market for several reasons. First, there was an absence

of a captive market during 1970s; second, there was a subsequent change in demand conditions from simple machines to CNC and high-end products during the 1980s; third, various promotion privileges were seen to go against purchase of locally-made machine tools.

b. Supply conditions: The government has so far played only minor role in the building of necessary production infrastructure. Thus, these is a wide-spread lack of technical manpower particularly in the fields of metallurgy, mechanical, testing, design, and other engineering services. Furthermore, the past government policy had not provided any significant and specific support to the industry except in the form of some general tariff protection measures.

c. Market structures and firm's strategies: Most Thai firms spent little effort to explore and diversify to other potential or related products, but seemed contented to adopt inward-looking market strategy and imitative technology strategy. In contrast, newly-established foreign firms tend to employ outward-looking market strategy and defensive technology strategy with the main aim toward manufacturing competitive products for the world market.

d. Supporting industries: The industry also faces constraints in the availability of supporting industries like high-quality casting, forging, machining, and heat-treatment. Moreover, there is no local supply of electronic control devices for CNC machine tools. Makers of these machine have to depend on imports at high costs and without know-how to effectively install these devices in contrast with foreign firms who are strongly supported by parent companies.

Technological Analysis

a. Technological capabilities: Both foreign and Thai firms are seen to lack either innovative or adaptive capabilities. Similarly both groups are not much different in term of acquisitive capability. However, there is a large difference in the operative capability. Thai firms tend to have low production efficiency and inconsistent product quality unlike foreign firms. Moreover foreign firms tend to invest substantially in human resource development in addition to up-to-date machinery and equipment.

b. Technological contents: Foreign firms are stronger in process and product-specific technology than most Thai firms, and somewhat surprisingly, both groups are weak in production-management technology. Another common characteristic is that both do not pay much attention to the use of design technology.

c. Technological embodiments: In general Thai firms are found to be inferior in technological embodiments than foreign firms. Machinery and equipment in Thai firms are simple and of manual type or largely second-hand; skills are scarce and tend to reside with only the owner or a few top personnel; information is minimal and not consciously acquired and used; organization is weak with most decisions made by only one or few persons.

D. THE MOLD & DIE INDUSTRY

Production of molds and dies evolved from machine shops using the experience from repairing imported dies. The demand for dies has increased in line with expansion of user industries such as automotives, machinery parts, metal products and plastic products. In the automotive industry for example, the local content requirements necessitate the demand for dies in the making of several automotive parts. Furthermore, computer peripherals have emerged as an important export industry which presents another important source of demand for precision dies.

Economic Analysis

a. Demand Conditions: Domestic die production was estimated at 1,700 million baht in 1989 with import and export of 1,738 and 171 million baht respectively. In 1990, the import and export values of dies jumped to 3,069 and 255 million baht respectively. The rapid rise in the demand was induced by a rapid expansion of user industries. The expansion is however more apparent among large firms dominated by subsidiaries of large user companies and joint-venture firms.

b. Supply Conditions: Most serious short-coming of the supply conditions is a serious shortage of engineers, experienced technicians and skilled labor. BOI promoted firms for whom acquisition of efficient machinery poses

no serious problem are generally well equipped, unlike non-promoted firms who face considerable problem due to high import tariff.

c. Supporting Industries: Important supporting industries are machining, casting, forging, heat treatment and electroplating. In recent years, there have been significant developments of all these industries. High quality cast steels for die making can be produced by several firms though at a relatively high price due to limited number of these suppliers. Heat treatment technology is somewhat underdeveloped. Electroplating service is widely available, though good quality of plating is usually hard to find.

d. Market Structure and Firm's Strategies: While competition on a cost basis at the low end of the die market is very keen, the high end segment is oligopolistic and competition is restricted by technological capabilities. Most small firms have rather narrow technology perspective, and generally stay at the low end of the market. Among large firms, vertical integration is quite common in order firms to meet their own needs.

In the middle is the group of firms founded by former engineers or technicians from large firms, their strategy tend to emphasize higher value added rather than lower cost.

Technological Analysis

We may broadly classify firms into 2 groups. The first are those supplying products in the high end and middle market. These firms possess a relatively high level of operative capability and represent only a small fraction of the total number of producers. Most are joint-ventures and foreign subsidiaries, and are among the most advanced die producers in Thailand with strong supports from parent companies. Design is carried out by a design staff consisting of engineers and draftsmen and is facilitated by software programs on computer aided design equipment. They are well equipped with modern machinery imported mostly from Japan. Raw materials are properly selected and finished products are thoroughly tested. These firms' technological embodiments are rated comparable to international standard level, with suitable machinery and equipment capable of producing standard quality of dies. Manpower have good proportions of design engineers, draftsmen, skilled machine operators and supervisors. They usually have good access to tech-

nological information, while their organizational structure and job descriptions are well-defined and appropriate management techniques are usually employed.

Although operative capability among this group of firms is generally high, many factors like the scarcity of qualified manpower, the lack of facilities and supporting institutions make it more practical to acquire new technology through a transfer mechanism than innovating one. Thus, even leading firms in Thailand generally have low innovative and adaptive capability.

The second group of die manufacturers made up of firms founded by former engineers and technicians tend to have lower technological capability. Their design capability, though higher than most average Thai firms, are not on par with the first group of mostly foreign and joint-venture firms on account of inferior human resources and equipment. The surveyed sample did not cover the third group of small Thai firms with very limited technological resources and manpower whose characteristics can be inferred from various past studies. These firms are expected to remain unchanged at the low end market throughout the entire life span because of the low educational background of the entire personnel.

E. THE TELECOMMUNICATION EQUIPMENT INDUSTRY

Up to only four to five years ago, the much underdeveloped telecommunications equipment and related industries was seen to be caused, among other things, by the heavy regulations and control under the state. Majority of firms in the electronics industry firstly concentrated in the consumer electronics sector, then came the component manufacturing followed by computer and peripherals in the late 1980s.

The telecommunication services deregulation in the U.S. in 1984 gave a major impetus to the customer premises equipment industry growth first among Asian NICs. Then major industrial shift precipitated by rising labor costs among these countries forced many labor-intensive operations to be relocated elsewhere mostly to lower labor cost countries including Thailand. At least some 30 over telecommunications equipment and parts manufacturers are already

in operations today compared with just a handful of local firms prior to the mid 1980s. While imports continued to grow to satisfy unmet domestic demand to 10,889 million baht in 1990, exports jumped dramatically from a mere 9 million baht in 1980 to 86 million baht in 1986 and grew strongly to 5,153 million baht in 1990.

From a narrow range of radio transceivers and simple telephone sets for the local niche market, the product range expanded quickly to include mass-production for export of cordless telephones, telephone answering machines, key telephones, small PABX, facsimile machines, as well as an increasingly wide range of parts and components.

Economic Analysis

a. Demand Conditions: Demand for telecommunication equipment in Thailand has grown steadily since industrialization began in the 1960s. However, there was a near absence of a telecommunications equipment industry to meet the demand which had to be largely imported. The biggest immediate boost to stimulate the growth of the domestic market is expected from the programme to bring the telephone density of the country to about 8 per 100 persons from the current level of under 3 per 100 persons today. Many spins off from an increasing demand in customer premise equipment are likely to follow. While it is likely that local demand for single-line telephone sets could be met, however, there is substantial amount of unmet demands for PABX systems, cellular phones and facsimile machines as shown by the strong growth in imports. At the same time, with the continuing growth of the world market for telecommunications equipment, growth prospects remain good therefore for the telecommunications equipment industry in Thailand to meet both the local and the export demands at least during the next decade.

b. Supply Conditions: The production in Thailand is confined mainly to the assembling of parts and components mostly imported from abroad. Manufacturing of input materials into parts are relatively rare. Thailand, with an abundance of low-wages labor force while land are relatively cheap in price and plentiful, is naturally a favorable destination for the relatively labor-intensive assembly products and parts. However, there are a number of major weaknesses needing urgent attention such as the lack of a strong supporting industry, or a strong linkage of parts and intermediate goods

suppliers with the equipment manufacturers, an inadequate supply of skilled manpower, and the weak technical infrastructure.

c. Market Structure and Firms' Strategy: Most Thai-owned firms tend to lack strong technology and marketing supports for world market compared to joint-ventures or foreign subsidiaries. These firms have to develop a certain degree of self-sufficiency and tend to concentrate on somewhat rather small domestic market niches. They seem to accord relatively more attention to product development and marketing, but less to advanced and efficient production machinery, know-how, management, and manpower development in contrast with foreign firms who establish facilities in Thailand predominantly as a manufacturing and export base. More often than not, the higher technology-content and less labor intensive production type of activities is rarely transferred into Thailand.

d. Supporting Industries: There is very little local sourcing and backward linkages inspite of the export boom in both the finished products and parts and components, the domestic industry remains largely dependent on imported parts and CKD kits. The country began lately to see an increase in localization, these backward linkages have tended to involve foreign subsidiaries supplying exclusively to other exporting foreign-owned final product assemblers however.

Despite the increasing number of such instances, the industry overall still has a low local content ratio (of less than 30 percent in average) among exporting assemblers of final products.

Technological Analysis

a. Technological Contents: Firms belong to the domestic market segment of the industry tend to have the characteristics common of most local Thai firms. While they tend to possess the whole spectrum of technological contents, they are however not in-depth, nor very advanced, and less attentive to engineering and management techniques for higher production efficiency and quality.

In the case of exporting firms most of which are foreign and joint-venture firms, they typically employ up-to-date production and process

technologies for efficiency and consistent product quality and reliability. Complete production and processes know-how are usually transferred from foreign manufacturing base often accompanied by foreign technical personnel. However, design and product-specific technologies often remain weak or are completely absent in Thailand.

b. Technological Capabilities: Thai-owned firms tend to possess a fair amount of acquisitive capability in sourcing technology and inputs, as does their operative capability. While the level may not be high, they do have some adaptive capability from reverse engineering. However, very little innovative capability is to be observed, although most of them have some in-house designing activity.

On the other hand, export-oriented firms all have a strong operative capability using similar production and processes from their home bases to ensure the same production efficiency and product reliability. However, acquisitive, adaptive and innovative capabilities, in-so-far as the local subsidiaries alone are concerned, are weak generally as the bulk of inputs and machinery are supplied from the parent firms. Products and process changes if any are largely made from the parent companies.

c. Technological embodiments: Majority of Thai firms generally are weak in all technological factors. Capital facilities are simple and only sufficient to handle the low production output required. These firms in general employ only few qualified engineers and technicians, partly because their costs and partly because of the current technical manpower shortage; information is relatively few with hardly any attention paid to it; organizational structure tends to be unsystematic and weak in terms of decision-making, and marketing. However, most foreign firms' technological embodiments are strong in all the components.

F. THE COMPUTER INDUSTRY

Among the electronic products, computers and peripherals has shown the highest growth in export since the mid 1980s, from a negligible amount in 1980 to 31 percent of total electronics exports in the late 1980s.

The Thai computer industry began modestly in the early 1980 with a small local Thai firm assembling computer terminals from imported CKD kits for exports. The entry of the Thai firm was subsequently overwhelmingly overshadowed by a number of major computer parts and components producers in 1987 mostly from the present world production leaders. In 1989, computer peripherals segment of the electronics industry overtook the leading exporter since the late 1970s - the integrated circuit, with an export value of close to 27 billion baht as compared to some 18 billion baht for ICs to become one of the highest principal export items of Thailand second only to textiles and garments.

Economic Analysis

a. Market Structure and Firms' Strategies: Though the industry's growth has been most impressive its share of the world production and export markets, however, is still minimal.

The product line where Thailand can likely follow the example of NICs and be a part of the world computer industry is in the production of personal computers and related peripherals because impediments to entry are less. As Thailand is abundant in efficient low-skilled labor, it is therefore naturally suitable to be an export base for labor-intensive production of computer peripherals and parts.

b. Demand Conditions: The foreign firms relocating that part of their production which need labor-intensive processes to Thailand did so in response to changing world conditions. First, wages and the domestic foreign exchange values had risen rapidly and cost competitiveness was quickly eroded. At the same time, the U.S. and E.C. countries introduced other protectionist measures. The Thai economy was booming and the fact that BOI and GSP privileges were available greatly added to an already favorable investment climate therefore.

c. Supply Conditions: Management teams of MNC subsidiaries tend to consist of personnel from the parent companies partly because of local shortage of engineers and managers. In addition, local engineers and technicians are usually sent to the parent companies for training prior, and

subsequent to production, thus they do acquire some technical (mostly operational) knowledge from the MNCs.

While firms can benefit from the low wages and high productivity of unskilled labor, some processes do need imported modern machines and equipment. Most of the complicated maintenance which has to be done by engineers or consultants from the parent companies or the machine suppliers overseas, is seen as time consuming and costly.

Supporting Industries

Not only does machinery and equipment come from abroad, but also most of the raw materials. Local materials are, in fact, limited to a few components produced by other BOI - promoted firms under the indirect exporter status. Indeed, the lack of efficient supporting industries could well adversely affect a firm's production growth.

Technological Analysis

a. Technological Contents: Local firms largely produce small quantities for the local market, whereas foreign MNCs produce in large volume for export and need maximum production efficiency and quality for competition in the world market. It is very important for exporting firms to use a high level of production-management technology, process technology and to some extent product-specific technology, but not design technology. In contrast, while local firms incorporate the whole range of technology, the levels possessed are not particularly high.

b. Technological capabilities: Similar pattern of characteristics with the telecommunications equipment industry can also be observed within the computer industry in that, most foreign firms do have very strong operative capability, though they tend to overlook the development of other capabilities. On the other hand, local firms generally have a fair amount of all the technological capabilities except in innovative capability.

c. Technological embodiments: Again, a similar situation exists here as with the telecommunications equipment industry. The limitation in technological embodiments among local firms makes it difficult for them to enhance their

technological capabilities, hence the opportunity to enter into OEM manufacturing is consequently less likely to occur.

G. STRATEGIES AND POLICY RECOMMENDATIONS

The general policy trend of the Thai government is currently toward liberalization of industry and reduction of protection. While we are in general agreement, we are also of concern that free competition or market force alone may not be the most efficient way to develop industries. In a World Bank report, it suggested four key roles a government can play in the development of electronics industry which are seen to be generally applicable to other industries also. They are: to develop technical human capital; to strengthen the basic technological infrastructure ; to provide incentives to improve technological levels, and to provide an environment for flexible adjustment to production structure.

The present Thai government policy has tried to address the fourth but has by and large ignored the first three. Certainly the first two roles are considered part of the obligations that a government should provide to facilitate the development of a country.

The current acute technical manpower shortage especially engineers and skilled technicians has negatively affected productive efficiencies, project expansion, and product development programs and is therefore in need to be urgently addressed. Basic technological infrastructure such as calibration, testing, inspection, contract R&D, consultancy, information and training are insufficient and sometimes non-existent prompting firms to seek alternative overseas services at much higher costs and lead-time.

Strategies

a. Phase I (0 to 5 years) : creating a strong support industry

For machine tool industry, the basic support industry is the metal working industry which is also basic to many other industries ranging from electrical and electronic to automotive industry. The mold and die industry needs casting, machining, heat treatment and electroplating. In turn, the

mold and die industry is itself a support industry to the fabrication of metal, plastic and metal parts. The telecommunications and the computer and peripherals industries need many mechanical parts from the metal-working industry including mold and die industry. As for electronics industry-specific processes important supporting industries are printed circuit board etching and other electronic parts and components.

The strategies in Phase I proposed are:

1. to continue the promotion of foreign direct investments, joint-ventures and technology licensing in the machine tool, mold and die, telecommunications equipment, and computer and peripherals industries particularly in their support industries as a first step in enlarging the value-added chain (Fig. 6.1).

2. to promote greater backward linkages as well as OEM manufacturing for foreign firms. Up to now, spill-over effects from FDI, if any, is largely limited to production-management and process technologies, and practically no design capability, marketing know-how, subcontracting, or establishment of new local firms by former managers, engineers, or technicians.

3. to strengthen the basic technological infrastructure provided by government agencies as well as private organizations providing such services as calibration, standards, testing, information, consultancy and training. Access to foreign expertise and technology should be emphasized.

4. to use government procurement as a mean to nurture local firms, promote backward linkages, access and acquire foreign technologies, diffuse and adapt technologies.

b. Phase II (5 to 10 years) : intensifying design and fabrication activities.

As industries mature, comparative advantages will gradually be shifting from low cost of production workers to low cost of engineers (based on engineering and design capability) and managers (based on marketing and management skills), development strategy over the medium term (5 to 10 years) should focus on expanding the value-added chain's activities upstream to RD&E

(research, development and engineering) as well as downstream to cover marketing function.

For machine tool industry, after good metal parts are widely available in the country, assembly and fabrication activities become more feasible and could be led by prominent international machine tool firms to create market and skills. For mold and die industry, the emphasis should shift to mold and die design. At the same time, more attention should be paid to small-size and high precision molds and dies for the electronics industry like stamping die for IC package connector-pins. For the telecommunications industry, some target products could be selected based on market needs as well as indigenous capability. Potential targets could be: feature phones, cellular telephones, pagers, PABX and facsimile. The microcomputer industry may feature more sophisticated hardware and software design to enhance competitiveness. Design of peripherals such as keyboards and monitors should be possible.

The strategies of Phase I on investment and backward linkages when achieving their objectives can continue on their own momentum. The technological infrastructure however needs to be continually upgraded to maintain its usefulness. RD&E activities of the public sector should now be linked to those of the private sector. The government procurement policy is still applicable but measures should be carefully designed so as not to over protect the domestic firms to the point of being uncompetitive internationally. Such privilege should be coupled with demanding improved performance proven by export capability.

c. Phase III (over 10 years) : Own brandname manufacturing

For longer term strategies of over 10 years, domestic firms should finally aim for own brandname manufacturing and look out for opportunities in forming strategic alliances with suitable foreign companies. Targeting makes more sense at both firm (private) and national (public) levels due to the high investment cost and long lead time of R&D.

Policy Recommendations

Supply Side Aspect

a) Investment Promotion. These industries including parts and components manufacturing and support industries and services should be kept on the promoted list of BOI.

b) Industrial Linkage Development. BOI Unit for Industrial Linkage Development (BUILD) can provide information on available local supporting industries to large firms seeking subcontractors. Technical assistance to small and medium firms attempting to become sub-contractors may be provided by government agencies like MIDI or by large principals.

c) Technological Infrastructure Building. The government should take action to ease the problems of technical manpower braindrain (to the private sector) and budget constraint in governmental agencies.

d) Technical Human Capital Development. In the short run, there is no alternative but to launch massive short-course programs making full use of industrial experts already residing in the country. In the medium term, new private sector educational institutions may provide significant contribution along with reformed public educational institutions both at the degree and diploma levels. In the longer run, a clear vision of the future manpower needs of Thailand must be developed by public sector policy makers.

Demand Side Aspects

a) Government Procurement. The government should use procurement selectively as an instrument to promote local industry.

b) Incentives for Training. The government should encourage more training investment through provision of incentives along the success story of the Skill Development Fund in Singapore.

c) Social Status for Technicians. The country should consider schemes to institutionalize an appropriate certification systems in technical skills and proficiency rankings of workers so as to raise the social standing of

skilled craftsmen. This could be done by proclaiming a "National Technical Qualification Law" similar to the successful examples of Taiwan and South Korea.

d) Tax Rationalization. Together with the value-add tax, a more rationalized tax structure should increase the competitiveness of Thai industries.

DEVELOPMENT OF THE MACHINERY AND THE EQUIPMENT
FOR INFORMATION INDUSTRIES IN THAILAND

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CHAPTER 1: INTRODUCTION

1.1 RATIONALE

Over the last few years, the overall economy of Thailand expanded at an unprecedent average rate of 11.0 percent in real terms from 1987 to 1990, with the highest growth rate of 13.2 in 1988. The spectacular growth, though slowing down, is expected to remain rosy, at least in the next few years. Even with the recent Persian Gulf crisis, the Office of the National Economic and Social Development Board (NESDB) - the country's economic planning agency - estimated a growth rate for 1991 at 8.0 percent and projected the Thai economy to grow at an average rate of 8.2 percent over the Seventh Plan period (1992-1996).[1]

In fact, with a policy shift from the import substitution of the 1960s towards export orientation in the 1970s, the economy began to really take off in the late 1980s. Over the two decades from 1970 to 1989, the economy grew at an average rate of 7 percent a year. More significantly, during the same period the industrial sector has been expanding at a faster average rate of 9.2 percent while the agriculture sector shrunk to an average of only 3.9 percent. Indeed, the engine of growth firmly rests firmly with the industrial sector in recent time, particularly the various manufacturing industries for exports as seen from the two important structural changes in the productive sectors. The first was in 1984 when the industrial sector output exceeded the traditionally leading agricultural sector for the first time registering 19.8 percent and 19.5 percent, respectively, of GDP. Then in 1989, the trade sector had overtaken the agriculture sector behind the manufacturing sector which surged further ahead. The GDP share of the manufacturing, trade and agriculture sectors that year were 25.4 percent, 15.5 percent and 15.2 percent, respectively

With the steadily growing significance of industrial sector for the Thai economy, increasing awareness and attention of policy makers are turning more

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[1] See Appendix I for a more detailed treatment of the status of Thai economy.

than ever to the development of better technological and manufacturing capabilities of industries in key industrial sectors. Based on experiences of industrialized and industrializing countries particularly the Asian NIE's, two specially important sectors are the machinery industry, and the information equipment industry. The machinery sector has played a central role in industrial development since the era of the first industrial revolution. It's prominence had been challenged and shared only with the advent of computers arising from what is known as the microelectronics revolution 30 years ago. Subsequently, these particular two sectors side-by-side have formed the underlying basis for development of most if not all industries, including themselves.

Without exception, Thailand would need to urgently develop these two sectors further to support and strengthen the changing structure of production. Each sector in itself also covers a wide spectrum of factor proportion and technological requirements such that there is an ever expansion of intra-industry trades among countries resulting from subsector specialization. Therefore, to ensure realization of its full potential of comparative advantage in order to climb up the industrialization ladder, it is vital that Thailand has to pay far more attention to the development of these two industries. For that to happen, first an understanding of the past and current state of development, the impediments facing the industries, and the trends of foreign and domestic investment, world technological progress and comparative advantage shift would be needed.

More specifically, our study will concentrate on machine tools and molds and dies within the machinery industry, and computers and telecommunications equipment which make up the information equipment industry.

Machine tools warrant special emphasis because they form the core of all machinery in that machine tools are necessary in the making of all machines including themselves. Thus industrial development will necessarily require the extensive services or usages of machine tools as one major factor of production. A strong machine tool industry will present a country with a competitive edge therefore.

The mold and die industry is selected because it forms a very important supporting industry that are vital in the making of a wide range of metal,

plastic and rubber products and parts. Furthermore the strength of the industry plays a crucial part in determining the quality of products that use molds or dies in forming and shaping their configurations.

It is widely well accepted that the electronics industry has outperformed most other industries in the world in terms of growth over the last few decades without any sign of weakening at least for the medium term outlook. The industry looks likely to continue its strong growth on the strength of demand for information equipment as the world is steadily evolving from an industrial-based into an information-based economy in the coming decades.

According to Electronics (January, 1991), the projected growth in major world electronics market namely, the U.S., Japan, and Europe for 1991 was 9.5%, a figure difficult for any industry to surpass. By sector, computer and peripherals, and telecommunications will both rise at a higher rate of between 12% to 15% than the other sectors of the electronics industry. Without doubt, the worldwide electronics industry, in particular the information equipment segment of the industry, will continue to be the most significant growth industry the world has ever seen. Indeed, many NICs (like Taiwan and Singapore) have attained their newly acquired economic prominence, to a large part, on account of a strong information equipment industry (see section 3.2 for a more detailed treatment).

Moreover, a recent World Bank study by Dahlman found that the Thai manufacturing sector has undergone a profound change in structure from resource-intensive to labor-intensive industries during the past two decades [Dahlman, 1990]. More importantly export statistics of late seems to suggest that the country is beginning to develop some comparative advantage in the manufacture and export of differentiated or technology-intensive goods.[2] Central to the development and the enhancement of production capability to manufacture these differentiated products is the existence of strong and adequate machinery and information equipment industries (particularly the four sectors chosen for this study) whose outputs form important production capital goods for most any technology-intensive industries, including themselves.

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[2] The term used by Dahlman is products from science-based industry.

It is believed therefore that an understanding of the status of the machinery and the information equipment industry is both timely and appropriate at this juncture of the industrial development in Thailand. This study attempts to provide such an understanding.

1.2 SCOPE OF THE STUDY

The scope of this study is as follows:

1. To present an overview of the machinery industry and the information equipment industry (M&I) in Thailand with particular reference to demand, production, domestic and foreign investment, trade, employment and government policies.

2. To investigate in greater details the four sub-sectors of: molds and dies, machine tools, computer products, and telecommunications equipment industries, in terms of various important economic variables above, as well as some important technological aspects such as levels of technological capabilities, technological endowments, environment and firms strategies for technological development.

3. To give an account of the world and some selected Asian countries on the development of the M&I industries in terms of:

(a) trends of demand and technological change,
(b) production and investment,
(c) trade, and
(d) government policies

4. To assess the prospects of the M&I industries and their contribution to the development of the Thai economy with references to:

(a) domestic demand and export expansion,
(b) pattern of growth and diversification,
(c) roles of user industries and supporting industries, and
(d) changes in technological capability and resource endowments.

5. To understand impediments to the M&I industries' development in Thailand in the areas of:

(a) entrepreneurship and corporate strategy,
(b) human resources,
(c) technological infrastructure, and
(d) economic incentives.

6. To analyze where appropriate implications related to policies concerning:

(a) education,
(b) training,
(c) dissemination of technology,
(d) incentives for technological capability development,
(e) correction of policy bias,
(f) users-producers cooperation, and
(g) technological infrastructural development, etc.

1.3 ORGANIZATION OF THE REPORT

Following this introductory chapter, Chapter Two presents a conceptual framework developed for analyzing the various economic and technological factors that bear on the industries' development. It then considers the research procedure followed and finally presents profile of firms used in our study.

It is useful no doubt to learn of the state of the machinery and information equipment industries of, and the strategies and policies adopted by some selected countries in their development. This is the subject of Chapter Three which will serve to provide some understanding of how they succeeded or failed to achieve rapid development and growth in these two sectors of industry.

A detailed analysis of the machinery industry, in particular the machine tool and the mold and die subsectors of the industry in Thailand, is examined

next in Chapter Four. It begins first with an account of how the industry has evolved into what it is today, followed by an economic and a technological analysis which takes into account both the available macro-economic data and first hand findings from firm-level survey and interviews. Lastly, various key issues and problems found to impede present and future development of the industry are then presented to conclude the discussion.

In a similar manner, the information equipment industry, in particular, the telecommunications and computer equipment sectors of the industry in Thailand is analyzed in details in Chapter Five.

Finally, Chapter Six deals with the important aspect of policy issues and strategies that are considered useful or necessary to tackle various problems and issues raised in the preceding analyzes and discussions to conclude the study.

CHAPTER 2: CONCEPTUAL FRAMEWORK

This chapter describes a theoretical framework on which this study is based. It then presents the research procedure and followed by a description of sample firms used in our study.

While closely interrelated, the framework is broadly divided into two parts. The first is an economic analysis, and the other is a technological analysis. The economic analysis focuses on such issues as demand, factor conditions, foreign investment, and government roles. The technological analysis concentrates on the issues of production process, and other technological aspects such as technological capabilities and embodiments.

2.1 ECONOMIC ANALYSIS

This part of the analysis will focus on various major economic aspects such as the issues on demand, foreign investment, technology transfer, competitiveness, and government roles in the past and present development of the machinery and the information equipment industries in Thailand.

Discussion on demand issues will cover both domestic and export demand with varying emphasis depending on the nature of each industrial subsector. Foreign investment is found to be an important growth factor in the machinery and the information equipment industries. It is also one if not the most important means of transferring technology from more advanced countries. Many direct benefits are foreign exchange saving or earning, local value-added and employment generation. Various likely indirect benefits are for examples spill-over effects such as forward and backward inter-industry linkages, new entrants of local supporting/subcontractor firms, and of course, various technology spill-over. How much a country can attract foreign investment will depend on a number of factors like the roles of the government, the demand conditions and the supply factors. How much benefit a host country can realize will necessarily depend partly on the strategies of the foreign investors.

In presenting the analysis of the various economic issues outlined above, we shall adopt a framework which is essentially modeled from the method pioneered by Michael Porter in his recent work entitled "The competitiveness of Nations". Essentially, the economic analysis framework focuses on the following four components:

1. Demand conditions
2. Supply conditions
3. Market structure and Firms' Strategies
4. Supporting Industries

2.1.1 Demand Conditions

a. Home Demand

The absolute size of the total demand for products of each industry will be estimated, as will the growth in demand in recent years and the demand projection for the next few years. A breakdown of each market into various segments will be described. The characteristics of each market segment will be investigated to gain knowledge about the development prospects of each industry with respect to product composition, technological requirements, product development, price competition, non-price competition and marketing arrangement. The role of government, as it affects the home-demand condition, will be investigated in such areas as the creation of protection barriers, product standards and other regulations.

b. Export Demand

The quantitative aspect of export demand will consist of the total amount of export, share of export in total production, export growth, and breakdown of export by product type and destination. The qualitative aspect will consist of export marketing arrangement, standard and quality requirements, and competitive pressure from foreign producers.

2.1.2 Supply Conditions

This analysis will cover an identification of factor requirements related to production of each industry, an identification of strategic factors

in various stages of production, relative scarcity among various types of factors, sources of factor supply and input, distortion in factor and input market, changes in supply conditions and factors influencing these changes.

Following the concept introduced by Porter, a distinction will be made between basic factors and advanced factors. For example, non-specialized workers will be regarded as a basic factor while specialized workers will be regarded as an advanced factor. In general, advanced factors tend to be more important in higher value-added market where firms compete more intensely on quality and product differentiation.

Responsiveness of supply to changes in demand conditions will also be investigated. Basic factors tend to be more easily mobilized between industries in response to changes in demand conditions. Changes in the supply of advanced factors are more time consuming. Special emphasis will be given with regards to creation of relevant advanced factors.

2.1.3 Market Structure and Firm's Strategy

The market structure of each industry will be analyzed with respect to number of competitors, degree of market concentration, market segmentation and nature of competition among firms in each market segment. The degree of competition will be assessed in terms of barriers to entry, relative advantages between large and small firms, and the survival rate of producers.

Firm's strategies will be analysed with respect to type of ownership and management, selection of market niches, strategies employed in response to cost competition, and product differentiation. The analysis will also cover the firm's strategies in the areas of vertical integration, product diversification and input sourcing.

2.1.4 Supporting Industries

The analysis on this subject will begin with an identification of related industries whose development tends to enhance the competitiveness of the industry of main interest. The relationship between the supporting industries and the one of main concern will be explored. An assessment will

be made of the present status of supporting industries with respect to price competitiveness, quality and prospect of market expansion. Alternative means to utilize and/or develop supporting industries to improve the competitiveness of the industry of main interest will be investigated.

2.2 TECHNOLOGICAL ANALYSIS

Our technological analysis framework is an integrated approach based upon a number of technological assessment frameworks used in a number of previous works. among them are the analytical frameworks of technological embodiment [Sharif, 1991], technological capability [TDRI, 1989], and technological content [TDRI, 1991]. While our approach generally adopts the concepts cited in these works some modifications are however made to a number of definitions of technological components. Such modifications are considered useful in our attempt to integrate the various sets of technological components previously considered separately on their own account. Under the integrated framework, interaction between modified versions of technological embodiments, technological contents and technological capabilities will be described.

We begin with the definitions of components for technological embodiments, technological contents and technological capabilities in section 2.2.1 followed by a treatment of the relationship among these components in section 2.2.2.

2.2.1 Definitions

Our analysis of the status of technology in the machinery and information equipment industries in Thailand will center on three main components: technological embodiments, technological contents and technological capabilities. Each of these will be divided into four sub-components. Technological embodiments consist of manpower, machinery, information and organization. The sub-components of technological contents are production-management technology, process technology, product-specific technology and design technology. The sub-components of technological capabilities are operative capability, acquisitive capability, adaptive capability and innovative capability. Definitions of these sub-components are given below.

a. Technological Embodiments

Technological embodiments describe a firm's technological resource endowments in four categories. The concept of technological embodiments in this study is essentially the same as those elaborated by Sharif [Sharif, 1991]. We have altered the terminologies simply owing to a preference for more simplified terms. In comparison with Sharif's terminologies, the term humanware is replaced by manpower, technoware by machinery, infoware by information, and orgaware by organization.

Manpower designates person-embodied human ability such as skill, knowledge, expertise and creativity.

Machinery refers to such object-embodied physical facilities as equipment, machine, and factories.

Information refers to record-embodied documented facts such as specifications, methods, drawings, manuals, and statistics.

Organization represents institutional-embodied organizational framework, as in the links, relations, and management techniques that largely determine the effective utilization of manpower, machinery and information.

All four components interact with and influence one another in a dynamic manner. Machinery is of no practical use without the skills and expertise of manpower. Without machinery, productivity of manpower is greatly limited. Without information, manpower is inefficient. Without organization, machinery, manpower and information lack coordination, and productive activities are unlikely to be economically feasible.

b. Technological Contents

Technological contents of a firm describe its accumulation of technology relevant to its operations. Possession of technological contents allows a firm to exploit its resources with greater technical efficiency, such as by lowering cost, raising product value, and internalizing profit from design activity. The definition of each component of technological contents follows.

Production-management Technology

Production-management technology is the method of organizing all activities involved in the production of a firm to achieve high efficiency. Examples of production-management technology are "just-in-time" (JIT), "total quality control" (TQC), "statistical quality control" (SQC) and "manufacturing resource planning" (MRP).

Process Technology

Process technology is the know-how needed to transform input into output. The main process may involve physical transformation such as from basic metals to metal products and from machine component to assembled machines, or chemical transformation such as from basic chemicals to chemical products. Basic know-how in process technology is indispensable in any production activity. Advanced know-how is required to improve technical efficiency, such as by reducing defects, increasing yield and improving quality.

Product-specific Technology

Product-specific technology is a type of know-how whose application is limited to a narrowly-defined group of products. It often involves various detailed characteristics of products, inputs, machinery and production processes. Product-specific technology can generally be regarded as having an important supportive role. Application of product-specific technology can help a firm to fine-tune its product characteristics, properly select and utilize inputs and machinery, and adjust production processes to achieve greater efficiency.

Design Technology

Design technology can be divided into product design and process design. Product design provides information necessary for the creation of a prototype, while process design provides information necessary for a commercial scale production. Design technology can be accumulated from formal education as well as from practical experience. In general, a good combination of theoretical knowledge and practical experience is required for

one to be a competent designer. Design technology is largely embodied in manpower. However, design equipment, laboratory support and materials such as handbooks, manuals and catalogs are very helpful, and often imperative.

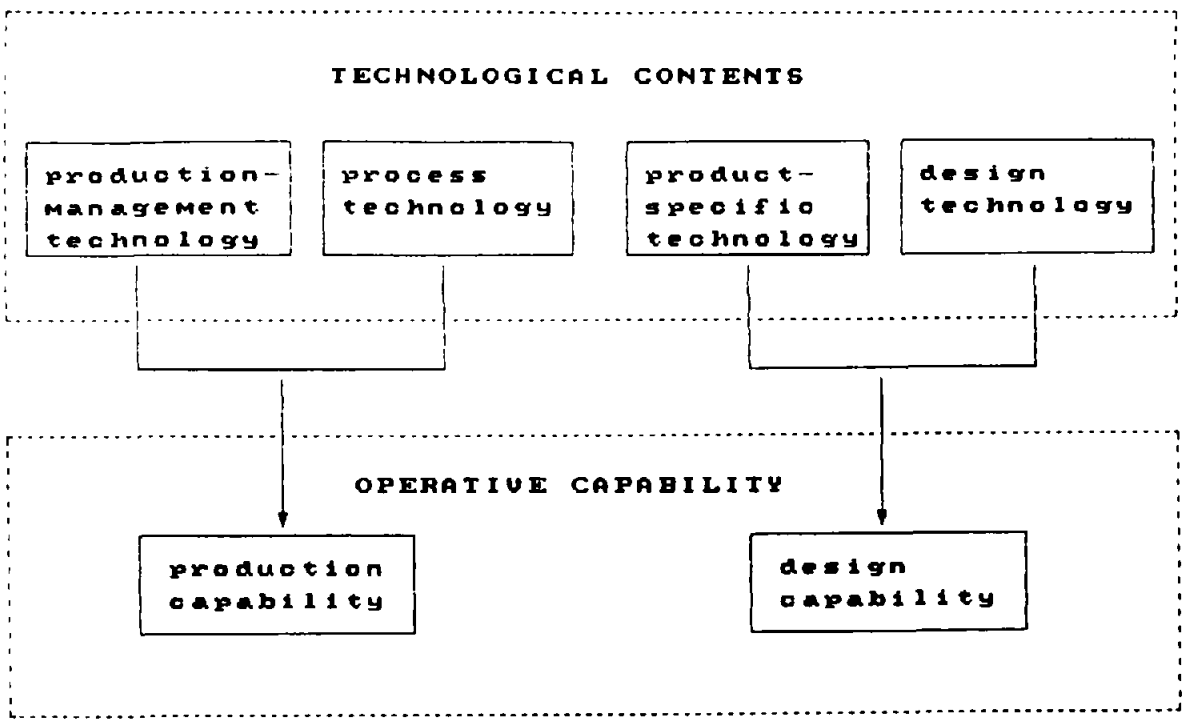
c. Technological Capabilities

The concepts of technological capabilities have been employed in various studies, including Westphal [TDRI, 1989], Dahlman [Dahlman, 1987] and TDRI [TDRI, 1991]. There are slight deviations among them in terminologies and definitions but the concepts are essentially similar. This study uses the same terminologies used in previous TDRI works with some modification to the definitions, as described below.

Operative Capability

This study divides operative capability into two sub-components: production capability and design capability as shown in Figure 2.1.

Figure 2.1 : Relationships between operative capability and technological content components



Production capability is defined as the technical efficiency of a firm in its production activities. Technical efficiency may be observed either from a firm's practices or from its results. Observation of results can be based on product quality and cost effectiveness. Observation of the practices encompass numerous activities such as maintenance and use of machinery, inventory control, production management and quality control. Consequently, production capability is basically dependent on the application of production-management technology and process technology.

Design capability is reflected in design performance that may be assessed by the variety, sophistication and quality of designs. If observation of design performance is inadequate for assessment, the input side, such as the knowledge and experience of designers, will serve as supplementary data. Design capability therefore depends largely on product-specific technology and design technology.

Acquisitive Capability

Acquisitive capability is defined as the ability of a firm to search, assess, process and absorb new technology from external sources. A grey area separating acquisitive and adaptive capabilities, lies in the absorption process. Absorption is treated as part of acquisitive capability as long as there is no observable change in the acquired technology, such as in the form of product and process modification.

Adaptive Capability

Adaptive capability is defined as the ability of a firm to modify product characteristics, input combinations and production processes to suit its resource endowments. Adaptive capability improves the operative capability of a firm over time as it modifies the use of the firm's resources to achieve a higher level of efficiency. A firm may increase its efficiency through acquisition rather than adaptation, in which case the adaptive capability may still be needed to improve the acquired technology depending on the firm's resources and its environment.

Innovative Capability

Innovative capability is defined as the ability of a firm to introduce new applications of scientific knowledge or experience with major impact on the market and industry through indigenous efforts. It is difficult to draw an exact dividing line between adaptation and innovation. However, it is customary to treat small incremental changes as adaptation and major changes or endogenous creativity as innovation.

Among the four technological capabilities, the operative capability can be considered to be a static component, while the other three components give technological dynamism to a firm. Without acquisition, adaptation and innovation, a firm's operative capability will be basically unchanged. Operative capability might be said to determine current profitability, while the other capabilities would determine potential profitability.

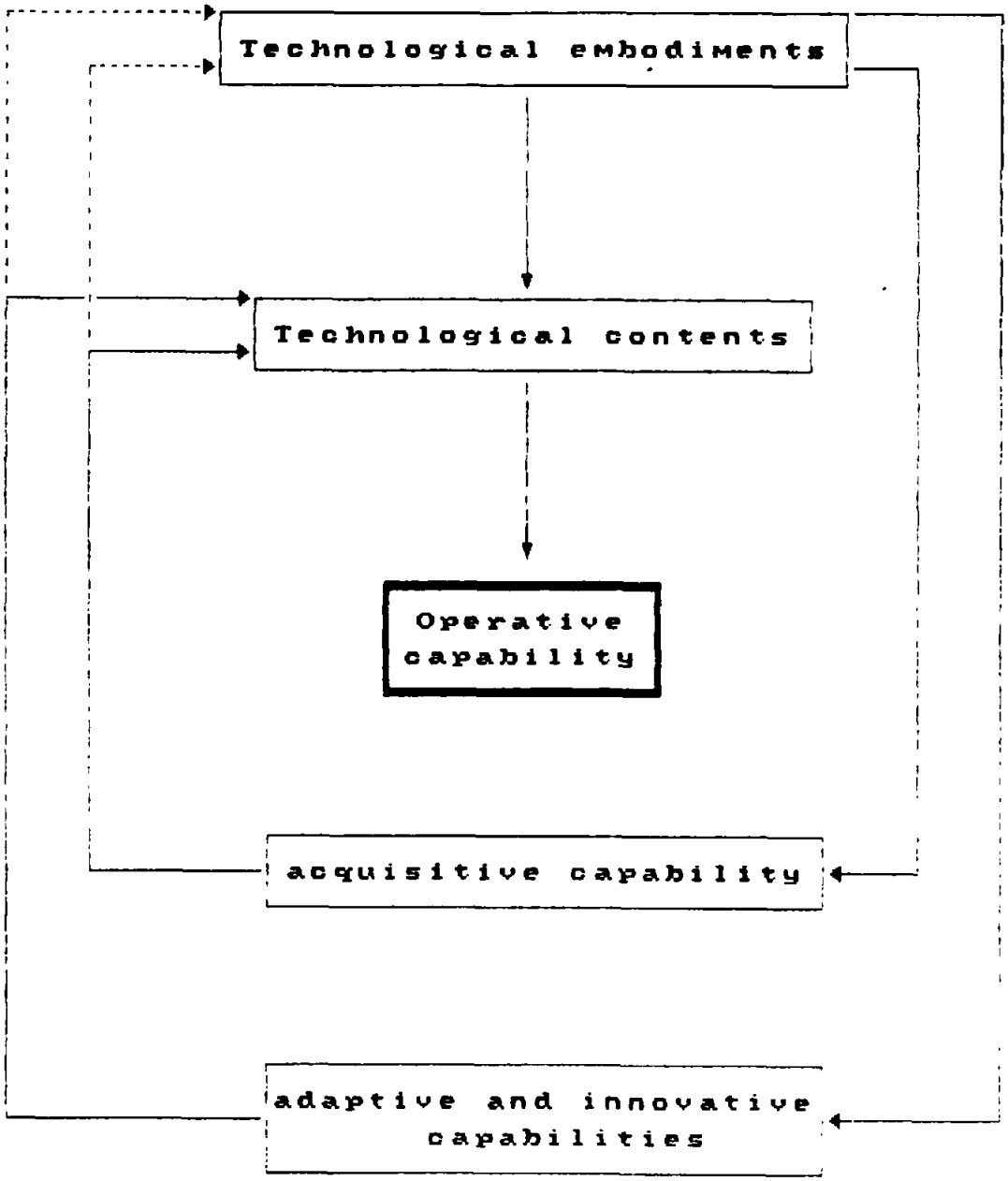
2.2.2 Interactions among Key Components

We may summarize the concept of the three technological components as follows. Technological embodiments focus on a firm's technological resources endowments. Technological contents focus on the possession of technology embodied in these resources and the use of it. Within technological capabilities, the operative capability focuses on the present technological performance of a firm in a static sense. Its potential performance will be determined by acquisitive, adaptive and innovative capabilities, which will be translated into the future operative capability.

Interaction between technological embodiments, technological contents and technological capabilities is shown in Figure 2.2.

A firm's technological performance will be assessed from the measure of its operative capability, which is determined by its technological contents. Technological contents of a firm are the result of its accumulation of technological embodiments and its improvement over time by its acquisitive, adaptive and innovative capabilities.

Figure 2.2 : Interactions between technological embodiments, technological contents and technological capabilities



A firm's operative capability is divided into production capability and design capability. A firm that has good production capability but ignores design capability has to rely on designs from outside and thus lacks potential for independent progress. Production capability depends heavily on production-management and process technologies. Design capability depends largely on product specific and design technologies (see Figure 2.1).

All technological embodiments jointly determine each component of technological contents. The relative importance of each embodiment to each content, however, is varied. In general, machinery and equipment have the greatest influence on process technology. Manpower is probably the most important factor in the creation and application of design technology. Information is most relevant to product-specific technology, and organization has great influence on production management technology.

Technological embodiments also determine the acquisitive, adaptive and innovative capabilities of a firm. Manpower is the most important factor which determines these capabilities. Organization, information and machinery play supportive roles. At the present level of Thailand's technological development, technological acquisition plays the most important role in advancing industrial technology. Technological adaptation has limited contribution. Commercially successful technological innovations are rare.

Acquisitive, adaptive and innovative capabilities have a feedback effect on technological embodiments and technological contents. Acquisitive capability is required to sustain a firm's competitiveness as new technology replaces old technology. Adaptive capability is required to apply the acquired technology in a suitable manner to a firm's resources and environment. Innovative capability creates new opportunities and strengthens a firm's competitiveness.

Technological acquisition, adaptation and innovation directly increase a firm's technological contents. The accumulation of such technology must be embodied in a firm's manpower, information, machinery and organization. Interaction between these capabilities and technological contents and embodiments entails a dynamic process that determines the sustain ability of a firm's technological performance, which is reflected in its operative capability.

The product composition within an industry group of a particular country is governed by the composition of technological contents of the industries in that country. Low intensity of design and product-specific technologies in Thailand has resulted in a low proportion of original designs and limited varieties in the product composition in each industry group.

The relationship between the types of production and technological contents can be summarized by a matrix as follows:

Type of production / technological content	production management technology	process technology	product-specific technology	design technology
assembling	***	**	*	-
manufacturing	**	***	**	-
processing	*	***	**	-
design	-	*	***	***

*** means high intensity or necessary
** means moderate intensity or important
* means low intensity or not so important
- means negligible or unimportant

The method used to assess each key component and the results of the technological assessment of those firms surveyed within the machinery and the information equipment industries can be found in Appendix II.

2.3 RESEARCH PROCEDURE

The study consists of the following main steps:

1. An account of the M&I industries in terms of employment, trade, investment, and production will be documented based mainly on past studies and statistics.

2. A total of about 40 firms, with 20 in the machinery industry and 20 in the information equipment industry, will be selected for interview to learn about the state of technology being adopted, the extent of technological absorption, the impediments limiting the development of the industries, and likely opportunities waiting to be sized upon.

3. Further insight information and opinion will be sought from a group of experts knowledgeable in the relevant fields of technology and industries.

4. In addition, some 10 related government agencies will be interviewed to learn of the current state policies and measures in force, and any existing implementation difficulties or problems.

5. A short visit will be made to the Republic of Korea and the Republic of China to observe and collect data on the development of their M&I industries.

6. Data and Information collected through various means above shall then be analyzed in terms of firms' behavior, growth and technological development, comparative advantage and product cycle, and technological capability and endowment.

7. The finding of the study will be disseminated by means of a public seminar, followed by publication of a final report taking into account comments offered at the seminar.

2.4 PROFILE OF THE SURVEYED FIRMS

In this study a total of 43 firms were used in our survey sample of which 22 firms were from the machinery industry and 21 from the information equipment industry. Tables 2.1 and 2.2 give details of firms surveyed, listing their main characteristics by type of ownership, BOI promotional status, number of employees and major products, for the machinery and the information equipment industries, respectively.

Table 2.1 : List of Interviewed Firms in Machinery Industry in Thailand

Firm	Ownership	BOI Promotion	No. of Employee	Products
Machine Tools				
M1	Thai	No	44	Lathes
M2	Thai	No	50	Presses
M3	Foreign	Yes	307	EDMs
M4	Foreign	Yes	46	Machining Centers
M5	Thai	No	38	Powered Hack Saw
M6	J.V.	Yes	8	Parts for Machine Tools
M7	J.V.	Yes	165	Grinding
M8	J.V.	Yes	22	Presses
Mold & Dies				
M9	Foreign	Yes	111	Plastic
M10	J.V.	Yes	51	Plastic
M11	J.V.	Yes	115	Plastic
M12	Thai	Yes	509	Aluminum
M13	Thai	No	150	Steel/Rubber
M14	Thai	Yes	120	Steel
M15	Thai	No	1,200	Steel
M16	Thai	No	40	Metal/Plastic
Other Machinery and Metal Working				
M17	Thai	Yes	300	Cast Steel
M18	Thai	Yes	56	Cast Steel
M19	Foreign	Yes	n.a.	Precision Machine Parts
M20	J.V.	Yes	208	Disk Drive Parts
M21	J.V.	Yes	350	Trolly, Container
M22	Foreign	Yes	30	Pressed parts

Notes : "Thai" indicates firms with at least 75% Thai ownership;
"Foreign" indicates firms with at least 75% foreign ownership;
"J.V." or "Joint-venture" indicates firms in-between.

Table 2.2 : List of Interviewed Firms in Information Equipment Industry in Thailand

Firm	Ownership*	BOI Promotion	No. of Employee	Products
Communications Equipment				
I1	Thai	No	45	Transceivers, Special Equipment
I2	Thai	No	40	PABX, Controllers
I3	Thai	No	60	Transceivers
I4	J.V.	Yes	70	Switching Systems
I5	Foreign	Yes	272	Key Telephones
I6	Thai	Yes	150	Satellite Antenna Dish and Receivers
I7	J.V.	Yes	520	Telephones, Answering Machine
I8	Foreign	Yes	2,450	Telephones, Color TV
Computer and Peripherals				
I9	Foreign	Yes	540	Keyboards
I10	J.V.	Yes	100	PC Computers & Parts
I11	Foreign	Yes	2,459	HDD Head, Printer Head Coils, Stepper Motor, Fax
I12	Foreign	Yes	900	Flexible Disk Drive
I13	Thai	Yes	60	PC Computers & Parts
I14	Thai	No	32	UPS, Voltage Stabilizer, Intensity Controller, Power Distributor Computer, Intercom
Parts & Components				
I15	Thai	Yes	1,500	IC Packaging
I16	Foreign	Yes	400	Ceramic Substrates
I17	Foreign	Yes	400	Quartz Crystals, Oscillators Delay Lines
I18	Foreign	Yes	97	Magnetic Coils
I19	J.V.	No	18	Reed Relay Coils
I20	Foreign	Yes	110	Linear IC Packaging
I21	Foreign	Yes	1,100	Ceramic Filters & Capacitors Piezoelectric Buzzers

Note : * Thai indicates firms with at least 75% Thai ownership;
Foreign indicates firms with at least 75% foreign ownership;
Joint-venture indicates firms in-between.

The Machinery Industry

Within the scope of this study, the two segments of the machinery industry to be investigated are the machine tool and mold and die. In Thailand, the number of machine tool firms has remained small even though this segment of the machinery industry has been in existence for more than 20 years. An estimate is about 30 firms at present. They include foreign subsidiaries, joint-venture firms and local Thai firms. About 70 percent of the machine tool firms are Thai firms, most of which are non-BOI promoted and small in size with less than 50 employees. In contrast, foreign and joint-venture firms are mostly recently established firms of less than five years under BOI promotion. However, except for a minority few, they are also small in size like Thai machine tool firms. Majority of these firms are subsidiaries of well known machine tool makers from Japan and Taiwan.

The mold and die segment of the machinery industry in Thailand is a much bigger industry in terms of the number of establishments than all the other industries under study. It consists of over 400 producers according to a recent survey by the Metal-working and Machinery Industries Development Institute [MIDI, 1990]. However, most of them are either a division within a larger firm or a subsidiary of another firm and produce mold and dies principally to meet their own internal demand, or that of their parent firms. Only about one-fourth of the producers are general mold and die vendors. Consequently, it is not surprising to find that the majority of the producers are small establishments with less than ten employees each. The largest users of molds and dies (metal, plastic and rubber) are from the automotive, electronics, electrical machinery and electrical appliances industries. Others are from makers of machinery parts, household products, containers, kitchen wares, stationery, shoes and toys.

The field survey used in our study had covered eight firms of each in the machine tool and the mold and die industries together with another six firms in the supporting industry such as steel casting, machining, metal molding and stamping, etc. The majority of the firms are medium and small firms (73%) and domestic-market oriented (64%), whereas close to half of them are local Thai firms with the rest either joint-ventures (32%) or foreign subsidiaries (23%). Table 2.3 shows the profile of the firms in the machinery industry together with the scheme used in the classification by ownership,

size and market-orientation.

Table 2.3 : Profile of Surveyed Firms in the Machinery Industry

Characteristics	No. of Firms	(Percent)
Total Population Used	22	(100)
Machine Tools	8	(36.5)
Molds and Dies	8	(36.5)
Supporting Parts and Services	6	(27)
By Ownership:		
Thai	10	(45)
Joint-venture	7	(32)
Foreign	5	(23)
By Market Orientation:		
Domestic	14	(64)
Export	8	(36)
By size:		
Large	6	(27)
Medium/Small	16	(73)

Notes : 1. Thai ownership denotes firms with at least 75% Thai ownership; foreign with at least 75% foreign ownership; Joint-venture means firms with in-between ownership percentage.
2. Domestic (/Export) denotes firms which supply over half of their outputs to the local (/world) market.
3. Large-size denotes firms with over 200 employees.

The Information Equipment Industry

The information equipment industry includes the telecommunications equipment and the computers and peripherals segments of the electronics industry. Both of them were relatively unknown of compared with the consumer electronics and the electronic parts and components segment of the electronics industry until some four to five years ago.

Currently, there are some 30 firms in the telecommunications industry and some 20 firms in the computer and peripherals industry in Thailand. With the exception of a few Thai firms in the telecommunications equipment industry, all the firms were practically newly established. The majority of these

firms are foreign-owned subsidiaries or joint-ventures with BOI promotional privileges. These foreign and joint-venture firms are mostly large-sized firms with employees ranging from a few hundred to several thousands. Moreover, they are associated with large and well-established electronics manufacturers from the U.S., Japan, Taiwan, Korea, Hong Kong and Singapore. Only about one-fifth of the firms in the two sectors are Thai firms. Majority of these firms are small-sized, non-BOI promoted, and domestic-market oriented. More than half these Thai firms have a history of over ten years, with some of them well over twenty years old.

Of the 21 sample firms used in our field study, eight belonged to the telecommunications equipment, six to the computer and peripherals, and seven to related electronic parts and components sectors of the information equipment industry. The profile of firms used in the survey of the information equipment industry is given in Table 2.4. About half the sample firms are large in size, while one-third of the sample are Thai-owned, half are foreign subsidiaries and one-fifth are joint-venture firms. In line with the overall industry composition, over seventy percent of sample firms are export-oriented.

Table 2.4 : Profile of Surveyed Firms in the Information Equipment Industry

Characteristics	No. of Firms	(Percent)
Total Population Used	21	(100)
Telecommunications Equipment	8	(38)
Computer and Peripherals	6	(29)
Parts and Components	7	(33)
By Ownership:		
Thai	7	(33)
Joint-venture	4	(19)
Foreign	10	(48)
By Market Orientation:		
Domestic	6	(29)
Export	15	(71)
By size:		
Large	10	(48)
Medium/Small	11	(52)

Note : Ownership, market-orientation and firm-size classifications are same as in Table 2.3.

CHAPTER 3: THE MACHINERY AND THE INFORMATION EQUIPMENT INDUSTRIES OF SELECTED COUNTRIES

This chapter presents an overview of the machinery industry and the information industry of some selected major world producing countries. It aims to provide an insight into the state of development as well as the strategies and policies used in their development so as to provide some understanding of why the two industries of these countries succeeded or failed to achieve rapid development and growth. Emphasis is placed on the experiences of Asian NICs and also Japan, lessons from whom, it is believed, will be of greater uses for Thailand who is considered to be among the next wave of newly industrialized country candidates.

3.1 THE STATUS OF THE WORLD MACHINERY INDUSTRY

The machinery industry may be divided into 5 broad groups namely transport equipment, electrical machinery (including electronics), general machinery, precision machinery and metal products. In 1987, machinery of all types accounted for 35.7% of the world total exports. Transportation equipment was the largest group, accounting for 32.3% of the total export of all machinery. General machinery and electrical machinery had roughly equal shares of 26.9% and 26.8% respectively. Precision machinery had the smallest share of about 2.1% and metal goods' share was about 7.7% (see Table 3.1).

Three largest exporters of machinery are Japan, West Germany and USA. Japan's share in the world's total machinery was 19.7% in 1987. The share of West Germany and USA in the same year were 17.9% and 14.4% respectively. France, UK, Italy and Canada had a combined share of 22.2%. The seven leading machinery exporters accounted for 74.2% of the world total machinery exports (see Table 3.2).

The newly industrialized countries (NICs), particularly Taiwan and South Korea, have targeted machinery as an important industry that is strategic to their development process. They have become significant machinery exporters

Table 3.1 : World Export of Machinery

Unit : Billion US Dollars

Country	1985	1986	1987
All Industry	1,938.6	2,115.8	2,482.4
All Machinery of which :	615.6 (100)	738.9 (100)	887.1 (100)
Metal Goods	47.1 (7.6)	57.1 (7.7)	68.4 (7.7)
General Machinery	165.7 (26.9)	199.7 (27.0)	239.0 (26.9)
Electrical & Electronics	157.1 (25.5)	192.9 (26.1)	237.6 (26.8)
Transport Equipment	206.9 (33.6)	242.0 (32.8)	286.5 (32.3)
Precision Machinery	19.7 (3.2)	14.9 (2.0)	18.7 (2.1)
Others	19.1 (3.1)	32.3 (4.4)	36.9 (4.2)

Source : Korea Association of Machinery Industry (KAOMI)
" Trade Statistics of Machinery Industry ", 1991.

Table 3.2 : Export of Machinery by Countries

(Unit : Billion US Dollars)

Country	1985		1986		1987	
	value	percent	value	percent	value	percent
All Countries	615.6	100.0	738.9	100.0	887.1	100.0
Japan	130.0	21.1	159.0	21.5	174.8	19.7
West Germany	94.6	15.4	130.1	17.6	159.1	17.9
US	108.4	17.6	110.2	14.9	127.4	14.4
France	36.9	6.0	47.0	6.4	57.4	6.5
UK	37.1	6.0	43.0	5.8	54.2	6.1
Italy	28.9	4.7	38.3	5.2	47.1	5.3
Canada	36.0	5.8	37.4	5.1	38.3	4.3
Others	143.7	23.3	173.9	23.5	228.8	25.8

Source : KAOMI, " Trade Statistics of Machinery Industry", 1991.

in recent years. For example, Korea's share in the world export of machinery was 2.3% in 1987.

In this study, special emphasis is placed on machine tool and die industries.[3] Machine tools are selected because they require relatively advanced technology in design and production. Attainment of the technological capability in this industry is a major step in the country's technological development. Design and production capabilities of this industry are applicable to various other machinery industries. The die industry is selected due to its crucial function in determining the quality of various products that use dies in forming and shaping their configurations.

[3] In the report, the term "die" will be used to refer to all types of molds and ides that are made of steel. By popular usage, dies used for making plastic products are called "plastic molds". We will use the term "mold" only when refer to a plastic mold or other similar kinds such as a rubber mold.

Major world producers of machine tools are also major producers of all machinery. As shown in Table 3.3, the world's largest producer of machine tools is Japan whose production in 1989 was about US$ 9,817 million. It is followed by West Germany, USSR and USA whose productions in the same year were US$ 6,860, 5,000, and 3,270 million respectively. Japan and West Germany have alternately led the world market in machine tool export in recent years. West Germany was the top exporter in 1989 with the export value of US$ 4,332 million. It was closely followed by Japan whose export value was US$ 3,765 million. The next largest exporters from the third to the seventh ranks were Switzerland, Italy, East Germany, USA and Taiwan.

Table 3.3 : Production and Trade of Machine Tools (1989)

(Unit : Million US Dollars)

Country	Production	Export	Import
Japan	9,817	3,765	481
West Germany	6,860	4,332	1,400
Soviet Union	5,000	380	2,000
United States	3,270	945	2,445
Italy	3,067	1,537	845
Switzerland	1,798	1,590	440
United Kingdom	1,597	628	838
East Germany	1,445	1,270	300
France	1,081	470	1,097
Taiwan	1,016	668	374
South Korea	761	76	760
Singapore	48	36	41
Hong Kong	12	0	9

Source : INVESTEC/IMRS "Development Strategy for Thailand's Machine Tool Industry" 1991.

The four Asian NICs are quite different in their ambitions in the machine tool industry. South Korea is the largest user among these countries. Its apparent consumption (production plus import minus export) was US$ 1,445 million in 1989. Taiwan's apparent consumption was US$ 723 million or about half of Korea's. But Taiwan's production was much greater than Korea's. In 1989, Taiwan produced US$ 1,016 million worth of machine tools. More than half of them were exported (US$ 668 million). South Korea's export of machine

tools was only US$ 76 million in the same year. Singapore and Hong Kong have low demand for machine tools. Their domestic demands represent less than one tenth of the other two countries. Their production and export are also negligible as compared to Taiwan and South Korea.

The world's total production of machine tools in 1989 can be roughly divided as follows: 36% by Western Europe, 32% by Asia and 32% from the rest of the world. Asia's share in the world's machine tool production has shown an increasing trend. It rose from 19% in 1980 to 32% in 1989. Major Asian producers are Japan (ranks first in the world), Taiwan (ranks 10th), China (11th), South Korea (13th) and India (22nd) [Otaka, 1990].

Machine tools can be regarded as the core of all machinery since they are built to be used for making all machines including themselves. They can be broadly classified into 2 groups: general purpose machine tools and special purpose machine tools. According to Sciberas and Paynes, Japan dominates the production of general purpose machine tools, especially in computerized numerical control machines (CNC) [Scriberas, 1985]. Seven leading industrialized countries accounted for 73.4% of world machine tool production in 1982. These are shown in Table 3.4.

In Japan, metal-working machine tools accounted for 1.4% of the value of all machinery production in 1988 (See Table 3.5). Between 1970 and 1983, production of numerical control (NC) machines in Japan increased very rapidly from 1,451 units worth 24.3 billion yen to 26,398 units worth 426.2 billion yen, an increase of about 17 folds. During the same period, production of other machine tools decreased from 255,243 units worth 288.0 billion yen to 113,690 units worth 275.3 billion yen. Among NC machines, there are three principal types: NC lathes, machining centers and electrical discharge machines (EDMs). In 1983, these three types accounted for 81.9% of the total value of all NC machine production, with machining centers accounted for 39.2%, NC lathes 28.5% and EDM 14.2% [Japan's Machine Tool Guide 1989/1990].

Table 3.4 : World Production Shares of the Main Producing Countries

(Unit : Percentage)

Country	1974	1980	1981	1982
Japan	12.9	14.4	18.2	17.1
US	16.9	18.2	19.4	15.9
Germany,Fed.Rep.of	17.8	17.7	15.0	15.4
USSR	14.6	11.7	11.1	12.9
Italy	6.1	6.2	5.7	5.5
Switzerland	3.6	4.0	3.2	3.4
UK	4.6	4.5	3.5	3.2
Total	76.5	76.7	76.1	73.4

Source : Sciberras, E. and B.D. Payue, "Machine Tool Industry", p.31.

Table 3.5 : Composition of Machinery Industry in Japan, 1988 (percentage)

Electrical Machinery	41.8
Transportation Machinery	36.7
Precision Machinery	2.0
General Machinery	19.5, of which
Metalworking Machine Tools	1.4
Total value (billion yen)	62,650

Source : MITI, "The Japanese Machine Tool Industry: Current Status and Long-Range Outlook", p.6.

Among the 111 members of the Japan Machine Tool Builders' Association (JMTBA), 80 of them have less than 300 production workers involved exclusively in machine tool manufacturing.[4] These producers are supported by some 5,600 primary subcontractors each of which is in turns supported by 10-20 secondary subcontractors. The subcontracting network in the Japanese machine tool industry is thus quite extensive.

[4] MITI, "The Japanese Machine Tool Industry: Current Status and Long Range Outlook", p.7.

Historically, the Japanese machine tool industry reemerged from the destruction during World War II in 1956 and expanded ever since through close cooperations among the producers and the government. By 1970, Japan became the fourth largest machine tool producer in the world. It moved into the third rank by overtaking the Soviet Union in 1980, then overtook West Germany to become the second rank in 1981. Finally it surpassed the US to become the world's number one producer in 1982.

The Japanese government interventions in the past development of machine tool industry include not only the imposition of protective measures, but also some forms of subsidy, guidelines and controls. These measures include provision of technology inputs by state owned research institutes and provision of subsidized credit, planned interventions to increase specialization and scale economies, interventions in the negotiation of technology agreements to minimize the degree of foreign control over Japanese industry [Fransman, 1986].

Taiwan began producing machine tools in the 1950s. Reverse engineering was the main mechanism in which Taiwanese producers acquired the production know-how. By the end of the decade, there were 19 firms in this business. Production was concentrated in simple machine tools such as conventional lathes, presses, sharpers and drilling machines. This pattern lasted until the early 1970s. By the mid 1970s, Taiwanese producers started to manufacture more sophisticated models for export to the U.S. and other advanced countries. These exports were such as high speed lathes, horizontal milling machines, surface grinders and radial type drilling machines.

The development of machine tool industry in Taiwan in the eighties was characterized by rapid growth in the production of NC machines. For example the production of machine centers increased from zero in 1980 to 3,374 million NT dollars in 1989, representing 12.8% of the total machine tools production (Table 3.6). By 1989, Taiwan ranked as the 10th largest world producer and the 7th largest world exporter of machine tools. Export accounts for about two third of its total domestic production.

Table 3.6 : Taiwan's Production and Trade of Machine Tools (1989)

(Million NT Dollars)

	Production	Export	Import
Lathe	5,926	n.a.	n.a.
Machine Center	3,374	2,247	n.a.
Drilling Machine	2,136	2,077	205
Grinding Machine	1,445	1,023	890
Presses	3,266	1,444	1,507
Others	10,116	10,255	6,967
Total Machine Tools	26,263	17,046	9,569

Source : INVESTEC/IMRS "Development Strategy for Thailand's Machine Tool Industry" 1991

Reverse engineering has been the major mode of technology acquisition by Taiwanese firms. This practice has been supplemented by surveys of current technologies in foreign markets and a limited number of technological cooperation agreements with foreign companies. The industry has been strongly supported by the Mechanical Industry Research Laboratories (MIRL) in developing the manufacturers' technological capability. In the early 1980s, the Taiwan Association of Machinery Industry (TAMI) was established with the government support to promote the dissemination of technical and market information. The government also provides research grants to private firms and research institutions. Government research funding for the machinery sector in 1991 was about one billion NT dollars.

An evidence of the success of MIRL is that many firms have sought assistance from it in the design of CNC machine tools and machine centers. By mid 1983, MIRL had 22 contracts with 18 firms, all involving the complete design of new CNC machine tools and machine centers. It was estimated that the firms' payments to MIRL represented only about one-third of the development costs. Moreover, the signing of a contract with MIRL helped a firm to acquire subsidized loans from the Bank of Communication. By mid 1983, 15 machine tool firms had borrowed a total of US$ 10 million. Compared to South

Korea, Taiwan's policy on machine tools is less protective [Fransman, 1986]. It is also less dependent on technology grants from Japan.[5]

Taiwanese experts generally believe that the technological capability of Taiwanese firms is about 5 years behind that of Japanese firms. At present, the quality of Taiwanese machine tools is one step below those of the Japanese. Moreover, the Taiwanese manufacturers depend heavily of CNC controllers supplied by Japan. Development of competitive CNC controllers by local manufacturers is the major challenge that will determine the future of Taiwan's machine tool industry.

3.2 THE PRESENT STATUS OF THE ELECTRONIC INDUSTRY IN THE FAR EAST

3.2.1 Introduction

At present, it is widely accepted that the electronic industry is a prime mover of the present economic change. The projected growth in the major world electronics market namely, the U.S., Japan, and Europe for 1991 was forecasted to be 9.5 percent to a total of US$ 635 billion [Electronics, January 1991]. Thus, the worldwide electronic industry in continues to be the most significant growth industry the world. It is foreseeable that, with a more moderate growth of 5 to 6 percent from now to the year 2000, the industry would become a one trillion dollar industry. Also, the electronic industry of the Asian Pacific Rim countries has clearly become the source of growth and the fastest-growing in the world electronic industry. It is expected that the electronic tigers in this region will be led by Japan, Korea, and Taiwan. Other tiger cubs will include Singapore, Hong Kong, Malaysia, and Thailand.

Accordingly, it is very interesting to investigate into the policy framework, economic performance, and technological profile of the Asian electronic industries whether there are any common strategies and consequences which the rest of the world can learn.

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[5] Taiwan received only 3 grants for machine tool technologies from Japan while South Korea received 18, China received 9 and India received 9 [Otaka, 1990].

3.2.2 Policy Framework

Although all of the Asian economies (i.e. Japan, Korea, Taiwan, Hong Kong, and Singapore) are market-led economies, governments play a large part in creating dynamic comparative advantages. By pulling resources together (e.g. manpower, money, and effort), governments with consent from private firms target a few strategic industrial sectors and products to create the countries' dynamic growth. Generally speaking, governments have manipulated the industry in one way or another. Even in the case of Hong Kong, the so-called "government-intervention-free state", it is in the process of reconsideration.

Three common policies among the aforementioned governments are their roles in building supporting industries, creating competitive firms, and providing technical support. First of all, all governments play a large part role in building up supporting industries, including of Hong Kong. Second, they all provide an environment to create competitive firms and dynamic market competition. Third, except Hong Kong, they strongly foster and support the industry with various science and technology (S&T) infrastructure: manpower, services, grants, loans and technical supports regarding research and development (R&D) activity. The only one difference among them is the creation of markets and demand conditions by the governments. Some certainly do, such as Japan, Korea, and Taiwan to a certain extent. Of course, although these incur certain risks, experiences reveal that returns by far outweighed risks however.

Japan: government orchestrating more basic research

In 1957, Japan already targeted the electronic industry as one of the strategic industries with the Temporary Act for Promoting Electronics Industries. Without her own technology at the outset, Japanese government and private firms virtually agreed to import technologies (both product and process technologies) and imitate them since then. In 1960s, the Ministry of International Trade and Industry (MITI) targeted assembly of consumer electronics as the starting point. Based upon the huge domestic market and the high growth rate of the world economy, the "assembling" industry grew rapidly. Nevertheless, the government (through the Agency for Industrial Science and Technology, AIST) pushed ahead local production of key components and research

and development on various consumer electronics. Only a decade of painstaking effort, color televisions and audio equipment based upon Japanese technologies were the leading products which partly made Japan as No.1 consumer electronics producer in the 1970's. Following the success of video cassette recorders (VCRs) introduced 1982, video camera recorders have become the leading product since 1987.

Nevertheless, as consumer electronics became matured and profit margins became smaller, in order to stay competitive, concentration on consumer electronics was replaced by electronic components, and computer and telecommunication equipment since the mid 1980s though it continued to lead in new consumer electronics products like camcorders. The production value of industrial equipment and electronic parts has risen sharply since around 1985. For electronic parts, the increase was due mostly to very large scale integrated circuits (VLSI) and other advanced components for computer and telecommunication equipment. Thus, the Japanese electronic industry, like those in the many earlier industrialized countries such as the U.S., is moving away from production for export of consumer equipment to computers and related high-technology devices and parts. Moreover, there is a growing number of transfer of high value-added production processes and R&D activities to the new offshore centers in the U.S. and E.C. countries as well as cases of relinquishing managerial authority to local personnel.

Apart from the shift of government strategy to industrial electronics (in particular, computers and telecommunications), some notable trends emerged as follows [Yamada, 1990]:

(a) A large scale transfer of labor-intensive manufacturing.
(b) Opening up new markets through new product creation.
(c) Targeting basic research expecting results in the next 10 years, e.g. the fifth generation computer.
(d) Pouring resources for AIST and Tsukuba Science City to generate indigenous innovations.

Korea: giant firms grown from government fostering

Similarly, government's policies in Korea have played a prominent role in promoting the electronic industry which consequently put South Korea

as one of the newly industrialized countries. The government specifically targeted electronics as one of the highest priority industries by importing and adapting electronic technology and its production know-how from advanced nations, such as the U.S. and Japan. The electronic industry started in 1959 with the assembling of radios, followed by B/W televisions in the mid 1960s. Production was initiated by local firms to supply the domestic market by relying upon complete packaged technology imported mainly from the U.S. This included assembly processes, product specifications, production know-how, components and technical personnel.

Nevertheless, along with the Technology Promotion Law, two main government bodies, Korean Institute of Science and Technology (KIST) and Korean Institute of Advanced Science (KIAS) (later merged as Korean Advanced Institute of Science and Technology, KAIST in 1987) were established. Government's strategy intensively used the phase of import substitution to build up local technological capability in product design and manufacturing by licensing packaged technology and training local personnel by technology suppliers from abroad. The government tried its utmost to encourage private firms to absorb and adapt technologies quickly and to diffuse technologies through the mobility of experienced technical personnel within the country. With several specific sectoral programs, foreign technology was diffused rapidly, and hence the need for imported package technology was greatly curtailed [Choi, 1990].

With the capability to adapt imported production technologies during the 1960s and backed by a large domestic market largely protected by high tariff from import, the industry took off rapidly in the early 1970s capitalizing on its labor cost advantage to assemble high labor-intensive consumer electronics. The second wave was the more dramatic rise when the rapid growth was not based on labor cost competitiveness, but resulted from the application of greater skills and capital-intensive production systems, and investment in R&D. However, Korean strategy was based upon the big three conglomerates: Samsung, Goldstar and Daewoo. The rationale was that these big conglomerates had all necessary financial, manpower, technological and marketing strengths. These were necessary to break the late-entry barriers and move up the higher-technology and higher-growth ladder. Also, they could gain from economies of scale and scope in manufacturing and R&D compared to smaller firms.

At present, with the establishment of the Electronics and Telecommunications Research Institute (ETRI), the importance of consumer electronics was clearly replaced by industrial electronics, namely, computers and telecommunications. Recent programs in electronics have targeted at the technology-intensive and higher value-added electronics, such as communications equipment, computers, audio/video products, and advanced components and parts. Such programs have been given appropriate measures of supports through import barriers (such as high import tariff or ban), subsidies and tax breaks, foreign investment incentives, technology import inducements, and support for private sector R&D. Other supports include a new town for science and technology research, the Daedok Science Town.

Taiwan: a pro-active government creating industry

In contrast with South Korea, Taiwan's industrial strength and economic progresses owed to a considerable extent on the flexibility of its small & medium sized enterprises (SMEs) coupled with well developed marketing and information networks. The flexibility of SME's supported by marketing and information networks means that Taiwan is best at responding very swiftly to new market niches and opportunities suited best to most of the electronic products. Taiwanese government's policies have greatly contributed to her electronics industry. In the early 1960s, the government set up a number of export processing zones and gave various incentives to the export industry in order to create the assembly of electronic goods to take advantage of her low cost labor. In the mid 1970s, with a tremendous worldwide computer and semiconductor growth, the government designated the electronic industry as a strategic industry with far more preferential treatment than ever.

The importance attached to the electronic industry cannot be more evident when the government announced on December 5, 1990 through the Council for Economic Planning and Development a list of 10 strategic areas that the government will accord the highest priority for development. The 10 targeted areas are: telecommunications equipment, computers, consumer electronics, precision automatic machinery, semiconductors, high technology materials, specialty chemicals and pharmaceuticals, space industry, health-care, and environment conservation and pollution controls. It is interesting to note that four out of the ten areas above are directly associated with the electronic industry, while a number of other areas depend on a considerable extent of

the application of electronic-related technologies. The priority areas were further narrowed down to five of which four are related to electronics technology while the fifth to materials technology.

Clearly, two strategic areas identified by the Taiwanese government for highest development priority make up the information industry. They are the telecommunication equipment and the computer industries. This is not however the first serious effort at developing the information industry. In 1979, the government set up the Institute for Information Industry (III) as a government supported nonprofit organization. The III is entrusted with the tasks to promote effective utilization of information technology and to help develop the information industry, viz the telecommunications equipment and computer industry. It is to conduct training and R&D in software engineering, AI, office automation, Chinese computing, etc.

The III is not alone in supporting the information industry in Taiwan. In fact, the Industrial Technologies Research Institute (ITRI) was established as a multi-disciplinary research institute in 1973 to acquire, adapt, and develop a number of key technologies (for example, IC technology from RCA in 1973) for transfer to and commercialization by the private sector. A division of ITRI - the Electronics Research and Service Organization (ERSO) deals exclusively with Taiwan's information technology industry. Major areas of R&D by ERSO are for examples, semiconductor technology, a BIOS (for basic input-output system) for the IBM AT - personal computers (which led to the emergence of its computer industry), another BIOS for IBM PS/2, a parallel processing superminicomputer. In addition, the government developed the Hsinchu Science-based Industrial Park for local and foreign corporations to develop new products.

Singapore: foreign MNCs led by local government

Although Singapore is the smallest economy of the four Asian NICs, it has a very large electronic export base. The industry has played a dominant role in contributing to the national economy. The ratio of electronic production to GDP is about a half, the highest among the four NICs. It has the highest share of electronic data processing, followed by the components and parts, with the consumer electronics a distant third.

The electronic industry in Singapore started in the 1960s with the assembly of consumer products such as radios and B/W television sets. After three decades of development, its electronics production in 1989 ranked 9th in the world behind other Asian countries only to Japan, Korea and Taiwan contributing 1.8 percent of world output in electronics. While it is producing quite a range of consumer equipment, the sector was firstly overtaken by the component sector, mainly in semiconductor, and subsequently by industrial electronics producing products such as computer peripherals. Indeed, Singapore is now the world's largest producer and exporter of disk drives. In the 1980s, the electronic industry has become the leading industry within the manufacturing sector in terms of production outputs, exports and employment.

The government strategically and periodically shifts the industry towards more advanced industrial equipment. This was beneficial to Singapore for a number of reasons to sustain economic growth. First, Singapore is a small country having population of some 2.65 million and a labor force of only 1.3 million. Second, domestic labor and overhead costs have soared steeply under the government's wage policy in order to discourage low value-added industries. The country has therefore lost its comparative advantage in labor-intensive low value-added assembly of relatively low technology-content consumer electronics. On the other hand, its has a large pool of relatively low-cost engineering personnel best suited to knowledge-intensive and skills-intensive activities needed by high technology-content industrial electronics. Also, Singapore's electronics industry is practically dominated by foreign multinational corporations (MNCs). Unlike Taiwan and Korea, none of the big players is home-grown, nor are the products exported under their own brand-names through their own marketing channels.

Thus the recent move by the government (through the Economic Development Board, EDB) is to actively attract foreign direct investments with generous incentives and strong supports to steer the country down a path of enhanced product sophistication and process automation in products like computer peripherals, printed circuits, semiconductor design and wafer fabrications, medical and telecommunications equipment. A number of Japanese firms has been attracted to develop software for electronic switching equipment, integrated-circuit (IC) design, and component procurement centers. SGS-Thomson Microelectronics was the first to set up a semiconductor wafer fabrication facilities, and has recently undergone further expansion.

The government's strategy to attract foreign firms has been based not only on the development of the well trained labor force but also the excellent physical and communications infrastructure. The government has played a crucial role in increasing the skill level of its workforce. Through its Skill Development Fund (SDF), all companies make compulsory contribution to the fund which they are eligible to make use of in upgrading the skill levels of workers through on-the-job training and other relevant training programmes. There has also been a significant increase in formal education oriented to the higher technical and engineering areas especially electronics. About 40 percent of all students enrolled in higher education (degree and diploma levels) are in engineering. Also, a number of technical institutes were established as collaborative ventures with foreign electronics firms or the home country governments of leading investors. For instance, Nippon Electric Corporation (NEC) and International Business Machines (IBM) are given special incentives and even special grants to train more people than they actually need in critical areas. Further, several government statutory boards and technical programmes are re-organized and strengthened, such as the National Science and Technology Board (NSTB), the National Computer Board (NCB), the Singapore Institute of Standards and Industrial Research (SISIR), and Singapore Science Park.

Hong Kong: a reconsidering non-intervention government

The electronic industry in Hong Kong has so far been developed under free market forces with virtually no direct role of the government. The industry thrived and grew rapidly due to productive workforce, availability of capable engineers and managers, good infrastructure, easy access to information and market trends, ease of sourcing components and at cheaper price, and the excellent response to market needs in terms of quick product development and manufacturing lead time.

The electronic industry in Hong Kong began in 1959 with a number of small local factories assembling radios. Having taken its root for a decade, the radio industry expanded rapidly in the 1970s when audio equipment like cassette tape recorders became another major item of production. During the early stage of the development, its has been very attractive for small to medium scale subcontracting business due to its fast response and short lead time, and great flexibility to meet clients' varying need. During the 1970s,

consumer electronics (known as fad products) which are products having short demand cycles and rapid price reduction, such as electronic games, digital watches, TV games, and game computers) were the dominant player. This was followed by electronic components and parts. Industrial electronics was negligible.

With the abundance of low-cost labor, low tax rate, a good commercial infrastructure, and minimum government interference, Hong Kong had become a favorite location for foreign investors in electronics. A number of leading U.S. component companies began to assemble electronic components such as core memory for computers, diodes, transistors and capacitors in the early 1960s. Subsequently, testing of semiconductor memories and ICs by these foreign subsidiaries followed. The packaging and testing of semiconductors was later overtaken by the assembly of computer parts.

Up to now, firms spent very little on R&D. Their strategy has traditionally been aimed at short-term returns based on quick production for niche markets, fad products being a typical example. More sophisticated products produced are mainly from the assembling of advanced components imported from Japan. If the trends continue, Hong Kong will likely drop out of competition with South Korea, Taiwan and Singapore over advanced computer and communications products which are the highest growth sectors in the electronic industry. Because of the above trends, the Hong Kong government has seen the need to upgrade from assembly-intensive activities to engineering and knowledge-intensive ones. These include design and manufacture of more specialized products namely computers and peripherals (such as disk-drive, modems, printers, and add-on cards), private automatic branch exchange (PABX), cellular phones, facsimile machines, and computer-aided design and testing equipment. This lifted the industrial electronic products from virtually a no-position sector into an equally dominant sector with consumer electronics.

Thus, the government in recent years began to take steps in assisting the industry, and has started to focus on the education and training of electronic engineers, and promotion of direct foreign investment that contributes to the diffusion of more advanced technology necessary for it to remain competitive. The drawback from the general strategy of laissez-faire is increasingly strong with respect to the electronic industry. Without the government playing a lead role, it is unlikely for it to move upscale into

higher technology products (both equipment and components), hence high added value. The introduction of a science and technology university and the initiation of a science park by Hong Kong government are good examples.

3.2.3 Economic Performance

Economically speaking, the electronic industry significantly contributes to production outputs, export earnings, and employment of the Asian Pacific Rim economies. Within the information equipment sector, Japan is the sole country capable of manufacturing the full range of communications equipment and computers. Korea is growing with the personal computer (PC) market which Taiwan already has a large market share. Singapore and Hong Kong are merely in computer peripherals and parts. Nevertheless, while Singapore presently remains the largest world producers of hard disk drives, Hong Kong occupies no specific sector.

The electronic industry

It is apparently that Japan and the Asian NICs were ranked among the top of world producers of electronic products. While Japan maintained her second rank among the world producers in 1987, Korea and Taiwan were ranked at the sixth and seventh respectively. As shown in Table 3.7, the total output of Japan's electronics industry amounted to US$ 121.6 billion which was 5.7 percent of the country's GNP in 1987. In the same year, the total production in Korea and Taiwan was tantamount to US$ 18.9 and 13.0 billion equal to 5.1 and 5.3 percent of the country's GNP respectively.

Owing to the strategy of outward-looking through export-led-growth policy of Japan and the Asian NICs, it is evident that their exports generate a large amount of foreign exchange for the economies. For instance, in 1987, Japan generated US$ 53.4 billion from the exports of electronic products which accounted for 23.8 percent of the country's total export. Likewise, Korea and Taiwan earned US$ 11.2 and 10.7 billion in the same year accounting for 23.7 and 18.7 percent of the countries' total export.

In stead of job diminution due to introduction of automatic equipment into the production process, employment in the electronic industry of Japan and the Asian NICs experienced an increase and shared a large portion

Table 3.7 : Production Outputs, Export Earning, and Employment of the Electronic Industries in the Far East in 1987

(Unit : Billion US Dollars)

	Japan	Korea	Taiwan	Singapore[a]	Hong Kong[a]
Production outputs	121.6	18.9	13.0	10.7	6.9
% of country's GNP	5.7	5.1	5.3	-	-
Export earnings	53.4	11.2	10.7	13.2	n.a.
% of country's total	23.8	23.7	18.7	-	-
Employment (1,000 persons)	1,026	377	302	117	110
% of total manufacturing employment	9.7	8.5	9.3	-	-

Note : (a) Figures in 1988
Source : EIAJ, EIAK, III.

in the manufacturing sector. Employment in the electronics industry (ISIC 3832) in Japan and Korea was equal to 1,026,000 and 377,000 persons or 9.7 percent and 8.5 percent of the total manufacturing sector in 1987. Taiwan accounted for 302,000 persons or 9.3 percent of the total manufacturing employment in 1987.

Table 3.7 presents some important statistics of electronics production, exports and employment for Japan, Korea, Taiwan, Singapore and Hong Kong in 1987 illustrating the overall economic significance of the electronics industry, while Tables 3.8 and 3.9 give a comparison of the performance in 1988 of the two sectors of the electronics industry to be further discussed below. They are the computer and the telecommunication equipment sectors.

The computer sector

Japan: second only to the U.S.

The Japanese computer industry has maintained a strong growth since the beginning of the 1980s. In 1988 it ranked second behind the U.S. in

terms of production. It accounted for 1.4 percent of the Japanese GNP in 1988. The production breakdown of computers and related equipment reveals that the computer

Table 3.8 : Production and Export of Computer & Peripheral Classified by Country (1988)

(Unit : Billion US Dollars)

	Japan	Taiwan	Korea	Singapore	Hong Kong
Production	52.0 (27.8)	2.5 (13.0)	4.4 (31.7)	4.2 (39.9)	1.3 (19.4)
Export	16.4 (8.8)	2.3 (12.4)	4.8 (34.7)	5.2 (48.6)	2.0 (28.4)

Note : ( ) = % of Production in Electronics Industries

Source : Yearbook of World Electronics Data 1990
- America, Japan & Asia-Pacific

Table 3.9 : Production and Export of Telecommunication Equipment Classified by Country (1988)

(Unit : Billion US Dollars)

	Japan	Taiwan	Korea	Singapore	Hong Kong
Production	14.6 (7.9)	6.4 (7.3)	0.9 (6.7)	0.2 (2.3)	0.4 (5.9)
Export	5.2 (2.7)	6.2 (3.0)	9.1 (3.6)	0.3 (3.1)	0.7 (9.7)

Note : ( ) = % of Production in Electronics Industries

Source : Yearbook of World Electronics Data 1990
- America, Japan & Asia-Pacific

sector registered a very strong growth of almost 18 percent per year, followed by the peripherals, and the terminal equipment sectors at 10 percent each. Major products in Japan are Fujitsu, NEC, and Hitachi. Together they gave a combined share in 1987 of about 30 percent of the world mainframe computer

market. Their combined share in the world supercomputer market is just as impressive, at 36 percent in the same year [Yamada, 1990].

In 1988, exports of computer totalled 2,064 billion yen, exceeding the imports by about 1,600 billion yen. Two major trading partners in the computers and related equipment and parts are the U.S. and E.C. countries, accounting for over 80 percent of trade consistently over the period [CICC, 1990]. With its vital role in establishing an information-oriented society in Japan and elsewhere in the world, the Japanese computer industry is expected to continue its very strong growth well into the next century.

Unlike in the U.S. where PCs have become the front-runner of the computer industry's growth, in Japan, all types of computers from large mainframes down to PCs continue to show strong growth. Strong demand for all types of computers is due to the investment made throughout the Japanese society at large in preparation to become an information-oriented society.

Since the introduction of point-of-sales (POS) in 1972, over half of all department stores, supermarkets, and gasoline stations are offering POS services to customers. Computer Numerical Control (CNC) and robots began to appear in factories throughout Japan since 1975. With the introduction of Japanese-language information processing in 1980, more than 96 percent of large enterprises and 41 percent of smaller firms utilize computers in their works from office automation (OA), flexible manufacturing (FA) to computer-integrated manufacturing (CIM) [Yamada, 1990]. It is expected that the computer industry may grow at a rate of 12 percent per year until the year 2,000.

Korea: growing with PCs

The computer sector in Korea is primarily composed of personal computers (PC) and associated peripherals. With a total production in 1989 of US$ 3,180 million in the sector, PC accounted for US$ 1,689 million and peripherals US$ 1,423 million, only US$ 68 million was for other computers according to published statistics by the Electronic Industries Association of Korea [EIAK, 1990]. Though the computer sector is relatively small in South Korea, it is nevertheless one of the fastest growing sectors. During the

period from 1981, the sector grew in production by 77 percent and in exports by 89 percent.

The PC sector basically began with the purchase of 5,000 sets of 8-bit computers for educational purposes by the Ministry of Science & Technology in 1983. Since that time, it grew by leaps and bounds largely due to fast growth in exports demand from the U.S.. In a Ministry of Trade and Industry (MTI) Report in 1989, the South Korea PC production takes around 3 percent of the world's total PC production in value, slightly lower than Taiwan with 3.2 percent. Thus within a matter of a few years' time, the Korean PC production has almost caught up with that of Taiwan [Mody, 1989].

The computer and related equipment industry is basically export-oriented one. Since the start of the PC computer production in 1983, the export share of the total production output has ranged from 55 percent to 80 percent between 1983 and 1989. Major overseas markets are the U.S. and E.C., mostly on Original Equipment Manufacturer (OEM) basis. Imports of computer and related products has been modest and declined (50 percent in 1985 to 30 percent in 1989). However, the country still had to rely on products, mostly from Japan and U.S., in the more advanced, larger or more sophisticated computers and peripherals which it cannot yet produce.

Another feature of the industry is the equally dominant position of the peripheral sector whose output has been growing at a rate of 75 percent during 1981 to 1989 with a volume comparable to that of the PC computers. However, in terms of exports, its volume has traditionally been larger. Major items of the peripherals sectors are dumb terminals and monitors which are relatively easy to assemble given their low technological content. They could be expected to remain major export items at least until serious challenges from other lower labor-cost Asian countries arise.

Taiwan: the PC tycoon

In 1987, Taiwan ranked 7th in the world in terms of computer hardware production behind the U.S., Japan and four other E.C. countries of W. Germany, U.K., France and Italy, in that order. But considering its growth of 80 percent over the previous year compared with the world's top six producing countries which managed growth rates all below 10 percent the same year, it

can be expected soon that Taiwan will become among one of the top five producing countries in the world [San, 1990]. However, its products are nearly all low-priced and high-volume types for OEM markets. For example, while it produced 15.9 percent of the world's total number of microcomputers, it only accounted for 3.3 percent in the product's total value. The two most important products in Taiwan are microcomputers and computer cards which, between them, shared over 61 percent of the total production in 1987. Terminals and monitors share 33 percent in 1987.

The U.S. market has been the single largest market for Taiwan's microcomputers and related products, accounting for over half its total information product exports, followed by the E.C. and to a much lesser extent, South-east Asian countries. While, the U.S. export share of its computer products has declined from 73 percent in 1983 to 51.3 percent in 1987, the E.C. is becoming a very important market, with 32 percent share in 1987. The E.C. market may soon overtake the U.S. as the largest export for Taiwan's information products. Further, Taiwan has started to diversify its market to Asian Pacific countries (9.9 percent) and Central & South America and Africa (4.63 percent).

No doubt, Taiwan would have to continue importing minicomputers, main-frame computers and other application specific systems and related products from its major suppliers - Japan and the U.S.. During the period from 1983 to 1987, imports from Japan grew from 26 percent to 44 percent, overtaking that from U.S. which declined from 60 percent to 32.5 percent during the same period.

Singapore: The world largest hard-disk drive manufacturer

The industrial electronics sector was overwhelmingly dominated by the electronics data processing products (EDP) group with a share of 40 percent of the electronics industry in 1988, compared to 2 percent of telecommunications equipment. Surely, the EDP group was heavily skewed with the computer disk drives occupying a lion's share of output. There are at least 10 MNCs in the peripherals business of which six are hard-disk drive (HDD) manufacturers [UNCTC, 1987]. Many of them are the world's largest HDD companies making Singapore the largest HDD producing center in the world.

The country earned a substantial amount of trade balance mainly from the EDP products group. The situation may be expected to continue in the near future as the high growth rates in production and imports far exceeded the growth in domestic demand.

Hong Kong: An infant computer industry

Although Hong Kong was outstanding in production of fad consumer electronics (such as electronic games and digital watches) followed by a range of parts and components, it was an infant in industrial electronics. Despite a significant effort towards industrial electronics over the past decade, largest contribution to the rise of industrial electronics still confined to computer peripherals and parts. Nevertheless, the small computer segment in Hong Kong has kept growing at the highest rate. What seemed to trigger off the surge in their production and exports are the boom in the world market for EDP parts and PC computers in the early 1980s.

It is a matter of fact that the computer industry in Hong Kong remains in the infant stage. This reflects through the very high volumes of imports of EDP parts for production and computer equipment in general. The import dependency in Hong Kong is largely marked by the lacks the manufacturing base for advanced components and parts which are especially a significant proportion of this group of high-technology products compared with consumer electronics. A substantial portion of parts and components comes from Japan, its leading supplier for electronics imports to Hong Kong.

The telecommunications sector

Japan: a new giant

The telecommunication equipment industry in Japan is expected to grow with PBXs and new media equipment. Further, while the country is gearing to move into full digital networks nation-wide by the year 2000, satellite and space communications are likely to expand considerably in the 1990s, along with mobile telephone. With the deregulation of telecommunications in 1985, the NTT monopoly was turned into a private corporation. Fifteen new common carriers came into business along with another 660 firms entering into the value added network (VAN) business generating a combined revenues of more than

US$ 6 billion in 1987 [Yamada, 1990]. With an aim of becoming a full-fledged information-oriented society by the end of this century, the first integrated service digital network (ISDN) in the world was launched in Japan in 1988. By 1990, it is projected to cover some 130 cities.

Statistics compiled and cited by Yamada shows that, between 1965 to 1985, total production was seen to double approximately every five year or a steady growth rate of 15 percent per year for the Japanese telecommunications industry. With the deregulation of telecommunications in 1985, the year 1986 saw a dramatic jump in production over the previous year by almost 44 percent. This enormous growth was sustained for the next two years 1987-1988 presumably on the strength of the conversion plan of its analog switching system throughout Japan to digital switching system and the introduction of ISDN services in 1988 as well as the plan to enlarge its coverage to 130 cities by 1990.

In March 1988, switching systems were 26 percent digital, to be rising to about 40 percent by 1990, and eventually 100 percent by 2,000. With the digital switching system saw the replacement of old type of dial pulsé telephone sets to new MF (multifrequency) telephone sets and feature phones with a number of added features for greater convenience and versatility. Then there was added demand for mobile cellular telephones and wireless telephones for greater mobility and personal use.

It is interesting to note that Japan appeared to import negligible number of key telephones and facsimiles from other countries. If it should in future, it would probably be from Japanese subsidiaries overseas. However, it exported about 35 percent of the total production, of which facsimile machines accounted more than half the export value, followed by parts and telephone sets.

It may be interesting to note that the future growth of the telecommunication sector in Japan predicted by the MITI shows it would be only a half of the computer sector. This may be because many major telecommunication equipment manufacturers have diversified into the computer industry and are also leaders in VLSI manufacturers themselves. These major players are therefore able to link VLSI development to new computers and also in the best

position to create information technology necessary to take the country into a full-fledged information-oriented society.

Korea: a growing industry

The telecommunications equipment industry is even a smaller sector than the computer industry. This is because the sector is predominately developed as a domestic industry, unlike the export-oriented computers, consumer electronics, and semiconductor sectors. One main reason lies perhaps in the high technology content of products like facsimiles (FAX machines) and switching systems, except for the rather unsophisticated and standard product in telephone sets. Latest production in 1989 for the sector amounted to US$ 2,396 million or 8.5 percent of the total electronics industry output. The sector grew during the period 1981 to 1989 at a satisfactory rate of 27.0 percent in tune with the entire electronics industry which registered a growth of around 29 percent over similar period.

However, the sector does have a good potential for growth as South Korea, like the many other industrialized and industrializing countries, is moving into an information-oriented society. Demand for telecommunications products is certain to grow rapidly especially in FAX machines, optical fibre cables and equipment, and public and private exchanges.

As noted earlier that the sector is predominately domestic in nature where the majority of the output is to meet domestic demand, except the two years during 1987 to 1988 when export share of the sector's production output jumped to 58 percent from 44 percent in 1986. The sudden jump could be explained by the near doubling of the telephone sets exports to the U.S.A. following the deregulation of the telecommunications market there [Mody, 1989].

Export volume has remained insignificant compared to the consumer and parts and components sectors until 1987 when the situation improved somewhat. Exports were largely limited to simple telephone sets and C.B. transceivers and are likely to remain so given the large technological gap at present. Imports are even smaller in volume than exports of late, given the country a trade surplus in telecommunication equipment since 1986. Being at an infant stage of development, the government has been limiting foreign

penetration in order to protect the industry. Since the government is the largest single buyer in this sector, it can easily limit the right to bid for its purchases to domestic producers only.

Taiwan: a neglected sector

In contrast with the information technology sector, the telecommunications equipment sector has the largest technological gap and is the least developed among the electronics sectors in Taiwan. This is because the telecommunications equipment have been under heavy regulations by the government on national security reasons. While government's policies over the past three decades toward the electronics industry have been most supportive and favorable, the industry as a whole developed rapidly. However, this is not the case with the telecommunications equipment. Most telecommunications equipment even for civilian use is not allowed to be produced nor marketed.

The only bright prospect in the industry came from the deregulation of the telecommunication in the U.S. in 1983, resulting in a surge in U.S. demand for telephone sets. Being a relatively matured and unsophisticated product with readily available components, the Taiwanese electronics industry was therefore able to respond very rapidly to the surging demand. A considerable number of firms, old and new, entered the telephone set market, pushing its production of telephone sets from 3.5 million units in 1982 to 22.6 million that year. After the initial surge, its production fell back in 1984 to 12 million units but climbed back to 21 million units by 1987 [Mody, 1989].

Singapore: the user of telecommunications

There is no doubt that Singapore is a leading country in Asia which is well equipped with telecommunications equipment and services. However, it largely plays a role of consumers rather than producers. The production of telecommunications equipment accounted for just above 2 percent of the total electronics output in Singapore. Though telecommunications equipment expanded at an even higher rate of 64 percent, its position was however rather insignificant. Major products within telecommunications group are telephone sets and facsimile machines.

The country still earns a substantial amount of trade balance mainly from the EDP products such as computer peripherals and parts. The situation is expected to continue in the near future as the high growth rates in production and imports far exceeded the growth in domestic demand.

Hong Kong: no place for telecommunications equipment

In 1988, Hong Kong's major electronics export items are: parts and components (36 percent), watches and clocks (21.7 percent), computer peripherals (6.7 percent), telephones (3.6 percent), radios (5.1 percent), TV sets (4.3 percent), video tapes (3.1 percent), and other consumer products (19.2 percent). Integrated circuits, semiconductors, printed-circuit boards, printed circuit assemblies, and liquid-crystal displays are major items of parts and components industry. Electronic toys, watches and clocks, TV set, and CD players are major products of its consumer electronics industry. Telephone sets, cellular telephones, PC computers and peripherals, and facsimile machines are major products in the industrial electronics industry [Dataquest, 1989].

However, most of the products is heavily relying on imported parts and components as reflected from the high percentage share to the electronics production of about 60 percent on the average for 1984 to 1986. Major imported items included IC, watch movement, EDP parts, and CPT (color picture tubes). Major suppliers are Japan followed by the U.S. for advanced and high-grade parts. Taiwan and Korea are the main suppliers for general purpose parts and components.

Within this sector, Hong Kong earned a balance of trade largely from the computers and peripherals exports, and negligibly from the telecommunications equipment whose main product is telephone sets with low technology content and little value-added compared to computer products. The main market for Hong Kong is the U.S. where it enjoys a large share of the cordless telephone market. In fact, American Telephone and Telegraph (AT&T) obtains all its cordless telephones from OEMs in Hong Kong and Taiwan.

3.2.4 Technological Profile

Japan: targeting human computers and global communications

Technological progresses in computers and telecommunications equipment are tied closely with the progresses made in the semiconductors hardware technology on one hand, and software on the other. In Japan, government research institutes and private R&D centers are gearing themselves to develop state-of-the-art technologies in the world. They have paid heavy attentions to C&C (computer and communication) technologies for decades. At present, they are second only to the U.S. in the computer field, and perhaps neck to neck in the telecommunication field.

COMPUTER HARDWARE

Hardware capabilities have continued to improve greatly each year. Processing speed have increased ten times over a span of ten years through improved logic design and decreased geometry or enhanced circuit density. In addition to enhanced VLSI capabilities, parallel processing technology has added another dimension to processing speed. Along with the fifth generation computer project, Japan not only targets for computers that work and think like human beings but also are smart enough to learn by themselves. In this respect, Japanese electronic firms in collaboration with government research institutes have made good progress in the intelligent computer systems and supercomputers similar to the present world's fastest supercomputer named "The Touchstone Delta" by Intel Corp. which was made up of some 2,000 processors in a single computer system.

In addition, Japan's main memory chips and other external storage devices have continued to improve performance to price ratio. Mass production of 4M-bit DRAMs was seen in the second half of 1989 by several companies: NEC, Hitachi, OKI, Toshiba etc. It is expected that in few years, a 5-inch magnetic disk will hold 1 Gbyte, and a 3-inch disk 500 Mbytes.

COMMUNICATION NETWORKS

NTT and some other Japanese firms have for some time put the ISDN network into business and industrial uses. Networking of computers has made impressive progress that it is becoming a common feature of computer systems. Connections with ISDN and the use of satellite communication will accelerate. Optical fiber will be the main medium for local area network applications, with enhanced speed, distance and reliability performance.

SOFTWARE TECHNOLOGY

Major R&D efforts in software technology are centered around the two areas of computer-aided software engineering (CASE), and artificial intelligence (AI). CASE provides tools to support software development, an area vital to the full exploitation of the information processing power of computer systems. As demand of software engineers increases with the further proliferation of computers due to rapid falling prices of hardware, CASE is seen as a necessary means to relieve software engineer shortages, as well as to increase software development productivity.

Japan has been undertaking a 10-year fifth generation computers project since 1982 involving major computer makers in Japan under the coordination of the Institute for New Generation Computer Technology (ICOT). One major area of this massive national R&D effort is focused on AI and expert systems that enable computers to have human-like capabilities like learning, reasoning, knowledge base management, and natural language processing.

Korea: catching up in semiconductors and switching system

Although Korea made much progress in design and manufacturing capabilities of PC product ranges which is close to frontrunners, there still remains a gap of one to two years in new product development since reverse engineering has recently been prohibited on account of intellectual property rights protection. Hence, Korea can turn nowhere, except building its own technology. Similarly, major progresses in telecommunications technology only began to take place after the introduction of the telecommunications moder-

nization plan in 1982. Areas of development emphasized are in the switching system, transmission technology, and ISDN terminal equipment.

ASIC TECHNOLOGY

With advances in ASIC (or application-specific integrated circuit) technology, many custom ICs have been introduced which greatly reduce the number of components and shrink the profit margin from manufacturing of personal computers. While ASIC technology is already matured in U.S. and Japan, followed closely behind by Taiwan, it has just started in Korea with the entry of firms such as Goldstar, Daewoo Telecom, LSI Logic Korea, etc.. However, they can only produce simple ASIC products for the consumer and telecommunications sectors.

WORKSTATIONS

The future trend is to see the industry moving away from low value-added PC computers towards higher skills and technology-intensive, hence larger profit margin products like workstations. Already Samsung has made entry into the low-end workstation arena with the development of a prototype [BK.Electronics, Sept. 1989]. It has subsequently entered into an agreement with Hewlett-Packard (HP) to use HP's RISC precision architecture technology to further develop and produce low-end workstations.

SOFTWARE

Another likely move is toward a greater emphasis in software production as the profit margin shrinks in the hardware production. The recent entry into South Korea by Microsoft will give some impetus to this sector of computer industry. Another big thrust came from the initiation in 1987 of the SUPER (Software Usability and Productivity Enhancement Research) Project with a stated goal of leading South Korea to be among the world's top five software exporters by the year 2000.

DRAM

Being one of the critical components for the production of PC computer, major producers are expected to enter into the 16M DRAM (or 16 megabyte dynamic random access memory) market. Goldstar has entered into a technology collaboration with Hitachi for its 1M DRAM process technology as a first step towards acquiring production capabilities in 4M and eventually 16M DRAMs. Samsung, the technology leader in DRAM in South Korea, has announced plan to start producing 4M DRAMs at the end of 1989 and will likely be pushing ahead with 16M DRAM development.

SWITCHING SYSTEM

The first ever made time division digital switching system in South Korea was to be manufactured by four domestic firms and scheduled for field trial, according to ETRI, by 1989 and full commercial service by 1991. The TDX-1A is the first stage of development to provide the switching systems for the narrow band ISDN in Korea of up to 1.5 Mbps. This smaller system is targeted to replace the electro-mechanical and analog switching systems in small cities and rural areas. It will help to develop larger version like TDX-1B with line capacity of 22,528 lines and eventually TDX-10 with 100,000 lines for metropolitan areas whereby enabling the Koreans to narrow the technological gap and moves towards an ISDN system nationwide by 2000.

OPTICAL TRANSMISSION

To reap the full potential and benefits of an ISDN system, it is necessary to develop optical switching as the next generation switching technology as well as to install optical fibre as the high speed transmission medium for a wideband ISDN capable of operating up to hundreds of Mbps. Through technology transfer agreements, a number of Korean firms are now producing optical fibre cables mostly for the country's own consumption. The Korean Telecommunications Authority (KTA) has laid a total of 1,691 km. of underground optical cable in 1987. KTA and ETRI developed and tested optical communication system with speeds of 45 Mbps and 70 Mbps, a prototype of 565 Mbps in 1987, and are currently developing a 1 Gbps (1,000 Mbps) system.

STRATEGIC TERMINAL PRODUCTS

A research by Arthur D. Little of Japan in 1988 picked telephones, cellular phones, FAX machines, PBX, pagers, and dish antenna as the promising exports products for Korean telecommunications industry. Goldstar has recently selected FAX along with PC as among the strategic export items in industrial electronics equipment, while Daewoo has been negotiating for TDX-1A exports to the Philippines and Burma. However its progress towards being a significant player in this field will hinge largely on its progress in the technological development of IC design and production capability of which South Korea is still much behind world players at present.

Taiwan: making sub-micron technology feasible

With electronics industry named as a strategic industry for economic growth, the Taiwanese government is making a maximum effort to upgrade the industry in components, computer, software, communications equipment, industrial electronics, test equipment and consumer electronics products.

SEMICONDUCTORS

Undoubtedly, supply of advanced semiconductor devices are critical to the electronics industry, particularly in the hi-tech arena of computer and telecommunications equipment, as the supply shortage of memory chips in the late 1980s has painfully proven to the computer manufacturers. As a result, the government and industry alike are fully aware of the need to build up the country's capabilities to make critical semiconductor components. Thus, from only three in 1987, the number of IC fabrication firms is projected to rise to 14 by 1992 to make memory chips, application specific ICs (or ASIC), telecommunications IC etc., to meet the needs of local information industry firms. At the same time, the number of ASIC design firms has increased rapidly, from only five in 1984 to 30 by 1987, and over 50 by 1989 according to ERSO.

Thus, the government has sponsored the "Sub-Micron Project" under ERSO at a cost of US$ 1.25 billion starting in mid 1990 to develop 0.5 micron technology involving the collaborative effort of a number of leading

Taiwanese semiconductor manufacturers. The emergences of the wafer fabrication together with ASIC design business in Taiwan can be expected to give small and medium-sized firms the ability to offer innovative and differentiated products in the market place.

HIGH-DEFINITION TV (HDTV)

Another interesting major technological development is to be expected from the recently announced plan to develop high-definition TV (HDTV). The government has unveiled its plan to finance US$ 180 million in R&D over 5 years starting July 1991 in the HDTV program at ITRI [Reuter, Bangkok Post, 28 May 1991]. The program will concentrate R&D effort on TV sets and screens, but not to develop a broadcast system of its own, as in the case of U.S., Japan and E.C. However, it expects to enter into some kind of collaboration with the U.S. HDTV developers. Some potential spin-offs to other areas from the project include electronic publishing, teleconferencing, computer graphics, and medical systems.

Singapore: absorbing foreign technologies

Since the electronics industry in Singapore is heavily dependent on foreign firms. Key players for the computer and peripherals are: Apple computer and Hewlett-Packard in PC computer; Data General, and Digital Equipment in minicomputer; NEC, Data General, and Hewlett-Packard in software development; Minebea, Computer Memories, Maxtor, Miniscribe, Seagate, Tandon, Micropolis, Nixdorf Computer, Olivetti, Microscience, and Hewlett-Packard in computer peripherals; and Mentor Graphic in workstations. For telecommunications equipment, major MNCs are: Fujitsu in public switching systems; Philips in PBX; AT&T in telephone sets; Motorola in cellular telephones; EB Communications and King Radio in marine transceivers.

Such a near total dependency on foreign MNCs means that there can only be an absorption and diffusion of process, production and management technologies, but unlikely with regards to design and product technologies. Thus, current government strategy is to offer generous incentives to firms who are willing to locate in Singapore such activities like R&D, circuit design, or software development. A growing number of MNCs have responded to the

incentives, though few are yet willing to transfer R&D in important components and technologies [Sanger: Singapore's High-Tech Lure, International Herald Tribune, 16 May 1990]. However, Hewlett-Packard has set up R&D operation in Singapore to service its products for Asian markets. Matsushita has set up an audio-visual R&D center. SGS-Thomson Microelectronics has established an VLSI design center and a wafer fabrication facilities.

Hong Kong: moving around supporting technologies

From a survey conducted by HKPC and Dataquest in Hong Kong in 1989, it was found that a substantial number of firms had installed CAD mainly for schematic capture, system design, software design, and some instances of toolings and molds design. Due to limitation in capability, firms that do have design activities cannot handle all the product design and development work totally by themselves and need to subcontract some areas of design activities to private design firms.

SURFACE MOUNT TECHNOLOGY (SMT)

The same survey revealed that about half the respondents have adopted SMT in products like card-sized radios, portable computers, add-on cards, hard-disk drives, cordless telephones, and cameras, etc.. The main reason for the adoption of SMT was due to products miniaturization. Other reasons included the saving of labor, the need to upgrade processing technology, and good business opportunities. Firms employing SMT envisaged an increase of sales of products share using SMT from 30 percent in 1988 to over 50 percent in 1990.

WAFER FABRICATION

In 1989, RCL Semiconductor set up Hong Kong's first full wafer fab facilities for DRAMs. This augurs well for its electronics industry which is highly import dependence on advanced components.

3.2.5 Conclusion

It is evident that among all electronic sectors, computer and telecommunications equipment will be two major sectors of growth. Computer and peripherals will rise 12.4 percent to US$ 200 billion, on the strength of demand for workstations. Communications will rise between 12 to 15 percent to around US$ 76 billion as Europe and its Eastern-block countries expecting to construct major communication infrastructure. In contrast, faced with the uncertainties of prices in DRAMs, the semiconductor is expected to grow by about 6 percent to US$ 46 billion. Consumer electronics will continue to slowdown with a rise of 4 percent to US$ 64 billion. Only one bright spot will be the sales of a few hot items such as camcorders [Electronics, January 1991].

In addition, the electronics industry in the Asian Pacific Rim countries will continue to play an active role in the world production. Japan (the tiger mother) will clearly lead other growing tigers and tiger cubs through the 2000s in all fields. Korea and Taiwan will be another two fast growing economies in the fields of computers and telecommunications, while Singapore and Hong Kong will gradually follow.

CHAPTER 4: ANALYSIS OF THE THAI MACHINERY INDUSTRY

This chapter examines in detail the state of the machine tool, and the mold and die industry in Thailand. It begins with an overview of the Thai machinery industry by drawing on Thailand's aggregate structure of production, imports and exports. Subsequently, an examination into the development in fuller detail will be given in turn for the machine tool and the mold and die industry, as would a detailed economic and a technological analysis according to the conceptual framework in Chapter Two and based on a detailed firm level survey of the concerned industries. Finally the chapter concludes with a discussion of the various problems and policy issues of importance for the future development of the industries under study.

4.1 AN OVERVIEW OF THE MACHINERY INDUSTRY IN THAILAND

Thailand, like many other developing countries, has expanded its industrial sector by entering into joint-ventures with foreign investors. In the 1950s and 1960s, Thailand imported machinery parts and other equipment to produce consumer goods initially for domestic consumption and later for export. This path of industrial development led to high dependence on foreign technology and an unfavorable balance of trade. Therefore, starting from the Fifth National Development Plan (1982-1986) the Thai government has shifted to the development of capital goods industries, including the machinery industry, to strengthen the industrial structure and bolster linkages with other sectors of the economy.

Because of its nature and role in the industrialization process, the machinery industry has the following special features [BOI, 1991]:

1. Many products of the metal-working industry can be produced efficiently at small output levels. This includes products typically produced in small batches, or in a single production process. The industry can also serve fragmented markets. In some cases, small and medium sized firms can fill the gap when large enterprises find it uneconomical to undertake all facets of production. Small and medium scale firms can occupy niches in the industrial infrastructure that are still developing. This creates additional employment

and a more equitable distribution of income. In this way, it also encourages balanced industrial development throughout the country.

2. There are strong backward and forward linkages among machinery products. Most automobile and motorcycle assembly plants require a wide selection of parts and components, primarily of metal. Figure 4.1 illustrates the complex linkages among the metal-working products. The machinery industry not only has strong linkages among its product groups but also possesses strong linkages with other production sectors.

3. At present, Thailand still depends heavily on imports of metal-working products. It is, therefore, desirable to accelerate the growth of this industry which, in the long run, will form the foundation for other production sectors.

4. Although the technology required in the production processes of this industry has been developed and utilized in industrialized countries for many years, several processes have yet to be introduced in Thailand. Therefore, there are numerous opportunities to transfer this technology and adapt it to the local environment. Indeed, the constant adaptation of processes and equipment and the high levels of specialization and innovation, lead some to describe the machinery industry as the "carrier" of technological change.

Thus machinery is a critical component in Thailand's plan to cultivate industrial linkages, absorb technology and exploit skill spill overs. Machinery includes such product groups as engines and turbines, agricultural machinery, industrial machinery, machine tools, office and household machinery, and other machinery. Within these machinery groups, the machine tool industry is regarded as the key industry in the capital goods sector.

Figure 4.1 : The Metal-working Industry and Its Related Products

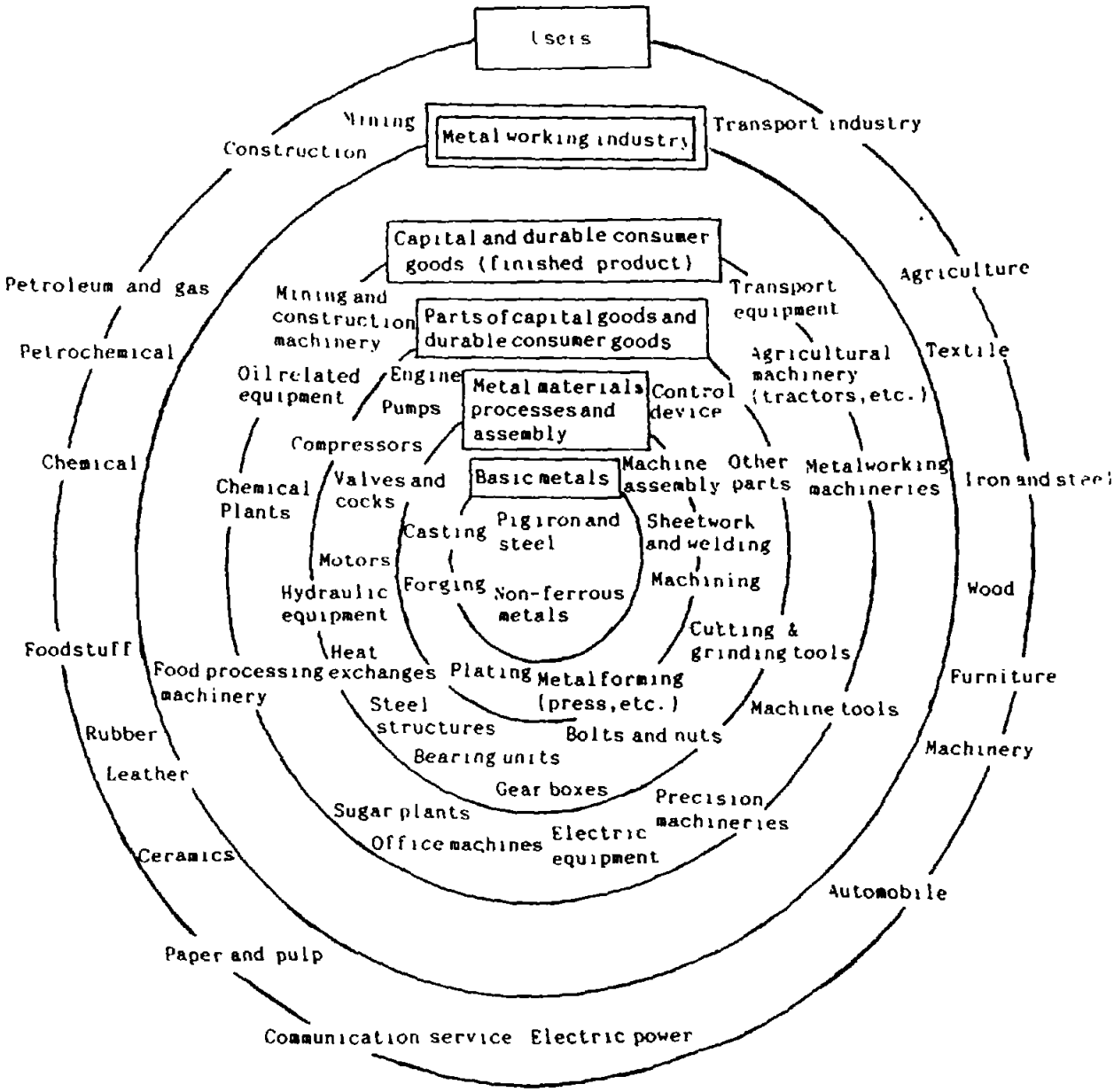

Table 4.1 shows the value added at current prices of machinery broken down into sub-sectors in 1985, 1987 and 1989. During the period 1985-1989, the highest growth sub-sectors of machinery products are office and computing machinery, air conditioning and household machinery. This surge resulted from the additional output from BOI promoted firms. The share of wood and metal-working machinery (machine tools) of the total machinery sector has not changed much during the 1987-1990 period, remaining at roughly 5-6 percent. However, the shares of the engine and turbines, agricultural machinery, and special industry machinery sub-sectors decreased during the same four year period. Therefore, it can be said that the non-electrical machinery industry in Thailand is still at an early stage of development and has not yet emerged as a major industry. In fact Thailand still relies strongly on imports of machinery and parts from developed countries. This dependence is illustrated by the data in Table 4.2.

During the Fifth Five Year Plan (1982-1986), the value of imports of machinery averaged 30,000 million baht a year and increased to 47,726, 89,890, 117,946 and 149,837 million baht in 1987, 1988, 1989 and 1990 respectively. However, the value of exports has also increased dramatically since 1987. Table 4.3 shows the values of import and export of machinery by production sub-sector in 1989. Sub-sector featuring the highest volume of imports are special industry machinery, office and computing machinery, miscellaneous machinery, engines and turbines, and wood and metal-working machinery. In the export column, highest volumes were recorded in the following categories: office and computing machinery, miscellaneous machinery, and air conditioning compressors.

Even though the share of the value added of special industrial machinery in the total machinery industry has been decreasing, Thailand still has a number of companies that specialize in making equipment and machinery for specific industries such as sugar, rice or tapioca mills.

For example, a local firm, which specializes in local tapioca factory machinery production, has been supplying the industry for more than a decade. In addition to local distribution, it has cultivated healthy export markets in South East Asia, and budding markets in Africa. Another example of a company which has had success in manufacturing machines for export is a joint-venture

Table 4.1 : Machinery Value Added at Current Prices

(Unit : Thousand Baht)

	1985	1987	1989
Machinery	5,789,456	7,768,961	13,942,082
Engine and Turbines	1,609,991 (27.8)	1,681,196 (21.6)	2,389,380 (17.1)
Agricultural Machinery	321,670 (5.7)	420,297 (5.4)	688,517 (4.9)
Wood & Metal Working	324,445 (5.6)	419,671 (5.4)	803,117 (5.8)
Special Industry	1,847,451 (31.9)	2,397,261 (30.9)	3,423,781 (24.6)
Office, Computing	272,283 (4.7)	683,114 (8.8)	1,807,318 (13.0)
Household Machinery	734,945 (12.7)	1,115,245 (14.4)	2,579,568 (18.5)
Air Conditioning	173,128 (3.0)	408,171 (5.2)	1,108,073 (7.9)
Other Machinery	505,543 (8.7)	644,152 (8.3)	1,142,030 (8.2)

Note : Figures in parentheses are percentage shares in total machinery
Source : NESDB

Table 4.2 : Imports/Exports of Machinery in Thailand

(Unit : Million Baht)

	1983	1984	1985	1986	1987	1988	1989	1990
Imports	31,154	33,196	33,392	31,151	47,726	89,890	117,946	149,837
Exports	826	1,892	4,704	3,948	8,926	22,175	38,059	56,027
Balance of Trade	30,328	31,304	28,688	27,203	38,800	67,805	79,887	93,810

Source : Department of Customs

Table 4.3 : Machinery Imports/Exports (1989)

(Unit : Million Baht)

	Imports	Share (%)	Exports	Share (%)
Engines and Turbines	13,716	11.6	454	1.2
Agricultural Machinery (including spraying)	1,101	0.9	204	1.5
Wood & Metal Working (including parts, accessories,moles & dies)	12,624	10.7	421	1.1
Special Industry	36,335	30.8	1,018	2.7
Office, Computing (Data Processing M/C)	25,960	22.0	27,437	72.1
Air Conditioning & Compressors	4,521	3.9	2,920	7.7
Other machinery (including bearings)	23,689	20.1	5,606	14.7
Total Imports	117,946	100.0	38,059	100.0

Source : Department of Customs

between Thai and West German partners. It develops its own designs for a full range of hand operated and semi-automatic machinery to produce aluminum tubes.

4.2 THE ANALYSIS OF THE THAI MACHINE TOOL INDUSTRY

This analysis of the development of the machine tool industry in Thailand, as with those of other industries that follow subsequently, is based upon various sources of information, namely expert interview, literature review, and firm survey. The firm survey covered firms which manufacture various types of machine tools. This represented about a quarter of the total number. In addition, a few firms in the supporting industry were also included.

The following discussion is divided into four main parts. First is the evolution of the industry starting from the early 1970s till the end of 1990s. Second is the economic analysis of the industry: demand conditions, supply conditions, firm strategies and market structures, and supporting industries. Third is its technological dimensions: product ranges, technological contents, technological capabilities, and technological embodiments. And fourth is the problems and policy issues.

4.2.1 Evolution of the Industry

The period of initial production, 1971-1980

In fact, the use of machine tools increased substantially from the early 1960s, when Thailand began her industrialization. However, no local production of machine tools took place until the early 1970s. Industrial policy in 1960s largely emphasized import substitution of consumer goods such as textiles, automobiles, and household appliances. Machine tools and perhaps the machinery sector as a whole were not in the policy pipeline. There was no tariff protection and other promotion incentives geared specifically to the machine tool industry. The tariff and business tax rates were, in average, about 15 and 3.0 percent respectively.

The production of machine tools took place in the early 1970s. With all imported critical parts, a number of Thai firms started manufacturing simple machine tools through reverse engineering. All machines such as lathes, presses, and powered hack saws were aimed for local uses. Starting from 8 machine makers in the early 1973, the number of machine tool manufacturers increased to 18 makers in 1977 according to a survey conducted by the Ministry of Industry (Table 4.4). However, over this period, product ranges and product improvements changed very little. In addition to planing and drilling machines, machine tools produced during this 10 years remained the same.

The estimated employment was about 150 persons in 1973 and 600 persons in 1977 since all machine tool firms established during this period were small Thai firms. They employed workers of about 20 persons in average (ranging from 5 to 40 persons). The value added generated by the industry was negligible so was the growth of the share of GDP in the total manufacturing

Table 4.4 : Number of firms, Employment, and Import Tariff of Thailand's Machine Tool Industry

	1973	1977	1985	1987	1990
No. of firm (firm)	8	18	13	27	30
Employment (person)	150	600	700	1,500	2,400
Tariff (%)	15	10	30	20	5

Source : Compiled from JICA, MIDI, and Department of Customs

sector. The GDP generated by the machine tool industry was only 17, 59, and 113 million baht in 1970, 1975, and 1980 respectively (Table 4.5). This represented about 0.07, 0.10 and 0.08 percent of the total GDP in the manufacturing sector. The reason was that most of the machine tools were imported. Local production of machine tools was only to serve some small repairing shops which undertook maintenance for production plants.

Table 4.5 : Production Value-added, Import, and Export of the Machine Tool Industry (current price)

(Unit : Million Baht)

	1970	1975	1980	1985	1990
Value-added	17	59	113	324	781
Import	132	430	791	2,177	11,364
Export	0	7	36	16	787

Source : Compiled from NESDB and Department of Customs

This made the import figure rose sharply from 132 to 430 and 791 million baht in 1970, 1975, and 1980 respectively (Table 4.5). The main import items were metal forming and metal cutting machine tools. They were,

for instance, stamping, press, forging, and bending machines; and lathes, milling, drilling, planing and shaping, and grinding machines. The value of imported wood cutting and stone and ceramic cutting machine tools was not high. With regard to export, there was no export of machine tools until the mid 1970s. It started from only 7 million baht in 1975 and rose to 36 million baht in 1980. Some main items were drilling, sawing, and press machines.

The period of demand change, 1981-1985

Although it was clear that the growth of the machine tool industry in the previous decade was underpinned by the demand for machine tools in Thailand, the situation in 1980s changed drastically. In other words, the local demand for machine tools no longer generated the growth of the industry since quality required by the demand was not matched by the supply of local production. Along with the government's export promotion policy, Thailand's industrial and production structures gradually changed towards export markets. Not only did the export market require higher product quality and lower product price, the domestic consumption also indicated the same trend. Furthermore, there were serious competitions from second-hand machine imports. Therefore, demands for local conventional and low-end machine tools began to diminish, so did the Thai machine tool makers eventhough the government has stressed industrial development in the Fifth National Plan (1982-1986). In order to promote the industry, government raised tariff and business taxes as high as 30 percent and 5.0 percent respectively in 1985 (Table 4.6).

According to a Japanese International cooperation Agency report [JICA, 1985], there was only 2 of the 8 firms identified in the aforementioned MOI survey who were still in business in 1982. Further, merely a few firms were newly set up in this period to manufacture similar type of products. Up to 1985, a survey conducted by the Metal-working and Machinery Industries Development Institute (MIDI) reported that there were totally 13 machine tool makers in Thailand: 6 lathe makers, 3 planing manufacturers, 2 press producers, and 1 sawing and 1 drilling machine makers [MIDI, 1988]. All of them were small Thai firms employing less than 50 workers each. Products manufactured locally during this period were largely the same as in the previous period. They remained conventional and low-end products such as center and turret lathes, C-frame and knuckle joint presses, powered hack saws, drilling machines, and planing machines.

Table 4.6 : Tariff Rates of the Machine Tool Industry

	1975			1976		
CCCN CODE	Tariff	Standard Profit	Business Tax	Tariff	Standard Profit	Business Tax
84.45	15	16.0	3.0	10	16.0	3.0
84.46	15	16.0	3.0	10	16.0	3.0
84.47	15	16.0	3.0	10	16.0	3.0
84.48						
Jig & Fixtures	10	26.0	3.0	10	26.0	3.0
Others	15	26.0	3.0	10	26.0	3.0

	1981			1985		
CCCN CODE	Tariff	Standard Profit	Business Tax	Tariff	Standard Profit	Business Tax
84.45	15	16.0	3.0	30	16.0	5.0
84.46	30	16.0	5.0	20	16.0	5.0
84.47	30	16.0	5.0	20	16.0	5.0
84.48						
Jig & Fixtures	30	16.0	9.0	20	16.0	9.0
Others	30	26.0	5.0	20	26.0	5.0

Table 4.6 : Tariff Rates of the Machine Tool Industry (cont.)

	1986		
CCCN CODE	Tariff	Standard Profit	Business Tax
84.45	30	16.0	5.0
84.46	20	16.0	5.0
84.47	20	16.0	5.0
84.48			
Jig & Fixtures	20	16.0	9.0
Others	20	26.0	5.0

	1988			1990		
HS CODE	Tariff	Standard Profit	Business Tax	Tariff	Standard Profit	Business Tax
84.56 to 84.65	20	16.0	5.0	5	16.0	5.0
84.66 (Parts)	20	16.0	9.0	5	16.0	9.0

Source : Compiled from Department of Customs

Value-added generated by the industry did not change very much from the previous period, in particular, shares in the total manufacturing sector. GDP created by the machine tool industry was 140, 217, and 324 million baht in 1981, 1983, and 1985 respectively. The industry's shares of the total manufacturing sector was 0.08, 0.10, and 0.14 percent during the same period. Although the share of the industry was somewhat higher than the previous decade, employment figures revealed a stagnant trend. The total employment of the industry was estimated about 700 persons in 1985. It increased by only 100 persons over the period of 8 years (from the estimated figure in 1977). Such low value-added and employment figures clearly marked the inability to meet the high demand for machine tools in Thailand because of little expansion of local production.

Machine tools imported during this period jumped drastically from 791 million baht in 1980 to 2,177 million baht in 1985. The average growth rate was 22.5 percent annually. The metal cutting machine tools recorded the highest growth, about 4 times of the 1980 figure. This was underpinned by the growth of planing and shaping machines, lathes, and grinding machines. They grew 5 to 10 times. Most of the high growth items were equipped with NC or CNC controllers. In contrast, the export figures dropped from 36 million in 1980 to 16 million baht in 1985. The cause was mainly due to decreases in stone and ceramic, and wood cutting machine tools. Metal cutting and forming machine tools, in fact, increased to some extent due largely to export of conventional lathes and press machines.

The period of foreign entry, 1986-1991

Whilst performance of the old Thai firms stagnated, a number of new foreign firms started up, as did new Thai firms. Although there was no change in Government's industrial policies both investment and export promotion policy, most of the new firms aimed at manufacturing computer-controlled and higher-end products for export, in particular, among foreign firms relocating their plants to Thailand. The main reason was owing to the lost of comparative advantages in their homelands. These included the higher labor costs such as direct and overhead costs and the availability of supporting parts such as casted, machined, and heat-treated metal parts. With regard to tariff protection, the long-existing high tariff rates were brought down owing

to the high demand for imported machine tools as well as production machinery. It was largely fixed at 5 percent for all equipment in October 1990.

According to the MIDI survey in 1987, the total number of firms increased to 27 firms: 15 press makers, three grinding producers, three sawing manufacturers, two lathe makers, and one milling, one shaping, one EDM, and one machining center manufacturer [MIDI, 1988]. Up to 1990, the total firms in operation have increased to 30 firms; of which Thai firms represented about 70 percent. However, most of the Thai firms are small and non-BOI promoted. Except a few firms, they largely employ less than 50 workers eventhough some of them have been in the business for more than 20 years. Management practices tend to be family-run business. Annual sales are largely below 15 million baht (about US$ 0.6 million). Customers are mainly local repairing and manufacturing firms located in the provincial areas. In contrast, foreign firms are largely new firms established of less than 5 years with BOI promotion privileges. All are subsidiaries of the well known machine tool makers in Asia, particularly, Japan and Taiwan. Annual turnovers are between 50-150 million baht (about US$ 2-6 million). Finished products are mainly exported to other Asian countries. Semi-finished products and parts are largely exported back to mother companies for final assembly.

Value-added generated by the industry rose gradually from 307, to 581 and 781 million baht in 1986, 1988, and 1990 respectively. These represent about 0.12, 0.15, and 0.14 percent of the total manufacturing GDP. Employment also increased. The estimated total employment in 1990 is about 2,400 persons, almost four times of the employment in 1985.

During this period, although there are more Thai who are able to export conventional and simple machine tools such as lathes, presses, and drilling machines, the volume of exports and the level of technology embodied in those machines are rather insignificant. The recent surge in exports is rather caused by foreign firms and joint ventures. A number of computer-controlled and higher-end machine tools are exported by foreign firms such as EDMs, grinding machines, and machining centers. The export figure has risen swiftly compared to the past performance of one and a half decade. Export of machine tools rose from 31 to 328 and 787 million baht in 1986, 1988, and 1990 respectively. Nevertheless, the value of imported machine tools was about 15 times higher than the exported ones. The figure rose from 1,805 to 5,757 and

11,364 million baht in 1986, 1988, and 1990 respectively. The average annual growth rate was about 58.4 percent which was twice of the growth rate between 1981-1985.

It is very interesting to note that although the development of the machine tool industry in Thailand is as long as other import-substitution industries such as textiles, automobiles and electronics, it constitutes a number of paradoxical phenomena. First, whilst other industries have grown immensely over the last two decades, this was not true for the machine tool industry. Second, although demands for machine tools in Thailand have soared sharply for over 20 years, the local production has hardly expanded. Third, although the industry has been protected for a long time, the number of local manufacturers, production capacities, and product ranges have shrunk over the years. Reasons are both economic conditions and technological environments.

The following two sections aim to shed some light on the causes and effects of the industry's techno-economic factors. The economic analysis of the industry will address the issues of demand conditions, supply conditions, market structures and firm strategies, and supporting industries. The technological analysis will focus upon production processes, technological contents, technological capabilities, and technological embodiments of the industry.

4.2.2 Economic Analysis

Demand conditions

As discussed in the previous section, it is very interesting to examine the paradoxical phenomena of the machine tool industry in Thailand which has had high demands and been highly protected for almost 20 years but has remained weak both in terms of economic and technological contributions. As revealed, the demand for machine tools in Thailand has, in fact, increased in an accelerating manner. Based upon the import figure (since local production was minimal), the demand for machine tools grew up from 132 to 791, 2,177 and 11,364 million baht in 1970, 1980, 1985 and 1990 respectively (Table 4.5). However, this high demand did not give rise to a healthier industry because the rate and direction of the industry's development could not keep pace with

the changing demand conditions. Reasons are threefold. First is the absence of a captive market during the import-substitution period. Second is the swift change in demand conditions from conventional and low-end to computer-controlled and high-end machine tools during the period of export promotion. Third is the promotion privileges which in effect went against the use of local machine tools.

The absence of a captive market during the period of import-substitution policy in the 1960s made a slow start for the industry. Lacks of investment incentives and captive markets clearly induced no transfer of foreign production to Thailand (in the form of joint ventures as in other industries) when the market is small and investment is large. Relatedly, this also did not create manufacturing infrastructure and induce competition in the local market. The commencement of machine tool manufacturing by local firms in the 1970s occurred in an un-organized manner. In other words, it was, by and large, a gradual expansion of many individual firms, undertaking maintenance work for production mills, in order to take advantages of their manufacturing equipment and skills. They rather built simple and general machine tools, imitated from foreign ones, in a small quantity and on an order-by-order basis. Consequently, this did not build up a strong production base as in other industries such as textiles, automobiles, and electronics.

Relatedly, when the demand swiftly changed in 1980s toward more sophisticated and specific machine tools needed in large quantity and at competitive price, the Thai machine tool makers had no ability to respond. In fact, when Thai firms started their businesses with a market condition which required conventional and low-end machine tools in 1970s, they served the market very well. However, when the demand conditions changed rapidly from the conventional and low-end to computer-controlled and high-end machine tools owing to the changing industrial policy and hence production structures, they could not catch up. One of the reason is that as the machine tools locally produced were initially sold to the repairing shops for agricultural machinery and production mills and to local manufacturers producing low-end products, the machine buyers did not require high precision and accuracy. They tended to require high loading capacity and cheap price. This did not build up the production base (equipment and general skills) to cope with the new demand for sophisticated and specific machine tools equipped with computer-controlled units, leaving aside the technological base (specific know-how and skills) to

create them. Further, as this new demand took place abruptly during the second half of 1980s, it has been largely fulfilled by the rapid increase of machine tools imported from Taiwan and Japan.

In addition to the absence of a captive market and the swift change in the demand condition, investment promotion incentives has also caused a slow progress of the machine tool industry in Thailand. Most of the firms creating high demands for high-end machine tools in 1980s have been largely export-oriented firms receiving promotion privileges which allowed them to import machine tools without taxes. Therefore, some types of machine tools, in particular, simple and low-end machine tools which can be produced locally are surely not in demand. This has driven out a number of Thai firms.

In contrast, foreign machine tool makers, using Thailand as an export base in the second half of the 1980s owing to the losing of comparative advantages for production of low and medium-end machine tools in their homelands, perform fairly well. In fact, this is a relocation of production plants outside their countries. The same production components (production and technological bases) are employed to meet the stringent requirements of their main export markets such as Japan, USA, and some European countries. Their customers are largely scale-intensive manufacturers who require precision, numeric-controlled, and accuracy-repeatable machine tools. They came to Thailand with a well-organized production to meet the demand requirements in the world market.

Supply conditions

Supply conditions, such as government policy and support, the availability of technical skills and services, and factor prices, are another crucial factor seen which hampers the development of the machine tool industry. As mentioned earlier, government has played little role in promoting the industry both in the import-substitution and export-promotion periods. Thus, production infrastructure to support the development of the machine tool industry in Thailand has been weak. The lacks of technical manpower in metallurgical and mechanical fields and of testing, designing, and training services are the main bottlenecks. In this respect, cheap unskilled-labor and low overhead costs do not present significant benefit to local firms having no technological bases. Such lacking of strong technological bases therefore

impedes the growth of the industry.

Unlike textiles, automobiles, and electronics, the machine tool industry has, hitherto, received neither specific support based upon government policy during the period of import substitution nor export promotion. The only one measure exerted by the government over the two decades related to this industry is tariff protection. However, it is worthy to note that the protection raised during the early 1980s was, in fact, not resulted from a deliberate government policy to promote the industry but purely a side effect of the tariff protection measure. Further, it seems ineffective to create industrial development as well. Therefore, it is not surprising to understand why government support in building up production infrastructure has been very superficial.

Technical manpower, which is the main production infrastructure and needs more support from the government owing to its market-failure characteristics, has received no specific treatment so far. The most critical and severe shortage of technical manpower is in the metallurgical field. The total production of metallurgical engineers in Thailand is less than 20 graduates a year. This is less than 1 percent of the total engineering graduates and 0.04 percent of the total university graduates. No metallurgical course is offered at the vocational level. Engineering graduates in mechanical fields are also low. The total production is only 600 graduates a year, which is about 16.2 and 1.2 percent of the total engineering and university graduates. Other related engineering graduate production such as electrical and electronics engineering is also not sufficient. Technical services including metallurgical testing, mechanical designing, and post-employment training services, are at present, in the initial stage. These services are all crucial supporting services needed to be established at the very early stage of industrial development.

Without investment incentives, large markets, strong production know-how, and good production infrastructure, cheap factor prices alone do not help much in the development of the machine tool industry. Compared with foreign machine tool makers, having strong production know-how, good supporting infrastructure, but facing high production costs in their countries, one can anticipate that their subsidiaries in Thailand would be geared up to manufacture higher value-added products and employ more labor-saving tech-

nologies compared to Thai firms. This is because they have another set of factor prices such as cheaper labor and overhead costs compared to their parent companies, and cheaper machinery and equipment and lower costs or constraints on capital investment compared to Thai firms. Of course, the levels of value added and production technology are largely lower than their parent companies since they tend to produce only older models which are not competitive to manufacture in the rising production cost countries such as Japan and Taiwan.

Market structure and firm's strategies

Apart from demand and supply conditions, the slow progress of the machine tool industry in Thailand is exacerbated by market structure and firm strategy and rivalry. The market structure of the machine tool industry in Thailand is neither a truly monopolistic nor monopsonistic market. However, it seems to be closer to a monopolistic competition when there are a number of suppliers producing some differentiated products for a few buyers. In addition, passive strategy adopted by most production firms lead to slow development. Thai machine tool firms tend to see themselves specific to a particular market of product. Little effort has been made to explore and diversify themselves into other potential and related products. Consequently, there exist segmented markets which introduce little competition.

In fact, the segmented market structure of user-producer relationship tends to yield productive results for both parties by supporting one another both in terms of production and technology. However, in the case of Thailand's machine tool industry, this relationship exists only when both parties are weak, hence the ability to support one another. The relationship is broken when users demand sophisticated machine tools which producers cannot supply. The market structure of the machine tool industry has created little competition and development so far. In particular, during the early period of development when the market is small, there is little competition and development. Each machine tool firm seems to work for and preserve its own niches based upon production order specific to customer firms. There is neither a price war nor product initiation. The present competition and development in the machine tool market is surely the competition among the sellers of imported machine tools, not the producers of locally produced machine tools.

Firm strategy also plays a large part in the stagnant and perhaps declining status of the machine tool industry. Among Thai firms, market strategy tends to be inward-looking, technical strategy tends to be imitative, and production strategy tend to be based on short-run objectives. Thus, products and production processes are mainly to serve the local market without long-term development and R&D support. In addition, the overall strategy tends to be passive and static. Hence, changes in production structures are rather slow compared to changes in environments such as changing demands, technologies, production costs, and supporting services. This obviously leads them to lag behind their foreign counterparts including joint ventures.

With regard to foreign firms which are newly established in Thailand, their market strategy is outward-looking, technical strategy is defensive, and production strategy is long-term development. Based upon the unfavorable production factors for the middle-end machine tools at home, their strategy clearly aims to manufacture competitive products sold in the world market based upon cheap labor and overhead costs in Thailand. Further, foreign subsidiaries have strong supports from their parent companies which is an important advantage over Thai firms. These include supports of necessary parts and components, established management practices, and more importantly, production know-hows and markets. This enables foreign subsidiaries to overcome the setting up turbulence in the short run and establish firmly in the longer run.

Supporting industries

Another fundamental factor retarding the development of the machine tool industry in Thailand is the availability of supporting industries. These are, for instance, high-quality casting, forging, machining, and heat treatment. It is worth noting that although the capability of supporting firms in the afore-mentioned metal-working areas has improved a great deal recently, there are only a few capable firms. Equally important, there is no firm in Thailand capable of supporting electronic control devices for machine tools.

In this respect, Thai firms are, de facto, constrained by limited technical sources and part supplies. Thai firms are, firstly, limited by the availability of quality metal-working parts such as casting, machining,

forging, and heat treatment parts. These parts are fairly different from parts for general production machinery. They require more metallurgical knowledge and skills to produce precise and robust parts resistant to continuous rubbing, dashing, shaking, and moving. The tolerance for individual parts is low. For instance, while standard machine tools require precision at the micron level, the very high-end machine tools require at the sub-micron level. General casting, machining, and heat treatment widely available in Thailand cannot meet this stringent requirement. Only recently, some casted parts for machine tools (and the subsequent metal-working processes such as machining and heat treatment) are available locally such as bases, saddles, and columns. However, there are merely a few firms capable of producing them. Further, there are a number of parts that cannot be produced locally, for instance, the moving and precision parts that for gears, axles, spindles, and leadscrews.

Equally importantly, local machine tool manufacturers are also constrained by the supply of electronic control devices. Eventhough some Thai firms try to upgrade their products by using imported control devices for their NC or CNC versions, they encounter insurmountable difficulties relating to the requirement for a huge ordered volume and/or an excessively high price. In addition, they lack installation know-how to effectively make use of those imported parts in order to compete with other machine makers.

Of course, weak supporting industries clearly hamper the development of local machine tool makers, and to some extent foreign subsidiaries. However, foreign subsidiaries are strongly supported by their parent companies in terms of production technology and high quality parts and components at competitive prices. They are equipped with both technical know-how to overcome some production bottlenecks and supply of necessary parts and components which cannot be produced in Thailand. This is the main reason enabling foreign subsidiaries to offer wider ranges of products and levels of sophistication.

4.2.3 Technological Analysis[6]

Product ranges

Among Thai firms, product ranges are rather narrow and conventional. They are, for instance, conventional lathes and presses, and powered hack saws without numeric or electronic control. Most of the firms manufacture only one product type with a few versions offered. Nevertheless, changes in versions are very minor and time-consuming (average 3 years) and are not much technically different. Differences in size and loading capacity are normally the main feature of changes in new versions.

M1 is a classic case which manufactures conventional lathes for over 20 years. Within this period, only 8 models are offered. All of which are manually controlled and mainly different in the saddle length. Mechanical improvements are minor such as changes in turning speed, column-gear location, and oiling system. No NC and CNC lathes and machining centers are in the future pipe line.

M2 is also very similar to M1 with regard to press machines. M2 has been in the industry more than 20 years. Main product is conventional press machines powered by motor through connecting rods. Differences in models are machines' power ratings, ranging from 1 to 50 tons. Other differences between versions are, for example, control-panel location and axle-connecting rod coordination. Attempt to produce pneumatic press machines has just started. No consideration for hydraulic machines, in particular big machines over 100 tons, is known as yet.

In contrast, wholly Japanese and Taiwanese owned firms (and to some extent joint-venture firms) offer a wide range of precision and computer-controlled products. These include grinding machines, CNC milling machines, machining centers, EDMs, wire-cut EDMs, and shaping machines. Also, models with some changes in functions and features are regularly introduced (average one a year). Nevertheless, products manufactured in Thailand are largely old versions of their parent companies.

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[6] Refer to Appendix II for the method and the results of surveyed firms' technological content and technological capability assessment.

M3 is a subsidiary of a large machine tool manufacturer in Japan. It was established in 1988. Main products are EDMs including wire cut EDMs. Differences in models can be divided into two main parts: mechanical operation and computer control. High-end versions are designed to produce quality work; of which, mechanical functions are electronically controlled. This not only provides precision work but also information back and forth between CAD and CAM. Low-end versions are limited in additional functions such as information feedback system and performance report.

M4 is a subsidiary of a well established machine tool firm in Taiwan. Its operation started last year. At present, it manufactures only one product type, vertical machining centers, which have only one version. However, additional products being planned for production next year are vertical and horizontal milling machines and CNC milling machines.

Production processes

Production processes of the machine tool firms in Thailand are largely confined to the assembling and manufacturing processes. Designing process virtually rests on parent company in the case of foreign subsidiaries. Thai firms largely carry out all production processes in-house ranging from designing to manufacturing and assembling processes.

M1's production process for conventional lathes is typical of local machine tool builders. It covers all processes ranging from designing to manufacturing and assembling processes. With regard to designing processes, all drawing, patterning, and specification defining are carried out in-house. Processing processes such as casting and heat treatment are undertaken outside. The manufacturing process which covers all machining processes such as shaping, milling, drilling, and grinding is also carried out internally. However, the testing process in the final assembling process tend to be absent or not well-tested.

The production process at M4 is also a good example of foreign machine tool producers in Thailand. That is to say, its main production process is to assemble final products for export. Thus, assembling and testing processes are the major concerns. Parts, machined in-house, tend to be only those which cannot be imported or subcontracted. Nevertheless, the

manufacturing process is only limited to some activities necessary to final assembly such as shaping, milling, and drilling. Processing processes such as casting and heat treatment are undertaken outside. Designing processes do not exist since the firm relies upon parent's company designs (product's specification defining, drawing, and patterning).

Technological capabilities

With regard to technological capability of machine tool producers in Thailand, foreign subsidiaries and Thai firms are not much different in terms of types but levels of capability. First of all, both of them have no innovative capability as does adaptive one. Next, acquisitive capabilities (searching, assessing, negotiating, and installing capabilities) are different in terms of technological sources, not abilities. Both acquire information and imitate products of foreign firms. However, one is of itself (parent company); the other is of various other general makers. The major difference is the operative capability. While foreign subsidiaries possess ability to operate, control, and maintain high production efficiency and product quality, Thai firms are less capable.

M2 is a Thai firm manufacturing press machines over two decades. Although it has in-house designing activities (drawing, patterning, and specification defining), it possesses neither design and product-specific technologies nor adaptive and innovative capabilities. Also, acquisitive capability is very minimal. It does not pay much attention for information searching and assessing. That is to say, its designing activity is almost an imitation of a foreign machine. Without any R&D activity, this type of adaptive capability (ability to absorb, digest, and command) surely cannot generate in-house design technology (knowledge and procedures to translate ideas into prototypes) and product-specific technology (specific knowledge and know-how determining the critical functions and features) of such a machine. This leads to the absence of adaptive capability (ability to ratify, improve, and enhance) and innovative capability (ability to develop, research, and invent).

In addition, M2's operative capability (ability to operate, control, and maintain) is based upon years of experience in the production line. There is a dearth of training in the company. What does exist is, in

fact, on-the-job doing, not training. Therefore, the defective rate is as high as 20 percent. The way of operation with such a high defective rate becomes common and is not controllable nor reducible at present. Despite having some CNC machines (second-hand milling machines and machining centers), they are improperly used and not well maintained. This leads to low production efficiency and unrepeatable product quality.

M3, a Japanese EDM maker, concentrates on the assembling (assembling and testing) process and to some extent manufacturing (machining) process. Therefore, it leaves the design and product-specific technologies to its parent company, and hence it possesses little adaptive and innovative capabilities. This also holds true for acquisitive capability.

However, with strong process technology (equipment and know-how for production) and good training, its operative capability seems very efficient. All machinery and equipment (both new and second-hand) are equipped with user manuals and operation instructions. Operators must obtain at least two-month on-the-job training. The training content not only covers operation but also control and maintenance. Therefore total defect rate (including machining, assembling and testing) declined from about 10 to 6 percent within the first year of operation. Product quality is assured through precision production equipment and tools including precision jigs and measuring instruments. For example, the precision for the spindle column is less than 10 microns and the surface roughness for all the parts in the column is less than 10 microns. In addition, maintenance is based on the firm's scheduled maintenance program.

Technological contents

Foreign (including joint-venture) and Thai firms not only differ in terms of product ranges and production processes but also technological contents. While technological contents of the former are strong in process technology (efficient machinery and equipment and strong production know-how) and to some extent product-specific technology, technological contents of the latter are scattered among process technology, product-specific technology and design technology. However, both of them are weak in production-management technology (engineering and management techniques to support production processes) due to the fact that machine tools are produced on a piece by piece

basis rather than in large quantity, although foreign and joint-venture firms are somewhat better.

M5 could be a representative of the Thai machine tool makers. Firstly, its process technology is not advanced. Machinery and equipment tend to be locally-made equipment or second-hand equipment from Japan or Taiwan (some are as old as 20 years). Tools (such as jigs and measuring equipment) are not much used or strictly or correctly used. Production know-how largely stems from years of experience in the production line. Secondly, even though M5, owning a patent of powered hack saws, gains a lot of benefit from its own product-specific technology in the production process, this is a rather exceptional case. Other Thai firms generally do not possess specific knowledge and know-how of the crucial functions and features of the product they produce. This is because they generally manufacture a product by imitation and reverse engineering.

However, apart from the aforementioned technological contents, M5 is very similar to other Thai firms. In other words, production technology such as engineering and management techniques to improve production efficiency and product quality are neglected. Design technology is also weak. Thai firms, in general, lack of industrial design equipment and basic metallurgical knowledge.

M6 is another typical foreign owned firm located in Thailand. Production machinery and equipment are imported from parent company. Taiwanese firms (including their joint ventures) tend to use more second-hand equipment than Japanese ones. Production know-how (e.g. working sequences, critical manufacturing points, and problem solving procedures) is also transferred from its parent company. M6 is generally strong in process technology in order to support their production processes (manufacturing and assembling processes). Production-management technology has clearly not been practiced. This is similar to other foreign subsidiaries that they are newly established and still overwhelmed with production trouble-shooting problems. Product-specific technology is transferred from parent company. However, it is only for production, not for product design. The designing process and thereby design technology is entirely left to its parent company.

Technological embodiments

Not only are Thai firms inferior to foreign subsidiaries in terms of technological activities and levels but also factors. Thai firms tend to be weak in all technological factors: machinery, manpower, information, and organization. Firstly, equipment-embodied facilities such as production machinery, equipment, and tools are rather simple and manually controlled. In addition, they are largely second-hand or locally-made. Secondly, human-embodied abilities such as experience, skill, and knowledge are not widely distributed within firms. They tend to be personally embodied. Merely the owner or few persons within the firms get transferred with these abilities. Thirdly, document-embodied information is scarce among Thai firms. This is partly because of no effort being paid to searching, processing, and documenting, and partly because of management and production being based upon believes and experiences. Lastly, organizational-embodied framework is also weak since decision-making, trouble-shooting, reporting, and rewarding processes tend to be undertaken by individual persons.

With regard to foreign subsidiaries, they are, in fact, a divided part of a well-established firm. Thus, a large part of the parent firm's technological factors are inherited, in particular organization and information. Machinery and manpower are to some extent transferred to affiliates in Thailand as well. Of course, as the affiliates in Thailand are newly established entities, foreign subsidiaries have to accumulate their own technological factors too.

Equipment-embodied facilities at M1 (e.g. planing, shaping, milling, turning, and drilling machines, and designing and testing equipment) are all manually operated. Although some machines are equipped with numeric control functions, these are very trivial. Human-embodied abilities in the firm are not technically high. They are mainly based upon experience and skills, not knowledge. In other words, they are able to imitate, but not to adapt. Any improvement in products or production processes largely stems from years of practices. Document-embodied information is not recognized as important. There is no action to accumulate and distribute nor to use. Organizational-embodied framework is also not well structured since the firm's operation is based upon one-man decision. Rules and procedures are created to cope with immediate problems only.

M4's equipment-embodied facilities are rebuilt machinery and equipment transferred from its parent company in Taiwan. There are, at present, three main machines (shaping, milling, and drilling) to serve some machining functions only. Other parts are imported from Taiwan and elsewhere. Human-embodied abilities initially come from Taiwanese engineers and technicians from the parent company. Nevertheless, this is gradually reduced as the firm starts building its own local personnel. M4 adopts the same manufacturing practices (working attitudes, norms, procedures, and rules) as its parent company. In fact, it employs exactly the same organizational-embodied framework of the parent company in Taiwan. This also holds true for document-embodied information.

4.2.4 Problems and Policy Issues

As discussed, the machine tool industry in Thailand marked at least three paradoxes, compared with other industries such as automobiles, electronics, and shoes. First, although it has been established for more than 20 years, its production made very little progress. While value-added generated by automobiles and electronics grew respectively from 850 and 490 million baht in 1970, to 2,800 and 1,940 million baht in 1980, and 9,500 and 5,870 million baht in 1990, the machine tool's value-added was only 18, 76, and 324 million baht in 1970, 1980, and 1990, respectively (Table 4.7). Even the shoe industry, its value-added generation surpassed the machine tool one.

Table 4.7 : Production Value-Added of the Automobile, Electronics, Shoe, and Machine Tool Industries (1972 price)

(Unit : Million Baht)

	1970	1975	1980	1985	1990
Automobiles	849.5	1,941.7	2,800.2	2,153.8	9,510.1
Electronics	490.2	813.0	1,937.3	2,488.0	5,867.9
Shoes	362.3	547.7	787.1	1,093.9	1,583.1
Machine Tools	18.3	46.4	76.4	173.8	324.4

Source : Compiled from NESDB

Second, although demand for machine tools has long been high, the industry has grown up very little. If one compares the value-added figure (representing production) with the import figure (representing demand), one can see that demand was far out-proportioned compared to production. For instance, while the value-added of the machine tool industry was 17, 113, and 781 million baht in 1970, 1980, and 1990, the import value of machine tools was 132, 791, and 11,364 million baht in the same period.

Third, although the machine tool industry has been highly protected, it has expanded very little both in terms of the number of firms and employment. Over decades of protection, the number of firms grew from 8 firms in 1973 to 30 firms in 1990 while employment rose from 150 to 2,400 persons in the same period. As a case in point, the total figure of employment of the industry in 1990 is lower than the employment of a single large electronic firm in Thailand.

Further, the machine tool industry in Thailand is presently composed of two different groups of machine makers, Thai and foreign firms. It is confident to say that if the demand conditions keep continue in this fashion and the supply conditions do not change, the Thai manufacturers will be out of the business sooner or later while the foreign ones will be firmly rooted.

The underlying problems are clearly the technological problems, not economic ones. This could be seen from the slow changing product line of the Thai machine tool makers. In particular, during the 1980s when the demand for machine tools changed rapidly from conventional and simple machine tools to the computer-controlled and sophisticated machine tools. Of course, this was because of the weak technological capability among Thai makers. To be precise, they have been weak in metallurgical knowledge and process technology, in addition to design capability. Without strong technological bases, production bases will, therefore, be definitely weak.

Therefore, the policy issues are basically related to the role of government. The policy of "tariff protection without technical support" in the past seems to end up with tragedy of local firms, leaving aside the recent trend of "no protection and no technology given".

4.3 THE ANALYSIS OF THE THAI MOLD & DIE INDUSTRY

4.3.1 Evolution of the Industry

Production of molds and dies in Thailand started from around 1960. The early group of producers evolved from machine shops in Satupradit and Rashtraburana areas in Bangkok. These producers gained the experiences from their services in repairing imported dies. The demand for dies increases in proportion to the expansion of user industries such as automotives, machinery parts, metal products and plastic products. Large users of dies often find it strategically important to have in-house supply of their own. Therefore another line of evolution of the industry is through the in-house production among large users.

Development of the die industry seems to be an incremental process. This pattern of development is due to several characteristic of the industry. A large segment of the market is served by small firms with low level of technological capability, so the market entry is relatively easy. Domestic development of the industry is enhanced by the user's needs for flexibility in which local suppliers can offer better than import. Imported dies can be gradually replaced by domestic supplies as the producers increase their technological, financial and managerial capabilities. The wide variations of the product properties divide the market into several segments which allow domestic firms to advance into higher market segments in steps.

The evolution of the die industry has been closely related to that of the automotive, electrical appliances and the plastic industries. In the automotive industry, the local content requirements necessitate the demand for dies in the making of several automotive parts. This demand is satisfied by three sources, namely import, in-house production by auto-assemblers and part makers, and by independent die producers. Production of automotive parts generates various types of dies including steel parts, aluminum parts, plastic parts and rubber parts. Dies used by this industry are of high quality since it requires high precision, durability for mass production and several parts have complex configurations. The electrical appliance industry is similar in nature to the automotive industry with regards to quality requirements. Plastic products industry covers a wide range of products and quality require-

ments. Export demand has played an important role in this industry. In the late 1980s, computer peripherals have emerged as an important export industry. This industry presents another important source of demand for precision dies.

Technological progress in the die industry has been induced by users' requirements. The die manufacturers have responded to the rapid increase of high quality die by upgrading the skills of workers, employing modern machinery such as machine centers and other NC machines and introducing computer aided design to save time and control quality. The brisk demand condition in the past few years has attracted many investment projects which aim at the upper segment of the market. Most of these projects involved Japanese joint-ventures. The expertise of Japanese partners is expected to contribute greatly to the technological development of this industry in Thailand. Information from the field survey and interviews of experts indicates that the local die industry has obtained significant transfer of technology from Japan. Hundreds of Thai engineers and workers have been sent for training in Japan and many Japanese experts have been expatriated to work with or to train Thai personnels.

4.3.2 Economic Analysis

Demand Conditions

There has not been any systematic compilation of the production and sale data of dies. A study by Chula Unisearch indicates that in 1989, domestic die production was estimated at 1,700 million baht [Chula Unisearch, 1990]. Foreign Trade Statistics shows that import and export of dies in the same year were 1,738 million baht and 171 million baht respectively. From these figures, we obtain the estimated domestic demand of about 3,267 million baht. In 1990, the import and export values of dies jumped to 3,069 million baht and 255 million baht respectively (Table 4.8). The value of domestic production is not known but can be expected to increase substantially as new capacity was added and all surveyed firms reported to have made full capacity utilization.

The rapid rise in the demand for dies in recent year was induced by rapid expansion of the user industries. For example, in the automotive industry, the demand for commercial vehicles increased from 53,102 units in

1986 to about 231,377 units in 1990, passenger car sales increased from 21,053 units to 73,768 units and motorcycle sales increased from 241,081 units to 715,115 units during the same period (Table 4.9). In export-oriented industries, export of plastic products rose phenomenally from 1,414 million baht to

Table 4.8 : Foreign Trade of Molds and Dies

(Million baht)

Year	Import	Export
1970	26.5	0.5
1975	53.0	1.7
1980	201.5	8.9
1985	377.1	42.8
1990	3,068.8	255.1

Source : Department of Customs

Table 4.9 : Production of Automotive Vehicles

(Units)

	1986	1987	1988	1989	1990
Passenger car	21,053	29,333	54,459	58,761	73,768
Commercial vehicle	53,102	68,815	99,724	154,775	231,377
Motorcycle	241,081	302,195	488,669	587,216	715,115

Source : Bank of Thailand

9,096 million baht between 1986 and 1990. Computer parts have become a large export industry in recent years. The rapid growth of this industry has increased the demand for dies significantly.

The volume growth of the die industry is also associated with its shift in product composition. The range of products has been more diversified and the proportion of more sophisticated, more accurate and higher quality products has risen. This trend is the response to changes in demand condi-

tions as the rapid growth in demand has concentrated in products that require stringent engineering specifications.

Most die factories are located in the Greater Bangkok area due to the high concentration of user industries in Bangkok.

Demand plays several important roles in the die industry. For certain types of dies, domestic production is not possible unless the market size justifies scale economies. Examples of this are such as front cover and door of passenger car, cathode ray tube and hard disk drive. Growth and stability of demand are important factors in any investment decision. Quality requirement dictates the direction of expansion of the industry with respect to technological capability development. Close communication between die producers and user industries has great influence on the spatial concentration of the industry. Despite various short-comings in the supply condition, the die industry has expanded rapidly in recent years due to the booming demand. The expansion is more apparent in the large firm group which is dominated by subsidiaries of large user companies and joint-venture firms in which the foreign counterparts have secured market with affiliated firms.

Supply Conditions

A recent survey by MIDI in 1990 [MIDI, 1990], shows that the majority of die factories (39 out of 60 surveyed firms) were medium sized with employees between 11 and 50. Six firms or 10% employed more than 50 workers and fifteen firms (35%) employed not more than 10 workers. It is suspected that this pattern of distribution was biased upward due to the sample selection procedure which is non-random. Anyway, a definite conclusion from this survey result is that there was a large proportion of medium and large producers in this industry.[7] The majority of the surveyed firms (nearly 60%) were older than 10 years which means that the industry had a large proportion of mature firms. The proportion of in-house production was also quite large as 77% of the surveyed firms were owned by user firms. Only 23% of the surveyed firms were independent vendor.

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[7] In general, a firm with not more than 50 workers is classified as small and a medium size firm referred to one which employs between 51 and 200 workers. This classification is not suitable for the die industry since in most countries, at least three-fourth of die factories employ not more than 20 workers.

The most serious short-coming of the supply conditions is concerning with manpower. There is a serious shortage of engineers, experienced technicians and skilled labor. Only 25% of the surveyed firms employed engineers and only 45% employed draftsman. Bearing in mind that these figures were probably biased upward by the sample selection, the actual situation is likely to be more serious than indicated by the surveyed data. Most small firms ignore the importance of drawings which results in product unreliability.

This problem has been fully realized by MIDI and the institute has attempted to solve it by an ongoing program of training for die makers. Many firms with foreign affiliates have been solving their own problem by sending workers for training abroad, mostly to Japan. A significant transfer of technology through this mechanism is expected.

For firms promoted by the Board of Investment (BOI), acquisition of efficient machinery poses no serious problem. These firms are generally well equipped with a complete or nearly complete range of machinery and equipment. Advanced machine tools such as machine center and wire cut EDM are common in promoted firms. Design equipment and high precision measuring instruments are generally available in these firms. Most of their machine tools come from Japan and Taiwan. Domestically produced machine tools such as hydraulic press are also used by many firms. Many firms also have some machine tools from western countries. In summary, promoted firms generally make appropriate selection of their machinery based on efficiency and cost considerations.

Acquisition of efficient machinery had posed considerable problem for non-promoted firms due to high import tariff. The problem has been eased to some extent by the revision of tariff rates for machinery in 1990.

Supporting Industries

Metal-working industries are supportive to each other. These industries include machining, casting, forging, heat treatment and electroplating. Steel casting provides raw materials for die making in addition to other imported steels. Heat treatment is needed to improve the properties of dies such as for surface hardening. Electroplating improves the smoothness

and the strength of die surface. Machining is the major process in die making. Metal-working industries tend to develop hand in hand. In recent years, there have been significant developments of all these industries in response to the booming demand. Major investments in this area not only increase the productive capacity in quantitative terms. Better output has been produced as a result of the acquisition of more advanced technologies.

There are more than 400 steel and grey iron casting factories in Thailand. Most of them are located in the Greater Bangkok area. A few are scattered in the Southern and the Northeastern provinces. More relevant to the die industry is steel casting which are all concentrated in and around Bangkok. High quality cast steels for die making can be produced by several firms. Some of these firms are able to compete internationally in the high end market. The domestic prices of high quality cast steel are relatively high due to the buoyant demand and limited number of suppliers. There is a good prospect for further expansion of the high quality cast steel industry. The major obstacle to this is the difficulty in acquiring technological capability.

There are various firms providing heat treatment service on a contractual basis. Some die factories perform heat treatment in-house. Heat treatment technology in Thailand is somewhat underdeveloped. Demanding users usually are dissatisfied with the quality of heat treatment. In may cases, however, the shortcoming was due to errors made by customers in that the properties of steel had been inaccurately specified.

Electroplating service is widely available. There are about 270 firms engaged in electroplating business. Most of them are small firms employing not more than 20 workers. Chromium, nickel, zinc and copper plantings are the most prevalent. Quality of plating is usually between low and intermediate. A few firms with good foundation in electroplating technology and active technological acquisition can offer good quality plating.

Market Structure and Firm's Strategies

Similar to most industries that contain various market segments, competition on a cost basis at the low end of the die market is very keen.

The high end segment of the die market is oligopolistic and competition is restricted by technological capabilities.

Vertical integration is quite common among large firms. These large firms may have a die section to meet their own needs or those of affiliated firms. In the latter case, they may supply solely to the parent firms or provide subcontracting service to other customers as well. Their services on a contractual basis may be binded with other downstream services such as in plastic injection. For vertically integrated firms, the major source of profit is usually in the downstream activities while die making is undertaken to control the quality of end products.

Most small firms are managed by owners who have low educational background and narrow technology perspective. Cost minimization is normally the only key strategy employed by these firms. Investment is kept at a minimum by employing cheap and old machinery. Workers are hired from those who have low formal eduction and no prior experience. Worker's skills are accumulated from learning by doing process. These firms generally stay at the low end of the market throughout the life of the firms.

Another type of firms is one in which owners are formerly engineers or technicians from large firms. These owners possess high educational level and sufficient technical as well as managerial experiences. This group of firms are mostly well organized and active in technological acquisition. Their strategy emphasize higher value added rather than lower cost. Therefore their products are concentrated in the medium and high end segments of the market.

Die making firms established by large user firms provide another interesting type. The parent firms are such as automobile assemblers and plastic injection firms. These firms are generally spin-off from the die sections of the parent firms. The establishment of these firms is least constrained by investment capital, technical know-how and manpower. Joint-venturing with foreign firms is quite common among these firms since it can facilitate in the acquiring of advanced technology from foreign partners. These firms are generally large and have high technological capability. Their products are concentrated in the high end market.

4.3.3 Technological Analysis[8]

Die manufacturers in Thailand may be broadly classified into 2 groups with respect to their technological capabilities. The first group consists of those firms supplying their products in the high end and middle market segments. In order to satisfy requirements of their users, these firms must possess a relatively high level of operative capability. Since competition on product differentiation is an important strategy in the high end market, the producers in this group need a constant pursuit of technological advancement. Therefore the high end die makers appear to be quite active in technological acquisition. The number of firms in this group, however, represents only a small fraction of the total number of producers. Most of them are joint-ventures and foreign subsidiaries.

The great majority of die producers are small firms typically with low technological capability. A typical firm in this group is run by an owner-manager. He and his entire workforce tend to have low education background which limit the firm's capability in technological absorption. Dies produced from this type of firms have low precision and durability.

Three firms in our surveyed sample are representative of firms in the first group. These firms are among the most advanced die producers in Thailand. Two of them had spun off from leading plastic injection companies. The other one is a leading firm in aluminum die casting. Dies from the first two firms are mostly used in the production of plastic parts of electrical products such as television, radio, electric fan and air conditioner. The last firm produces dies for its own use mostly in aluminum die casting of automotive parts. Dies made from these firms require relatively high precision and durability.

All of the three firms were established with strong supports from parent companies. The aluminum die casting firm belongs to the largest industrial conglomerate in Thailand. The two plastic mold companies are joint-ventures between Thai leading plastic injection firms and Japanese mold making firms. The three companies have well-organizational structures. Their

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[8] Refer to Appendix II for the method and the results of surveyed firms' technological content and technological capability assessment.

machinery and equipment are the most advanced in Thailand. Manpowers have good proportions of engineers and skilled technicians.

Design in each of these firms is carried out by a design staff consisting of engineers and draftsmen. Their design tasks are facilitated by software programs on computer aided design equipment. The shopfloor is well equipped with a full range of machinery such as machine center, EDM and wirecut EDM, NC milling machine, grinding machine and lathe. Most of these machinery are imported from Japan. Raw materials are properly selected and finished products are thoroughly tested.

The technological embodiments of these firms are rated at comparable to international standard level. A typical firm at this level is one which has suitable machinery and equipment capable of producing standard quality of dies, manpower must have good proportions of design engineers, draftsmen, skilled machine operators and supervisors, the firm must have wide access to technological information, its organizational structure and job description are well-defined and appropriate management techniques are employed. The three firms all meet these criteria.

Technological contents of the three firms are also rated at the international standard level. On design technology, they have good command in the design technology and utilize them efficiently in production and quality control. Their production technology closely follows the modern practice generally employed by internationally competitive firms.

Operative capability of a firm can be judged from its productivity, product quality and cost control. Other aspects may be added such as pollution control, safety and working conditions or plant's amenity. We are unable to closely monitor costing nor measure productivity of the firms. Since the market is relatively open and these firms are commercially quite successful, their productivity and cost control must be at satisfactory levels. The acceptance of the firms' products in the high end market indicates that their product quality is of high standards. Experience of workers is an important factor in die making. Although these firms are newly established, many of their workers have considerable experience in die making since they had previously worked for the parent companies.

The three firms acquire new technologies from various sources such as from joint-venture partners, visits to foreign plants, instructions and training from machine suppliers, publications from scientific institutions, technology licensing and recruitment of foreign experts. Off-the-job-training of workers includes training abroad with affiliated firms and training organized by various institutions.

Research and development are relatively rare in Thailand. The reasons for this include the scarcity of qualified manpower, the lack of facilities and supporting institutions and the lagging stage of technological development. These make it more practical to acquire new technology through a transfer mechanism than innovating one. Even leading firms in Thailand generally have low innovative capability.

Three other firms in our surveyed sample are representative of the second echelon of die manufacturers in Thailand. These firms have lower technological capability than the first group but higher than average Thai firms. The founders of the three firms formerly were chief technicians of large companies in related business. The first firm is fully dedicated to die making. It produces various metal dies and plastic molds. Its products are sold to general customers. The second firm's main activity is in steel forging. Die making in this firm is to support its main activity. The last firm has quite diversified activities including production of rubber parts for automobile, roofing materials, machinery parts and metal products. Die making in this firm is mainly for rubber molding. Among the three firms, the first one appears to have higher capability in die making than the others while the last firm is the least capable among the three. The difference among them is chiefly due to different levels of specialization. All the three owners are highly capable technicians turned businessmen and still technically competent.

Each of the three firms has a small number of engineer (1 or 2) and its workforce consists of those having vocational level of education or lower. All of them have design capability which is one of the main distinctions from average Thai firms. Their design capability is lower than firms in the first group with respect to human resources as well as design equipment. The machinery and equipment in these firms are less advanced than the first group but better than average Thai firms. The market they serve is between medium and high end segments.

Our surveyed sample does not cover average Thai firms since the characteristics of these firms can be inferred from various studies. These firms are typically operated as a family business. Low educational background of the entire technical personnels (not higher than primary school level) limits their capability in technological acquisition and absorption. Their machinery are typically old and not well-maintained. Design capability is almost completely absent. Job instruction consists of verbal, samples and sketches since they lack the ability to draft and read drawings. Their products reliability is low with respect to precision and durability. Timing of delivery is not punctual due to unorganized management system. Their products are sold to customers who pay more attention to price than quality and reliability.

4.3.4 Key Issues and Problems

The development pattern of the die industry appears to have followed a relatively smooth path. The demand and supply conditions are as to be expected for the stage of economic development of the country. However, Thailand has reached a turning point as the country approaches the phase of a newly industrialized economy. At this stage, technological capabilities of industries will be increasingly crucial to accommodate the shifting pattern of competitive advantage of the nation. Since the 1970 decade, Taiwan and South Korea have rapidly shifted their production and export structures from labor intensive industries into more technology intensive industries. Their parallel successes in rapid economic growth and technological advance have been greatly promoted by the governments. The key difference between Thailand and the two countries is that the Thai government has paid relatively low priority to technological development promotion as evident from low budget allocation and activities in this area. The governments of Taiwan and South Korea have been very active in all areas of technological promotion including education, research and development, fiscal and financial incentives for private sector's development of technology and a vast system of technological supporting infrastructures.

The lack of technological promotion effort has resulted in shortage of technical manpower especially in various engineering fields. At present, shortage of engineers and skilled workers is a very acute problem for Thai industries including the die industry. The capacity for expansion of

universities to produce more engineering graduates is severely constrained by unattractive remunerations to engineering professors. The current braindrain to private sector among engineering civil servants including university lecturers is pervasive and it further limits the development of technical supporting agencies.

The key strategy for development, not only confined to the die industry but for a transition of the economy in general, is in human resource development. Among priority areas are the engineering and technical educations. Supporting measures for the near future should include greater allocations of government resources to promote technological development such as in manpower training, technical assistances to small and medium industries and fiscal incentives to private sector's development efforts. Above all, the functioning of market force is the most important factor in guiding both economic and technological developments. Liberal foreign trade policy and promotion of domestic competition should be advocated as the basic principle in development strategy.

CHAPTER 5: ANALYSIS OF THE THAI INFORMATION EQUIPMENT INDUSTRY

As with the preceding Chapter Four, this chapter will deal with the information equipment industry in Thailand starting with an overview of the electronics industry, followed next by a detailed analysis in turn of the telecommunications equipment and the computer and peripherals industry, and finally by a discussion of the major problems and policy issues of considerable concerns for the Thai information equipment industry.

5.1 AN OVERVIEW OF THE ELECTRONICS INDUSTRY IN THAILAND

The electronic industry can be classified into three main groups: consumer electronics, industrial electronics, and parts and components. In Thailand, consumer electronic products include radios, televisions sets, cassette tape recorders, and stereo sets; radios and televisions are the major production items. Industrial electronic products include telecommunications equipment (telephones, radio transceivers), personal computers and their peripherals (keyboards, printers, and disk drives). In the parts and components group, integrated circuits, ball bearings, printed circuit boards (PCBs) and assemblies (PCBAs), capacitors, and radio and television parts are the major products.

A detailed product-tree classification of the electrical/electronics products by NIRA into components, computers, telecommunications, measuring equipments, and consumer products can be found in Appendix IV. It can be seen therefore that the range of electronics goods produced in Thailand is rather shallow at present.

The Thai electronics industry began with the assembly of radios in the early 1960s, when a Thai-owned firm was established under the Board of Investment's (BOI) promotion program to produce for the domestic market under the government's import-substitution policy. The industry expanded in the late 1960s, mainly because of a large increase in the number of Japanese-Thai joint ventures. Foreign investment was induced by the protected local market under the high tariff barriers of the period. This import-substitution period during 1960-1970 was noted for the high growth in the consumer electronics

product industry taking advantage of the rapid demand created partly by the government promotion of radio and TV broadcasting stations.

In the early 1970s when the government's trade and industrialization policy became export oriented, a couple of multinational enterprises from the United States set up operations in Thailand to assemble integrated circuits (IC) solely for export. The early export-promotion drive during this decade had not been met with great success. Apart from a handful of IC manufacturers from the U.S., investment in the electronics industry was rather low during this period. The growth was due largely to the high volume production of ICs for export.

More significantly, there was practically no accompanying development of the subcontracting and supporting industries for both the consumer electronics and the IC industries, except for a couple of consumer electronics assembling firms who starting manufacturing some components and parts for their own consumptions [FIAS, 1991]. Thus practically all the parts and components for products assembled for export were imported. The situation has not changed significantly even to this day.

Then in early 1980s, government policy had renewed the drive for export promotion, in particular for high growth industry like electronics. The first half of the decade saw not only a number of major electronics firms moving into Thailand, like the Minebea group and Fujikura from Japan, Seagate Technology and AT&T from the U.S., but also a couple of local Thai establishments setting up plants to package IC and manufacture PCBs for export. As Table 5.1 shows, foreign direct investment meanwhile continued to dominate the industry and the projects that were approved by the BOI during the first half of the decade alone (45 projects worth some 19 billion baht) exceeded the total investment of the previous two decades (23 projects worth about 4 billion baht).

Table 5.1: Investment and Employment of Electronics Industry under BOI's Promotion

	Approved Projects			Operated Projects		
Year	No. of records	Investment (Baht mn.)	Employment (persons)	No. of records	Investment (Baht mn.)	Employment (persons)
62	1	3	510	0	0	0
63	0	0	0	0	0	0
64	0	0	0	1	3	510
65	0	0	0	0	0	0
66	1	23	98	0	0	0
67	0	0	0	0	0	0
68	2	659	1,435	1	39	169
69	1	469	1,154	1	469	1,154
70	0	0	0	1	620	1,266
71	1	314	450	2	337	548
72	0	0	0	0	0	0
73	4	1,361	4,933	1	12,280	4,091
74	2	345	3,048	3	428	3,423
75	1	38	338	2	75	701
76	1	4	15	1	14	104
77	1	11	115	2	16	130
78	3	79	1,046	1	7	104
79	1	13	21	0	0	0
80	4	544	1,289	6	595	1,648
81	3	1,941	2,674	1	4	19
82	2	343	294	3	542	2,205
83	4	2,500	512	3	330	340
84	18	10,375	16,084	5	4,369	3,780
85	18	3,377	10,213	12	6,240	11,107
86	13	2,095	3,354	4	736	1,533
87	53	13,636	28,624	15	4,322	5,135
88	161	42,471	53,880	28	9,707	9,459
89	145	23,590	53,401	86	11,415	19,363
90	109	34,832	33,208	21	8,360	5,890
SUM	549	139,059	216,885	200	60,905	72,598

Source : Compiled from BOI

From then on investment in this industry grew rapidly and production diversified to include a wide variety of products, ranging from consumer and industrial electronic products for the domestic market to electronic components and computer peripherals for export. This growth in production and investment was particularly rapid after the mid-1980s when large amounts of direct foreign capital was invested in Thailand from many sources, mainly from Japan, the U.S., and Asian NICs.

The phenomenal growth of the electronics industry in Thailand during the mid to late 1980s was largely brought about by the realignment of world exchange rates, particularly the appreciation of the Japanese yen and Taiwanese dollar. It led to a major relocation of labor-intensive assembly type of production such as in many electronics products from Japan, Taiwan, and the Asian NICs to cheaper labor force countries. Investment in Thailand's electronics industry rose rapidly and steadily.

During the five year period from 1986 to 1990, the number of approved projects in electronics, compared with that during the previous 25 years, jumped by tenfold. During the same periods, the number of operational projects likewise increased three times. Of these, about 70 percent involved investment from Japan, 18 percent from the Asian NICs: and 10 percent from the U.S. The share of both promoted and non-promoted Asian NIC investment has increased at a particularly rapid rate in recent years (Table 5.2).

Table 5.2: Net Inflow Direct Foreign Invesment of Electrical Machinery Industry by Country

(Unit : Percent)

COUNTRY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
JAPAN	6.39	9.45	13.24	6.97	61.29	41.88	51.86	72.74	74.45	67.69
SINGAPORE	na	0.13	na	0.10	0.36	6.07	41.91	10.26	9.71	4.47
HONG KONG	45.57	4.41	4.02	12.10	4.76	2.57	0.16	0.15	6.33	4.27
USA	45.21	85.53	77.88	66.38	32.26	61.80	4.66	10.05	5.03	13.55
TAIWAN	na	0.43	na	0.03	na	na	0.34	5.68	2.40	7.83
KOREA. REP	0.83	0.14	na	1.46	na	na	na	0.09	1.36	0.22
WEST GERMANY	0.92	0.06	0.67	0.10	0.05	na	0.49	-0.11	0.20	0.61
UNITED KINGDOM	na	na	na	0.33	0.60	0.18	0.05	na	0.20	0.66
BELGIUM	na	na	na	6.41	na	-5.36	na	0.18	0.19	0.04
AUSTRALIA	na	0.10	0.13	na	0.11	na	0.05	0.26	0.13	0.10
SWITZERLAND	na	na	0.22	0.21	0.04	0.18	0.49	na	na	na
SWEDEN	na	na	0.37	0.00	0.00	0.89	na	0.04	na	na
NETHERLAND	1.09	na	3.45	5.92	0.51	-8.21	na	0.68	na	0.56
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
(mill.Baht)	447.90	623.40	666.80	390.20	960.00	280.10	616.50	1,136.50	6,309.30	8,863.90

Source : Bank of Thailand

These foreign investment concentrated on producing for export a wide range of products such as microwave ovens, VCRs, floppy disk drives, hard disk drives, printers, keyboards, telephones, public exchanges, modems, and a range of parts and components (electronics and non-electronics ones). Most interestingly, a number of large foreign and small Thai firms set up business during the same period to provide some degree of subcontracting for metal, plastic and other electrical/electronics parts.

The development of the electronics industry during the 1980s, particularly the second half, has resulted in a number of interesting changes within the Thai industrial and economic structures to be described below.

Towards a Leading Industrial Sector

The growth rates and changes in product composition of the electronics industry are shown in Table 5.3. According to the TSIC codes (Thai Standard Industrial Classification), electronics products are principally categorized

Table 5.3: Shares of Electronics Value-Added by Industry Group[1]

(Unit : Percent)

TSIC	Industrial Group	1970	1975	1980	1985	1990	Growth[2]
	Electronics Industry	0.08	0.41	1.06	1.59	3.78	27.5
35250	Office and Computing machinery	0.01	0.03	0.02	0.12	1.53	34.8
38320	Radio, TV and Communication equipment (incl. parts & components)	0.07	0.38	1.04	1.47	2.25	23.3
382	Machinery	3.12	3.03	2.63	2.50	3.34	11.4
383	Electrical machinery	1.88	1.83	2.42	2.65	3.40	12.4
3	Total Manufacturing	100.00	100.00	100.00	100.00	100.00	
	Total Manufacturing Value-Added (Million Baht)	23,937.2	58,128.7	142,873.8	231,972.3	557,493.0	9.3

Notes : (1) Share calculated from GDP data (at current prices)
(2) Compound annual growth rate between 1970-1990 calculated based on constant 1972 prices

Sources : NESDB

under the machinery industry (TSIC 382) for office and computing machinery and related products, and the electrical machinery industry (TSIC 383) for consumer electronics, telecommunications equipments and electronics parts and components. The industry's average growth rate for 1970 to 1990 was 27.5 percent, well above the 9.3 percent a year for the total manufacturing sector. The share of this sector in total manufacturing production also increased from a negligible 0.08 percent in 1970 to 1.06 percent and 3.8 percent in 1980 and 1990, respectively.

Among the many subsectors of the electrical machinery industry, the electronics subsector is the largest and has the highest growth rates. This subsector's production share has also increased rapidly since the early 1970s. Electronics production accounted for 43 percent in total electrical machinery production in the late 1970s, and increased steadily to 66 percent in the late 1980s. Likewise, the position of electronics production under the office and computing machinery group within the machinery industry has grown dramatically from an insignificant position prior to the mid 1980s to about 45 percent of either the total machinery or the electrical machinery production in 1990 (see Table 5.3). The electronics industry was indeed one of the fastest growing in the manufacturing sector with an average annual growth of 27.5 percent from 1970 to 1990. In fact, it is about double the rate of growth for the whole electrical machinery industry (12.4 percent), three times that of total manufacturing sector (9.3 percent), and four times the growth rate of real GDP (7.1 percent).

Like most manufactured products, the electronics exports started in the early 1970s. It's share of the country's total exports increased from 0.02 to 0.9, 5.1, 7.3 and 17.7 percent in 1970, 1975, 1980, 1985 and 1990 respectively (Table 5.4). The corresponding export value of electronics products rose from 3 to 447, 6,661, 14,194 and 104,521 million baht to become one of the top few export items of the country.

From Consumers to Integrated Circuits and an Emerging Industrial Electronics Sector.

The Thai electronics industry began in the early 1960s as an import-substitution industry, producing various consumer electronic products (mainly radios and televisions) under tariff protection and tax incentives provided by

Table 5.4: Exports and Imports of Thailand's Electronics Industry

(Unit : Million Baht)

Description	1970	1975	1980	1985	1990
A. Total Electronics Exports	3	447	6,661	14,194	104,521
B. Total Electronics Imports	1,289	2,059	5,920	15,628	104,636
C. Balance of Electronics Trade	(1,286)	(1,612)	741	(1,433)	115
D. Integrated Circuit Export as % of Total Electronics Exports	0.0	76.5	92.4	58.1	20.7
E. Integrated Circuit Export as % of Total Electronics Imports	0.0	1.7	1.0	10.1	37.0
F. Total Country Exports	14,250	47,505	130,406	193,366	589,813
The ratio of A/F (%)	0.02	0.9	5.1	7.3	17.7

Source : Calculated from Department of Customs

the government. Over time, government policies began to shift towards export promotion in the 1970s through promotional incentives to encourage direct foreign investment to assemble electronic parts and components for export. As a result, consumer electronics production for the domestic market grew moderately well under tariff barriers, whereas electronic components, and some of the industrial electronic products for export grew rapidly starting with components in the early 1970s and computer peripherals from the mid 1980s.

Export data in Table 5.4 shows that since the early 1970s until recently, electronics exports were made up of mostly ICs. This expansion was rapid in the late 1970s, but more recently, the growth rate has become less than the rate for industrial electronics exports, mainly computer peripherals. Most of the IC exports were assembled by U.S. MNCs and were exported to the parent companies or exported to third countries, mainly via Singapore and Malaysia.

In contrast, the computer peripheral industry, which recently experienced high production and export growth, is dominated by both U.S. and Japanese and to some extent, Asian NIC investment. Products are exported to the U.S., Europe, and some to the home countries. While the share of computer parts and peripherals exports grew dramatically since the mid 1980s, the share of ICs fell from 92.4 to 58.1 and 20.7 percent in 1980, 1985, and 1990 respectively.

Although official employment statistics at the sub-manufacturing sector level are not available, certain estimates of employment in the electronics industry are available. One estimate compiled from various sources such as Ministry of Commerce, Federation of Thai Industries and a firm survey estimated that the total electronics industry employed around 42,000 persons or about 2 percent of the total manufacturing sector in the second quarter of 1988 [TDRI, 1988]. Another latest employment figure compiled from the BOI database was about 72,000 persons in 1990. Though this latest figure represents those from BOI approved projects known to be operational, the small additional number of mostly small-sized local firms not accounted for is believed to be reasonably insignificant however.

However, the growth of the electronics industry and its exports has also entailed high import growth rates. Under the government's export policies, majority portion if not all of production must be exported as required by BOI promotional conditions, substantial portion of domestic demand has to be met by imports not just for finished products, but intermediate good, parts and components as well. The import value of electronics, increased some 80 times in twenty years from 1,289 million baht in 1970 to 104,636 million baht in 1990. During 1985-90, parts and components accounted for 43 percent of total electronic imports; computers and peripherals, 30 percent; communications equipment, 12 percent; and consumer electronics, 10 percent (see Table 5.5). Thus, despite being one of the top exporting industry, the country has mostly suffered a trade balance with exceptions only in 1980 and 1987.

In sum the main reasons underpinning the above state of the Thai electronics industry are: first, the product range has been rather narrow and limited by the technological capability of local firms; second, except in the consumer electronics market, foreign firms are more interested to produce for export; third, and perhaps the most important of all, there is very little backward linkage between the thriving electronic parts and components industry and the other sectors of the electronics industry. Many of the components produced locally are later imported back for assembly into final products, hence a substantial share of electronics import (of over 40 percent) has been in parts and components.

In the following sections, attention will now be turned first to a detailed techno-economic analysis of the telecommunications equipment, and the

Table 5.5: Growth and Share of Electronics Imports and Exports, 1970-1990

(Unit : Percent)

Industry group	1970-1975		1975-1980		1980-1985		1985-1990	
	Share	Growth	Share	Growth	Share	Growth	Share	Growth
Consumer products	18.73	(4.14)	13.90	28.26	15.95	15.09	10.42	46.68
Industrial products	31.47	8.56	36.44	31.84	46.74	29.29	46.98	36.22
Telecommunication products	15.21	2.42	17.96	39.76	20.73	16.70	11.78	29.49
- Telephone and telegram equipment	7.90	5.85	11.87	45.99	14.39	12.59	6.47	28.69
- Radio and television broadcasting equipment	1.14	18.28	0.94	2.19	0.80	25.73	2.72	104.49
- Other telecommunication equipment and accessories thereof	6.16	(4.78)	5.16	34.75	5.54	24.76	2.59	0.40
Computers and peripherals	2.19	35.90	2.76	14.80	5.72	66.49	25.28	74.52
Office equipment	4.67	11.01	4.33	18.29	8.79	57.93	5.04	(23.62)
Others	9.39	12.30	11.39	30.12	11.49	22.50	4.87	9.29
Parts & component	49.80	16.25	49.65	16.52	37.31	13.61	42.60	59.97
Total	100.00	9.82	100.00	23.52	100.00	21.43	100.00	46.27

Source : Caculated from Department of Customs

computer and peripherals industries respectively according to the conceptual framework of Chapter Two, and lastly to a number of key problems and issues facing the two industries as identified from the study.

5.2 ANALYSIS OF THE THAI TELECOMMUNICATION EQUIPMENT INDUSTRY

5.2.1 Evolution of the Industry

The Early Phase of Development

The telecommunications equipment include the following major groups of equipment: wire-telephone equipment like telephone sets, public and private switching systems; wireless telecommunications equipment such as radio transceivers, cellular phones, radar equipment; telegraphic equipment like telex machines, facsimile or FAX; and broadcasting equipment like radio and television broadcasting systems.

Prior to few years ago, the telecommunications equipment manufacturing had remained a relatively obscured sector within the electronics industry in Thailand. To begin with, the number of electronics manufacturing firms operating in Thailand prior to 1986 had been rather small. Up to the time, only some 68 electronics projects had received BOI promotions. They represented almost the bulk of the industry as the remaining unknown number of very small firms was seen to contributed only marginally to the total output of the industry. The majority of these promoted firms during that period were firstly concentrated in the consumer electronics sector producing such items as radio, television and electronics parts in response to the government's import-substitution policy. Then came the component manufacturing mainly in IC during the shift toward export promotion of the 1970s followed by computer and peripherals in the early 1980s.

The much underdeveloped telecommunications equipment and related industries was seen to be caused, among other things, by the heavy regulations and control under the state agencies of Telephone Organization of Thailand (TOT) and the Post and Telegraph Department. Such is, however, not unlike most other governments around the world. Even many countries with a formidable electronics industry such as Taiwan have not been spared. As a result,

simple product manufacturing within the technological reach of domestic firms like assembly of telephone sets was largely prevented to grow without the support of a free domestic market, thereby depriving local industry an opportunity to build up a production and technological capability foundation that would provide a platform to subsequently enter into the world market. On the other hand, technological intensive products like switching and transmission equipment would even be well beyond the capability for the domestic firms to contemplate. Consequently, only a handful of domestic firms can be seen most visibly in radio transceivers manufacturing with a history of over twenty years. The group however has dwindled from about six to only two at present, supplying mainly the domestic market to the public sector and a sizeable fishing fleet.

Changes to the situation was triggered off by the deregulation of the telecommunications services in the US in January 1, 1984. A number of governments had, in varying degrees, followed the move since, including Thailand. In October 1986, the TOT had taken the first positive step in liberalization of telecommunications equipment market by allowing consumers to purchase their own customer premises equipment such as telephone sets initially, and facsimile recently. However, the various development had not yielded any significant impact to the industry initially, as it was in a much too weak position to be able to respond. Major beneficiaries to the U.S. deregulation had initially been Japan and the Asian NICs.

The Recent High Growth Phase of Development

The telecommunication services deregulation in the U.S. in 1984 gave a major impetus to the customer premises equipment industry growth among Asian NICs with many new entrants in such products as telephone sets both wire and wireless types, telephone answering machines, key telephones and so on. Thailand at the time was without a sufficiently strong telecommunications equipment and parts manufacturing base and was therefore not in a position to readily reap any benefits like the Asian NICs.

Then came the major industrial shift precipitated by a strong pressure for Japan and Asian NICs to appreciate their currencies coupled with the rapid rise in production costs and the loss of GSP privileges to the U.S. and E.C. countries. Labor intensive manufacturing among these countries began

to be relocated elsewhere mostly to lower labor cost countries. Thailand was in a good position to gain significantly from it because of her comparative advantages like labor cost, sound macro economic management and policy, a stable currency and political climate, etc. Thus large influx of investment poured into the country which saw 468 BOI approved projects for the entire electronics sector within the last four years period from 1987 to 1990 with a combined investment of some 114 billion baht as compared to only 81 approved electronics projects from 1960-1986 at a combined investment of 24 billion baht (Table 5.1).

Among these 400 over approved electronics projects, at least some 30 over telecommunications equipment and parts manufacturers are already in operations today compared with just a handful of local firms prior to the mid 1980s. Led by one firm in our survey which assembles single-line and novelty telephones for the U.S. market in 1986, many others firms including a large U.S. telecommunications corporation quickly followed. Practically all their outputs are destined for the world market even though a number of the firms are allowed to sell a small percentage (usually not exceeding 20 percent) of productions to the local market. Thus, while imports continued to grow to satisfy unmet domestic demand to 10,889 million baht in 1990, exports jumped dramatically from a mere 9 million baht in 1980 to 86 million baht in 1986 and grew strongly to 5,153 million baht in 1990 (see Table 5.6).

Table 5.6: Exports and Imports of Information Equipment of Thailand

(Unit : Million Baht)

Description	1970	1975	1980	1985	1986	1987	1988	1989	1990
Imports									
Telecomm. products	230	259	1,382	1,991	4,540	4,531	6,021	8,683	10,889
Computer products	73	166	363	3,960	6,288	10,075	22,692	25,671	28,288
Exports									
Telecomm. products	0	0.1	9	26	86	141	284	2,108	5,153
Computer products	0	7.5	62	1,433	1,484	3,886	13,052	27,429	39,884

Source : Compiled from Department of Customs

From a narrow range of radio transceivers and simple telephone sets for the local niche market, the product range expanded quickly to include mass-production for export of cordless telephones, telephone answering machines, key telephones, small PABX, facsimile machines, as well as an increasingly wide range of parts and components.

The next two subsections present an economic and a technological analysis in an attempt to gain a better understanding of firms in terms of market structures and their strategies in responding to demand and supply conditions, and in the dealing with their development and management of the various important technological factors of production.

5.2.2 Economic Analysis

1. Demand Conditions

a. Home Demand

Demand for telecommunication equipment in Thailand has grown steadily, albeit slowly, over the two and a half decades from 1960 to the economic boom in the mid to late 1980s. One important indicator of the growth pattern is the number of telephones per 100 population which increased only two times over a decade from 0.41 in 1972 to 0.81 in 1981, to 1.03 in 1984 and in three years since, it had grown dramatically by over 60 percent to 1.67 in 1987. Within the next three-year period, the telephone density had further grown by nearly 44 percent to reach 2.40 in 1990.[9]

However, there was a near absence of a telecommunications equipment industry to meet the demand. Thus, practically all the domestic demand was met by import which grew at an annual rate of about 21.3 percent from about 230 million baht in 1970 to 10,889 million baht in 1990 (see Table 5.6)

[9] From TOT Telephone statistics Report, 1990.

The biggest immediate boost to stimulate the growth of the domestic market todate could be expected from a programme under the Seventh National Plan for TOT to increase telephone lines by at least four millions over the next five years from 1992 to 1996. The programme would bring the telephone density to about 8 per 100 persons from the current level of under 3 per 100 persons. For the first time, the TOT will be using its procurement to stimulate the development of the domestic industry, by requiring a minimum of 50 percent local equipment procurement for the programme. However an estimate of some five percent only in actual local value-added is likely to directly benefit the electronics industry mostly in the forms of PCB, PCBA, wire and cables, electronic components, and subscriber loop carrier products [STDB, 1991].

Equally importantly, many spins off are likely to follow. For examples, demands for customer premise equipment like telephone sets, office PABX, and facsimile machines will substantially increase. An estimate of some likely customer-premise equipment demand to be expected from an initial two million lines in Bangkok and one million lines in the provinces is given in Table 5.7.

Table 5.7: Demand Estimate for Terminal Equipment Expected from the Three Million Telephone Lines Project (1992-1996):-

Item	Metropolitan	Provincial	Total
1. Line Capacities	2,000,000	1,000,000	3,000,000
Small business/residence	1,815,000	985,000	2,800,000
PABX	185,000	15,000	200,000
2. Telephone Hardsets	3,103,000	1,362,000	4,465,000
Small business/residence	2,178,000	1,182,000	3,360,000
PABX	925,000	180,000	1,105,000
3. Facsimiles	40,800	10,400	51,200

Note : Estimates are computed based on T.O.T past statistics

In addition, many other telecommunications projects are in the pipe line. Concession has been awarded to a local firm to launch and operate a communications satellite. Siemens of Germany was contracted to set up an ISDN network for field trial in 1992. Comlink of Canada was awarded a 20-year concession to lay and operate 3,000 km optical fibre network along railroads covering some 33 provinces. These projects can be expected to generate new investment in the telecommunications industry. For example, Fujikura of Japan has recently announced plan to manufacture optical fiber in a new plant in the Northern Industrial Estate later this year.

Already one of the two major suppliers of telephone exchange systems to the TOT has built its factory and began its operations in 1990 to make electronic private automatic branch exchange. The company, NEC, has been a major supplier to TOT starting with the installation of a cross-bar telephone system for 380,000 lines back in 1967. It has since provided digital exchange systems throughout the country especially in the Bangkok Metropolis.

Many other equipment manufacturers that are producing or intend to produce in Thailand, for examples, telephones, small PABXs, and facsimile machines, though appear to supply the world export market, some have BOI approval to sell a certain smaller percentage of production outputs in the domestic market. For example, one firm surveyed is allowed to sell up to 20 percent of its 2.6 million telephones and telephone answering machines production locally, while another is allowed up to 5 percent of its key telephones and facsimile machines.

In addition number of recent investments from Taiwan, Singapore, Japan and Korea intending to produce and sell a fraction of their output in a range of equipment including telephone sets, the giant AT&T has already invested more than US$ 45 million in a telephone manufacturing factory employing some over 1,000 persons. Up to one fifth of the production can be sold locally.

It is likely that demand for single-line telephone sets could be met by the existing and a number of new entrants in the near future from among those BOI approved projects yet to establish factories and begin operations. However, there is substantial amount of unmet demands for PABX systems, cellular phones and facsimile machines as shown by the strong growth

in imports. Currently about five small-size Thai firms making small PABX systems for the growing domestic market are unable to cope with the demand inspite of the limited telephone lines available today. No doubt, when the 3-million lines come onstream over the next five to six years, substantial demands for PABX, facsimiles and so on can be expected.

b. Export Demand

Exports in telecommunications equipment was almost non-existence until a few years ago. Export volume in 1975 was a mere 0.14 million baht increasing in a decade to just 26 million baht (or US$ 1 million) in 1985. The period up to 1985 had been marked by an absence of foreign investment in this sector with only a handful of local manufacturers exporting radio transceivers to neighboring countries.

The telecommunication services deregulation in the U.S. in 1984 gave a major impetus to the user-premises equipment industry growth among Asian NICs with many new entrants in such products as telephone sets both wire and wireless types, telephone answering machines, key telephones and so on.

The major industrial shift in relocating labor intensive manufacturing bases from Japan and the Asian NICs to lower labor cost countries had benefited Thailand greatly, including a number of telecommunications equipment and parts manufacturers during the late 1980s. Production outputs by these foreign investments are largely for the export markets.

From a narrow range of radio transceivers and simple telephone sets, the product range expanded quickly to include cordless telephones, telephone answering machines, key telephones, small PABX, facsimile machines, as well as an increasingly wide range of parts and components.

With the continuing growth of the world market for telecommunications equipment at a rate of some 12-15 percent in 1991 and no foreseen drastic drop in world demand at least into the next decade as the developing and the underdeveloped countries are investing to improve basic telecommunications infrastructure and services, growth prospects remain good therefore for the telecommunications equipment industry in Thailand to meet both the local and the export demands.

2. Supply Conditions

The telecommunications equipment and related intermediate goods production in Thailand like other electronics manufacturing sectors is confined mainly to the assembling of parts and components mostly imported from abroad. Manufacturing processes of input materials into parts and finished products are relatively rare. Except for the few domestic Thai firms, designing process is virtually absent for practically all foreign subsidiaries which predominates the entire sector today.

Thailand, with an abundance of low-wages labor force while land are relatively cheap in price and plentiful, is naturally a favorable destination for the relatively labor-intensive assembly products and parts. Labor in Thailand is also widely known to be good in quality and highly effective for repetitive kind of operations, a quality well-suited to mass assembly work. The part on the high-quality labor force in Thailand has generally proved correct. In fact, on firm claims that the labor force here even performs better than its counterpart in its country. However, the same is not true when comes to staff, both clerical and engineering due to shortage in supply rather than quality.

The country, moreover, presents considerable opportunity as a potentially large market for telecommunications equipment and parts itself, as her telecommunications infrastructure needs massive development in order to graduate as another NIC. The deregulation of customer premise equipment market in 1986 and the increasing inclination towards more private-sector investment in developing the country's telecommunications are all seen as further positive steps to attract direct foreign investments. Few major weaknesses needing urgent attention exist however. They are the lack of a strong supporting industry, a strong linkage of parts and intermediate goods suppliers with the equipment manufacturers, the inadequate supply of skilled manpower, particularly engineers, the state of rather weak technical infrastructure such as information systems for market and technological trends, industrial standards and product testing services, to name a few.

3. Market Structure and Firms' Strategy

In general most Thai-owned firms are without formal links to large firms outside Thailand. They tend therefore to lack strong technology and marketing supports compared to joint-ventures or foreign subsidiaries. These firms have to develop a certain degree of self-sufficiency from acquisition of know-how, machinery and input material, product development, manufacturing, management, marketing to financing in order to be viable. Being smaller and less resourceful, they tend to concentrate on somewhat rather small domestic market niches not attractive as yet to larger MNCs or joint-ventures. Besides being relatively much smaller in value terms for the local niche market, the entry barrier into these well established domestic market niches is rather high, not in technological terms, but more in operative costs making it unattractive to large foreign subsidiary and joint-ventures. The high cost of entry involves learning and modifying product specifications to meet local regulations and requirements, investment in human resources and expenditure to break the firmly entrenched relationships built up by the local suppliers with the users, as well as the unfamiliar and cumbersome procedures in dealing with various concerned government agencies.

Thus, most local Thai firms tend to accord relatively more attention to product development and marketing, but less to advanced and efficient production machinery, know-how, management, and manpower development as the surveyed firms have demonstrated.

One local firm surveyed is exceptionally remarkable in that it wholly embraces the notion of product design and development as the key to growth. Since the firm was set up four years ago, the three lines of products it is making are designed and developed within the firm. Indeed, up to 10 percent of its budget are set aside for R&D. Likewise, another firm also places considerable emphasis on product design and development. Apart from a line of radio transceivers the firm has handled for some twenty years, it is looking into the development of cellular telephone and other telephone special equipment also. Finally, with the knowledge accumulated from 25 years of manufacturing TV antenna, another local firm developed and now manufactures a line of small-size satellite antenna dish. As for the satellite receiver equipment, the firm claims to engage about four engineers from the U.S. to do the product design and development in-house.

With regards to foreign firms or joint-ventures, traditionally FDI in telecommunications equipment manufacturing are made in order to (i) closely serve the local market with its slight variations in regulations and requirement, and (ii) regain lost competitive advantages in their home country as a manufacturing and/or supply base.

At present, only one large joint-venture firm belongs to the first category, as well as the second. The firm has been a major supplier to TOT for over twenty year. Its decision to build a PABXs plant here has obviously been prompted by this long business relationship with TOT and the country's aggressive expansion plan in addition to other factors like skilled labor cost for example.

On the other hand, most if not all foreign and joint-venture firms belong to the second category. Many of these firms are forced to relocate in the mid 1980s to countries like Thailand to regain cost competitiveness.

Their strategy is mainly to establish facilities in Thailand and makes it predominantly a manufacturing base to utilize the long tax holiday granted by the BOI, the abundant lower-cost and high-quality labor force for the largely assembly type of activities. They also benefit from the GSP privileges while at the same time be able to cushion the looming trade frictions. More often than not, the higher technology-content hence higher capital and less labor intensive production type of activities is rarely transferred. Similarly, skills and knowledge-intensive activities connected with the type of products manufactured here remain in parent firms, like product design and development, sourcing and marketing, etc.

Firms in this group employ few hundred workers to mass produce for exports. For example, one firm surveyed started with a projected employment of 237, in less than two years it now employs about 520 persons. The case of yet another firm is even more striking. Within a span of about five years, it has grown from a telephone (mostly novelty and decorative phones, speaker phones) assembly firm with a few hundred workers into a color television and telephone manufacturer with 2,400 employment and a 537,000 sq.ft. production space facilities.

Thus the situation is expected to continue into the near future. Until the infrastructure bottlenecks like transportation, telecommunications, and especially technical human resource base improve significantly, engineering and skills intensive hence much higher value-added activities are likely to remain overseas.

4. Supporting Industries

Important supporting industries for the telecommunications equipment industry, apart from the related components and parts industry, are for examples: PCB etching and PCB assembly, plastic molding, metal parts, mold & die, die casting, plating and packaging, etc.

In respect to the electronics components and parts industry, the segment has grown rapidly especially in the mid to late 1980s based largely on foreign direct investment (FDI) into a formidable and highly internationally competitive industry. Started with a number of US multinational subsidiaries in the 1970s assembling IC in the country in response to her export promotion policies, the range of parts and components has expanded to cover a wide spectrum of the electronics industry today.

However, the country's dual import-substitution policy aimed at the domestic segment of the market, and export-promotion policy aimed at the export market have worked to prevent these highly competitive parts and components produced in the country from supplying equipment manufacturers for the domestic segment of the market [FIAS, 1991]. Thus, there is very little local sourcing and backward linkages inspite of the export boom in both the finished products and parts and components. Thus, the domestic industry remains largely dependent on imported parts and CKD kits. In the export market segment of the industry, it was recently that the country began to see an increase in localization. However, these backward linkages have tended to involve foreign subsidiaries or joint-ventures with foreign firms supplying exclusively to other exporting foreign-owned final product assemblers. Some typical examples were found in our survey. A subsidiary of one world leader in ceramic substrate began its production about two years ago in a Northern region industrial estate near Chiangmai to supply to its major customer - Matsushita in Malaysia. It had began to supply earlier this year to another firm located within the same industrial estate, and intends to supply other

firms mostly Japanese subsidiaries in Thailand when expansion of production facilities is completed later this year.

Despite the increasing number of such instances of backward linkages, Thailand's telecommunications equipment segment still has a low local content ratio among exporting assemblers of final products. Our survey estimated an average import parts and components content of about 70 percent. Local contents mostly reside in for examples plastic molding, metal parts, cables, and packaging. Many supply-side problems remains to be overcome, such as reliability, quality, price and on-time delivery, for examples.

The increasing instances of backward linkage partly come about as the result of the indirect exports policy where parts and intermediate good intended soley for export markets under promotional privileges are allowed to be supplied to final products manufacturers for exports. However, rather cumbersome implementation procedures on one hand, and a lack of supplier information on the other have deterred a more extensive backward linkages among export-oriented manufacturers than would otherwise be possible. In order to overcome part of the latter problem, a BOI unit for Industrial Linkage Development (BUILD) was established in 1990 to first acquire and disseminate relevant information, and then to act as a catalyst in the development of targeted backward linkage deals.

For the domestic market segment, the government has taken the first major step towards local sourcing by requiring a local content of 50 percent for the equipment in the installation of the 3 million lines telephone project. The requirement should create opportunities for more subcontracting and developing backward linkages within the telecommunications equipment and supporting industries resulting in a number of benefits like improving balance of payments, more employment and local added value. Thus, for the first time in the history of the state-owned TOT that the government has link its procurement policy to the development of the local telecommunications equipment and parts industry.

5.2.3 Technological Analysis[10]

1. Production Process

Because of limitation to growth posed by regulations of telecommunications authorities, the weak technological embodiments and financial resources, the few number of local firms remained small in size. The recent customer premises equipment liberalization by the Thai government has so far not produced any significant effect on their technological capabilities. They are found to be inadequate in technological embodiments and capabilities compared with the much more technological endowed FDI firms operating in Thailand.

The production process of the group of domestic-oriented Thai-owned firms is rather similar. It tends to range from designing to assembling and testing. Beginning with specification definition, they proceed to circuit design and PCB layout, mechanical design and drawing. However, PCB fabrication, plastic parts mold-making and plastic parts molding injection are mostly subcontracted outside. Assembling and testings both in-process and final product are carried out in-house. Thus, product design and development, assembling and testing process are the main activities of this group of firms. Such is generally true for firms surveyed.

On the other hand, the production process typical of most foreign subsidiaries and joint-ventures tends to confine largely to assembling and testing activities based mainly on imported parts. With the support of the parent firms, advanced and in many cases the state-of-the-art production machinery and processes are widely found, backed by good pre- production and post-production training programs, often at their parent or sister companies abroad. However, design and development process is virtually dictated and carried out by the parent company in contrast with Thai firms who have to be self reliant to a much larger extent. Again most firms surveyed in this group have this characteristics.

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[10] Refer to Appendix II for the method and the results of surveyed firms' technological content and technological capability assessment.

2. Technological Contents

Firms surveyed that belong to the domestic market segment of the industry tend to have the characteristics common of most local Thai firms. Their process technology, production know-how and product-specific knowledge are largely stemming from years of accumulated experience in the production line, with the possible exception of one firm. As such, while they tend to possess the whole spectrum of technological contents, they are however not in-depth, nor very advanced. With a much smaller production volume to meet the domestic demand and a limited competitiveness to generate large volume exports, they therefore tend to pay less attention to engineering and management techniques for higher production efficiency and quality. Thus, the majority has a rating for production management technology at about the average of local firms, while ratings for process technology, product-specific technology and design technology at a level comparable to the best local firms are more common than not.

There is one a very interesting case of a Thai firm different from the traditional Thai-owned firms on one hand, as well as the traditional foreign subsidiaries and joint-ventures on the other. The difference stems basically from the way it was established. The firm is a subsidiary of a Thai company that markets a line of products from Japan, was only formed five years ago without any previous production experience, except marketing accrued by its managing director through working with its parent company. Together with an engineer friend who spent more than 10 working years in the U.S., the two top executives combine their respective experience and talents together to design, develop and manufacture from start to finish with the intermediate steps of PCBA and plastic injection subcontracted out to other local manufacturers. While it cannot claim to have world-class design, product-specific, process and production technologies, their previous experiences in these areas were certainly put to good uses.

In the case of exporting firm most of which are foreign subsidiaries and joint-venture firms, they typically employ up-to-date production and process technologies with modern production machinery and test equipment for efficiency and consistent product quality and reliability. Complete production and processes know-how are usually transferred from foreign manufacturing base often accompanied by foreign technical personnel.

These foreign experts would take control or supervise the day to day operation in the early phase after a product line has been introduced, until the local engineering staff have learnt and absorbed these technologies sufficiently. Production-management technology and process technology ratings are typically high, where a few of the firms were even ranked to be comparable with the word leaders in their industry.

On the other hand, design and product-specific technologies often remain weak or are completely absent as they remain behind at home bases overseas. While it is true that local firms may not have the capability as yet to absorb and assume the responsibility for product modification, or product design and development activities, there appears to be little tendency toward such a move in general. It remains to be seen four to five years hence, if and when the country can provide sufficient technical manpower stock, and good supportive and technical infrastructure while these firms have reached a sufficient state of maturity, whether design and product-specific technologies remain behind with parent firms overseas. Typical ratings in design technology is generally very poor, whereas a rating comparable to leading local firms is common for product-specific technology. Although the latter appears to be relatively higher in ratings, whatever product-specific technology possessed are mainly intended for production purposes, however.

3. Technological Capabilities

The group of Thai-owned firms with no formal links to leading producers in the world, therefore have to learn to be self-reliant to a degree to survive. They tend to possess a fair amount of acquisitive capability in sourcing components and parts, production machinery and testing equipment, as well as subcontractors to supplement what they cannot or ought not do in-house. While the level may not be high, firms in this group do have some adaptive capability from reverse engineering activities. Thus, they would try to absorb, digest, reproduce or modify either products or equipment for their own needs. However, at this stage of development, very little innovative capability is to be observed among most these firms. Finally, the majority have rather limited operative capability generally. As they produce in small quantity for the local market without intense competitive pressure, cost efficiency has not become a major factor therefore.

Most firms in this group have some in-house designing activity. Their products, radio transceivers and antenna dish, more or less do not change so rapidly in technology. With some twenty years of production experiences, the firms have acquired a fair amount of product-specific and design technologies sufficiently to remain in business while two or three other similar producers had been forced out of the market. However, they do not remain complacent, but pay attention to seek and assess new products or better equipment to retain their market position. One firm in particular also develops and produces other telecommunications special equipment and is also following closely the development of cellular telephones. While another rare case of a local firm firmly believes that the key to future success lies in a firm's design capability. It has designed and manufactured three ranges of OEM products. The firm does systems, circuit and mechanical designs including molds for plastic parts. To match the believe in the importance of design, the firm claims to spend about 10 percent of its operations budget to R&D.

Thus these firms generally have acquired a moderate to high levels of acquisitive, and adaptive capabilities; whereas operative capability is still weak or at best only satisfactory. However, innovative capability remains practically insignificant.

With the intense competition in the world market, export-oriented firms must have a strong operative capability to compete with products from their rivals. Thus, foreign subsidiaries and joint-venture which mostly make up this group have passed on or transferred the same production and processes from their home bases or subsidiaries elsewhere to ensure the same production efficiency and product reliability, while at the same time capitalizing on what other comparative advantages Thailand may offer.

Consequently, operative capability is normally very high with similar production technology and management technique in use among the firms surveyed.

Many other firms of the group achieve high yields and good quality in a satisfactorily short period of production. All have strong process technology, on-the-job training, systematic production planning and resource allocations, planned preventive maintenance, and adopt various QCC

and zero defect practices. All these contribute to a high level of production capability therefore, where a rating at comparable to international level is more of a norm than not.

Whereas production capability is generally rather high, acquisitive, adaptive and innovative capabilities, in-so-far as the local subsidiaries alone are concerned, cannot be considered so. This is because the bulk of inputs and raw-materials are supplied from the parent firms, so are production machinery and test equipment, even production jigs in an almost turnkey fashion. Products and process changes if any are largely made from the engineering department at the parent companies, while design and development are even less likely to reside in basically a purely manufacturing facilities set up here. As an example, even the design of one relatively simple product to meet different client requirement was found to remain in its home country. Thus, a low rating is typical in the design capability of nearly all the export-oriented foreign and joint-venture firms.

4. Technological Embodiments

In this respect, as the majority of Thai firms are SMEs, they normally possess far limited financial resources relative to large MNCs or joint-venture firms. As a result, these firms generally are weak in all technological factors. Thus in capital facilities such as production machinery and equipment, they are simple and only sufficient to handle the low production output required of them. In the human-embodied abilities such as knowledge, experience and skills, if any, tend to reside narrowly within a few persons like the owner or managers only. These firms in general employ only few qualified engineers and technicians, partly because their costs have been rising rather rapidly and partly because they cannot retain nor compete with the rising demand from large foreign firms and joint-ventures under the current technical manpower shortage in the country. Moreover, both the technical and operative manpower are rarely well-trained. This is certainly true in the firms surveyed. Document-embodied information is relatively few partly because less attention is paid to it by the management, and partly because the environment as existing in Thailand makes it difficult to be obtained. Lastly, organizational structure tends to be unsystematic and weak in terms of decision-making, evaluation, trouble-shooting, reporting, analysis, and marketing. Besides, most these firms do not either realize the

importance, or if they do, see it at the top of the agenda for change. A lack of institutional support from the government or the concerned associations adds to the problem.

On the contrary, having large manufacturing facilities competing for the world market, foreign firms and joint-ventures are naturally well endowed technologically. They tend to have first-class or even state-of-the-art production machinery and test equipment. For example, most the telecommunications equipment producers surveyed are equipment with automatic insertion machines. In fact one firm has 6 such advanced machines from the U.S.. In the same fashion, these companies are well endowed in manpower, with extensive on-the-job training, and backed by good supportive and engineering staff either locally or from the parent firms overseas. Similar document-embodied information and management methods and techniques are passed on directly to the firms to provide similar information, and organization endowment as in their parent companies.

5.3 ANALYSIS OF THE COMPUTER INDUSTRY

5.3.1 Evolution of the Industry

Among the three groups of electronic products -- namely, consumer electronics, industrial electronics, and parts and component -- the share and growth rate of parts and components (mainly IC) production and exports were the greatest from 1970 to 1985. After 1985, however, computers and peripherals showed the highest growth. Table 5.5 shows that the export growth rate of these computer products was, in fact, many times greater than the growth rate of total electronics exports for the entire 1980s period. computer peripherals notably disk drives and keyboards form the main export backbone of the computer industry. These export items increased from a negligible amount in 1980 to 31 percent of total electronics exports in the late 1980s.

Apart from a small number of computer retail shops scattered around the Bangkok metropolis which imported small lots of computer CKD kits for assembly at the back of their shops if and when ordered by customers, the computer industry was unknown until the early 1980s. As Table 5.6 shows, exports in computer products and parts was practically none throughout the two

decades between 1960-1980. All demands were met by imports which increased from 73 million baht in 1970 to over 360 million baht in 1980 (Table 5.6). Products imported during the decade were mainly mini and mainframe computers and accessories.

The Thai computer industry began modestly in the early 1980 with a small local Thai firm who switched from the assembly of TV sets for the domestic market to assembling computer terminals from imported CKD kits from Taiwan to which the finished products were mainly exported back. Production volume was modest and value-added was low however. The firm had again, made yet another switch in the later half of the 1980s to assemble PC computers based initially on imported Taiwanese design and subsequently its own design. The firm largely aimed at the local market under its own brandname at the time when demands for PC rose sharply due to declining prices, rising affluence and increasing awareness of the benefits of computer utilization. Though no statistics is available, the firm's market share was not particularly significant however, partly because of marketing capability limitation and fierce competition from imports from Taiwan and Japan.

The entry into the computer industry of the Thai firm above was subsequently overwhelmingly overshadowed with the move to Thailand by a number of major computer parts and components producers starting with the Minebea (NMB) group of Japan to produce miniature ball bearings, stepper motors, and fan motors initially. The firm then expanded and further diversified quickly into computer peripherals such as keyboards and printers to become the country's largest foreign employer with 17,000 employees among the group's nine companies in Thailand in 1991. Next, there were Seagate Technology from the U.S., making hard-disk drives and related parts; Fujikura and Melco from Japan whose major products are, respectively, computer cords and cables, and floppy disk drives. Products made by these major world producers were entirely for the world market.

The major influx of direct foreign investment in peripheral production nevertheless did not come until 1987. In 1987 the Thai economy had excellent economic prospects and the BOI became very active and assertive in campaigning for Thailand as an export production base for the various MNCs. The foreign invested firms which extended their production bases to Thailand from 1987 were mostly from the present production leaders, Japan, Taiwan,

Singapore, Hong Kong, and the U.S. They all obtained BOI - promotional privileges in the form of fiscal incentives and were allowed to remain wholly-owned by their parent companies. At least 80 percent of their total production, however, had to be exported. Exports were mostly to the major computer markets in the U.S. and Europe, but some products were exported to the home country or countries in the region for use as intermediate inputs in other electronics production.

Thus, exports in computer peripherals and parts drastically boosted up the sector's export share from a negligible value to the forefront position in the electronics industry. In 1989, computer peripherals segment overtook the leading exporter since the late 1970s - the integrated circuit segment of the electronics industry with an export value of close to 27 billion baht as compared to some 18 billion baht for ICs. It further surged ahead in 1990 as more foreign investment fueled its performance upwards to increase its share of electronics export to 37 percent (about 39 billion baht) from one percent in 1980 (Table 5.4). Indeed, the meteoric rise of the computer peripherals and parts industry within the past few years is clear considering that in 1990 it became one of the highest principal export items of Thailand second only to textiles and garments, representing 6.6 percent of the country's total exports compared with 11.2 percent for the textile and garment industry.

Currently there are about 30 firms in the computer and peripheral industry, both Thai and foreign owned. The Thai firms are much fewer in number and are usually small in terms of both number of employees and investment. These local firms assemble products using imported intermediate inputs. They also do some testing and production design. The firms engage in a variety of technological activities, but the technology content of their products is not high.

In contrast, large joint-ventures and foreign subsidiaries generally employ a large number of workers of at least a few hundred persons to produce high-technology goods. The production process is, however, mainly assembly of imported parts and components using local unskilled labor. Production design and development is done in the home countries. The plants in thailand assemble and test the products, using imported testing equipment so that product quality meets the standard requirement for the world export

market. A detailed economic and technological analysis of the industry based on information obtained from firm survey and interview follows in the next sections.

5.3.2 Economic Analysis

Market Structure and Firms' Strategies

Considering Thailand's short history of less than a decade in producing computers and peripherals this industry's growth has been most impressive. The industry's share of the world production and export markets, however, is still minimal. The product range of export-oriented computer peripherals is quite narrow and the personal computer production is minimal and largely for domestic market.

The world market structure of the larger-size computer industry (mainframe and minicomputers) is quite oligopolistic, and barriers to entering into the industry are many, due to economies of scale, product differentiation, and the large initial capital investment required. Until 1988, a handful of U.S. manufacturers dominated the production of computer of all sizes. During that year U.S. manufacturers supplied 95 percent in value of the computers used in the U.S. market; 60 percent used in Europe, and 70 percent used in the rest of the world except Japan. In the Japanese market only 20 percent of the demand was met by the U.S. [Yoffie, 1990]. As in other products, most of the Japanese computer demand was supplied by their own producers.

The world computer market was virtually dominated by a single large firm, IBM. This long-established company captures about 50 percent of the total world computer production of all sizes [Yoffie, 1990]. In fact, the greater the computer size the larger the market share of IBM and most other U.S. manufacturers. The logical area for firms from elsewhere to compete in the U.S. or the world market is only in the production of small-sized computers, namely microcomputers or personal computers.

Although microcomputer production is also dominated by IBM, "clone makers" replicate the world leaders' standard designs and are able to supply

the imitation products at lower prices for the lower-end market.[11] The producers of computer clones are concentrated in Japan, Korea, and Taiwan.

There are additional barriers facing Thailand and any developing country or even NICs wishing to enter into the mini and mainframe computer industry.[12] First, economies of scale exist in this industry at every stage from manufacturing to R&D in hardware and software to marketing and maintenance. However, the scale economies at the manufacturing stage are insignificant when compared to R&D investment and distribution. This is because the after-sales services from hardware maintenance to software and technical services are very important. The overhead costs include personnel and traveling costs incurred by providing services in person. This implies that the larger the firms' market share in different regions in the world, the greater the possibility of distributing the overhead to various customers, and thus lowering the market price of the products.

Second, consumers are usually biased in favor of established and well-known producers. Firms also ceaselessly attempt to find new technology strategies to distinguish their products form others and making it difficult to substitute parts and peripherals with other brands.

Third, the capital investment, from manufacturing and continuous R&D investment to distribution expenses, is much larger in this technology-intensive industry than in other traditional ones. In fact, the larger the computer size, the higher the capital investment required to start operation. Moreover, given the facts that the product life cycle of this industry is rather short and that prices decline rapidly, the returns to investment in the industry become even more uncertain. This very fact constitutes the major factor explaining why most firms have difficulty raising long-term funds from external sources to finance production or R&D expenses. In fact, both the financial and the technology requirement barriers are almost formidable for

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[11] The profit margins of personal computer clones however, are rapidly declining because the market is saturated quickly and the product life cycle is very short. Firms have to compete by offering new products quickly to the market before the existing products become obsolete and the prices decline.

[12] See detailed discussion in Pugel, T.A., et al., "Semiconductor and computers" in Moxon, R.W., et al. International Business Strategies in the Asia-Pacific Region: Industry Studies, 1984.

any LDC firm or even that of NICs wishing to enter into mainframes and minicomputer systems manufacturing.

The only product line where Thailand can follow the example of the NICs and be a part of the world computer market is in the production of personal computers and related peripherals. This is because impediments to entry are less in this segment of the industry, and the market demand tends to grow with a country's high growth rate, rapidly rising per capita income, and continuing real wages increases. The demand growth comes from rising income and the substitution of computer automation for labor to save wage costs and to increase productivity.

Moreover the only segment within the computer industry that MNCs find it advantages to be located abroad is one that can save unskilled labor costs such as in the production of computer peripherals like disk-drives, terminals, monitors, keyboards, and printers. As Thailand is abundant in efficient, low-skilled labor, they thus choose Thailand as an export base for labor-intensive production so as to gain from the country's low unit labor costs. In the future, when the country has a greater supply of better skilled labor the possibility for foreign firms to invest in more technology-intensive activities will certainly increase. However, unless special incentives are given to them, they will find it more profitable, as of now, to invest in design and R&D activities in their home bases, instead of in Thailand.

Demand Conditions

Currently there are about 30 firms producing computers, related parts and component and peripherals in Thailand. We interviewed six of them - a Thai and a Taiwanese joint-venture firm producing personal computers, another Thai firm producing various power supplies for computer system, and three MNCs from Japan and Taiwan producing floppy disk-drives, keyboards, printers, and a variety of computer parts. With the exception of the Thai firms, the other firms interviewed were majority or wholly owned by foreign investors. They had obtained BOI promotional privileges to produce for export. The exports were mainly to the U.S. and Europe.

The foreign firms relocating that part of their production which needed labor-intensive processes to Thailand in the late 1980s did so in

response to changing world conditions and to their own countries' economic conditions. First, wages and the domestic foreign exchange values had risen rapidly in their countries and cost competitiveness was quickly eroded as a result. Second, the Asian NICs were pressured by the major markets in the U.S. and the E.C. to graduate from the developing country status. This status upgrading terminated their eligibility for all trade preferential provisions such as GSP privileges. At the same time, the U.S. and E.C. countries introduced other protectionist measures. These factors certainly made it more difficult for export-oriented industries to maintain their shares on the world market. To do so, they had to move part of their production base to a third country offering lower wages, weaker currencies, and preferably still with GSP privileges. All this happened in the late 80s, a propitious for Thailand. The Thai economy was booming and the fact that BOI and GSP privileges were available greatly added to an already favorable investment climate.

Supply Conditions

Firms producing computer peripherals in Thailand are much more numerous and in general very much larger than those producing personal computers in terms of both capital investment and number of employees. The large-scale production of peripherals and parts, mostly by the MNCs, is for export; whereas the small-scale production of personal computers is for the limited local market only. Assembly/production activities, however, are both labor intensive. The number of workers in the MNC subsidiaries producing peripherals could easily range from 500 to over 2,000. There are generally no more than 100 workers in local Thai firms. Since the MNC subsidiaries are majority or wholly-owned by foreign equity holders, the management teams consist of personnel from the parent companies. In addition, since there is a local shortage of engineers, about one-third of the engineers (10-20 depending on a firm's size) are also from the home countries. Before starting an operation or introducing new models or products, local engineers and some head technicians are sent to the parent companies for training. Otherwise, experts from the home countries are brought in to train local staff and in some cases remain for a certain time period until smooth operations have taken place. Labor at the high skill level have thus acquired some technical (mostly operational) knowledge from the MNCs.

All firms agreed that among the many skill levels of labor, unskilled workers are more real cost competitive in Thailand than in other ASEAN and Asian NIC countries. Because of shortages, labor at high skill levels, such as engineers and financial managers, have salary scales approaching the level of the Asian NICs. In one firm's opinion, high salaries due to skilled labor shortages could hinder the cost competitiveness of the computer industry or of any other skilled labor or technology-intensive industries in the future.

On the other hand, unskilled workers are manually dexterous, easily trained, and willing to work long hours at tedious work. While their productivity level is only 70 to 80 percent the level of the parent companies, the wage rate in Thailand is a few times lower. Thus the unit labor cost of unskilled workers in Thailand is still quite low compared to other countries in the region.

While firms can benefit from the low wages and high productivity of unskilled labor working in labor-intensive activities, some processes need machines and equipment. These machines are all imported free of tax and tariff under BOI - promotional privileges. They are mostly imported from Japan, the U.S., Germany, and some from Taiwan. Some of these machines are highly automated and need only a few attendant technicians. In fact, one plant recently installed some 30 robotics to assemble flexible disk drives. Robotics had been used in the parent company in Japan for over three years before being transferred with the plant to Thailand. The advantage, of course, is that robotics are able to work 24 hours continuously without rest. However, operations have occasionally stopped, particularly because of power failures. Besides, it is costly and time-consuming to maintain robotics in Thailand where parts and components, and sometimes even the repair people, have to be brought from the home country.

In fact, in all of the firms surveyed only part of the repair and maintenance is done by local engineers. Most of the complicated maintenance has to be done by engineers or consultants from the parent companies or the machine suppliers. All firms complain that importing machine parts is both time-consuming and costly.

Supporting Industries

Not only does machinery and equipment come from abroad, but also most of the raw materials (about 70 to 100 percent used in personal computers and peripherals, mainly from Japan, the U.S., Germany, and the Asian NICs. Thus, the import content of the exports for this industry are very high indeed. Local materials are, in fact, limited to a few components produced by other BOI - promoted firms under the indirect exporter status. Other local materials include plastic cases and metal parts for cabinets and other fixtures, as well as paper cartons for packaging. One firm suggested that there should be measures to improve production quality and increase productivity of these supporting industries so as to compete with the imported products. An example is the complaint from one firm that local paper cartons are inferior because of the poor quality of paper used and the inefficient paper cutting techniques. This firm had to either import boxes from the parent company and pay high tariffs for the materials, or have their products downgraded to lower market values as a result of poor packaging and materials if local products were used. Indeed, the lack of efficient supporting industries could well adversely affect a firm's production growth.

5.3.3 Technological Analysis[13]

In discussing technology as a production input or technological development in the computer industry, it is useful to separate the discussion into different aspects, i.e., technological content, technological capabilities, and the major sources in which technology might be embodied and used in the production process. furthermore, it is necessary to divide the analysis into that of personal computer production which forms a very minor share of the sector, and that of peripheral production which is dominated by foreign-invested firms mainly MNC subsidiaries.

Technological Contents

As introduced in Chapter 2, technological content can be evaluated based on the four different types of technology used in the industry, namely,

[13] Refer to Appendix II for the method and the results of surveyed firms' technological content and technological capability assessment.

production-management technology, process technology, product-specific technology, and design technology.

Production-management technology in the Thai computer industry mainly involves methods of planning, controlling, and managing the assembly and testing of electronic parts and components and finished products to achieve the lowest costs and the highest quality. From our survey, the level of production-management technology is much higher in the foreign firms than in the local firms (see Appendix II). Local firms largely produce small quantities for the local market, whereas foreign MNCs produce in large volume for export and need maximum production efficiency and quality for competition in the world market. These latter firms have sought to save time, costs, and material inputs by using various productivity improvement techniques such as inventory control, total preventive maintenance, and manufacturing resource planning. They also used different quality control methods for maintaining product quality and reliability. It is very important for these firms to use a high level of production-management technology to increase and control quality because the existing products become obsolete and the prices fall very quickly.

As regards to process technology used in production it is, however, quite similar among firms producing either personal computers or their peripherals (although the level of complexity might be different). The technology mainly involves techniques of assembling various imported parts and components using local unskilled labor and the testing of assembled products using imported machinery and equipment. First, electronic parts and components are assembled, inserted, and soldered to various printed circuit boards, then the assembled boards are tested for reliability and quality. for most products, the assembled boards are further combined with plastic or metal parts and cases to make the finished product. The products are then sent for further quality testing before being packed for distribution.

Personal computers are assembled for distribution to the domestic market based on parts and components which are mainly imported from Taiwan, with some from Japan and the U.S. At the same time, a small quantity of main boards are exported mainly to the E.C. countries. As will be discussed more later that the firms not only do the assembly, but they also have to do mainboard and casing design of their own in order for the products to stay

current and avoid falling into obsolescence in the face of ever decreasing product life cycle of new microprocessors. However, one firm interviewed estimates that the process technology of the Thai computer industry is almost ten years behind the level of Taiwan.

The technology sophistication level is generally higher in computer peripheral firms than in personal computer firms. Almost all the assembly and testing of computer peripherals is done in MNC subsidiaries. Major production in Thailand, such as hard disk drives, floppy disk drives, and keyboards, is operated by using the most up-to-date assembly and testing techniques from the parent companies in the U.S., Japan, and the Asian NICs. The parts and components are imported directly from either the parent companies or sister companies in the region. The finished products are also tested by modern equipment in order to meet the standards required in the world export market. In fact, one of our sampled firms imported highly-automated machines and robotics to be used in its assembly plants to achieve greater speed, reliability, and product quality. some firms are able to assemble multilayered printed circuit boards and make effective use of high precision techniques in the production process. Clearly, this high level of process technology needs large capital investment with high production and management capabilities to operate the mass production plants for the export market. Large firms can certainly meet the above requirements better than small firms.

Computer and peripheral firms also normally invest in product specific and design technology to keep pace with the rapid change in technology and to stay competitive by having higher quality and value-added in general. Firms must learn to continuously improve the use of microprocessor and memory technology, electronic circuit designs, artwork design, and computerized testing to increase speed, to reduce the product size, and to perform more functions. However, while product specific technology is more intensive in foreign firms producing computer peripherals than in local personal computer firms, local firms need to conduct more design work for their products in order to compete with imported finished sets from Taiwan. In fact, the surveyed local firm designs its own mainboards, cards, cabinets, and molds, by collaborating with local research agencies, and some Taiwanese computer firms with which they have had previous trading contact.

Meanwhile, foreign firms invest very little resources on improving the product or the process designs in Thailand. MNCs find it more convenient to import readily available technology from the parent companies. Nevertheless, although local firms incorporate the whole range of technology in production, the technology levels or contents are much lower than those of the foreign firms, particularly in the use of production, management, and process technology.

Technological Capabilities

In the previous section it is concluded that the technological content of computer peripherals produced by foreign firms is higher than that of locally-owned personal computer and peripherals firms in all the types of technology used in production, except for design technology. In contrast, foreign firms tend not to pay much attention toward building up local technological capabilities than those of local firms except in the area of production capability. Like most any other segment of the electronics industry, foreign firms are obviously better than local firms at operating the assembly process, maintaining the machinery and equipment, training labor, and managing other production and quality control activities in order to achieve the highest technical efficiency as well as product quality. This is because these foreign firms produce in large volume for export. Therefore it is necessary for them to maximize efficiency and control product quality to obtain the lowest production costs and be competitive on the world market.

Apart from production operation, these foreign firms hardly conducted any other technological activities in Thailand. Generally before starting production firms have to search for certain production or process technology, and then assess, negotiate, and finally decide to purchase or invest in the technology. After receiving such technology, new production lines are designed and machinery and equipment is installed. All these technological acquisition activities were hardly found in the local MNC plants because are practically carried out in the parent firms. Personnel of the local plants simply process information and instructions available from head quarters. Furthermore, these foreign firms have not so far conducted any design or R&D activities in their plants in Thailand. Nor do they plan to do so in the near future. Thus, any potential transfer of design or innovative capabilities to local staff will continue to be absent.

As a contrast, local firms do have to rely on their own technological capabilities from acquisition and operation to product design or adaptation (except for R&D innovation) to successfully assemble a personal computer and accessories for supply to the local market. They usually have a broad range of technological capabilities, albeit not in-dept. With small-scale production, low process technology, and limited operational capability, it is highly unlikely at present that these small local firms are well prepared to win large OEM contracts with foreign firms. Since their design capability is still elementary and their production capability not so high, it will take many more years before they can enter and compete in the world market.

In sum, local firms still have low technological capabilities of all types, and improvement is needed before they will be able to supply the products in large quantity. On the other hand, although foreign firms have very high operative capability in Thailand, participation of local personnel at high level production, management, and technological activities is still low. Thus, the prospects for transferring technological externalities to local skilled workers is limited as well.

Technology Embodiments

The technological content can potentially be inherit or embodied in various factors of production such as human resources, machinery and equipment, information, and organization or institutions. The technological content of foreign firms are higher than that of the local firms because they have more highly-skilled personnel, more modern machinery and testing equipment, up-to-date specifications and informative documents from the parent companies. The management and organizational techniques and procedures are also superior. Foreign firms with far more economics of scale can support and do have more engineering and management personnel with higher technological capabilities than the personnel in local firms. When local engineers are in short-supply, they are brought in from the parent companies. When the number of local engineers in these foreign firms is limited, there is little opportunity for them to expand the range of products or shift to items with higher technological content. Thus, the possibility of transferring operative capability to local personnel is also constrained.

On the other hand, without adequate high-skilled labor in local firms their prospect for accumulating more technological capabilities is also limited. To be sure, it is difficult for a local firm to obtain the qualified human resources able to initiate OEM contracts on their own. However, it might be easier for large local firms with large capital to enter into joint-ventures with MNCs to start OEM assembly plants. It is hoped that the OEM plants can transfer more operative technological capability to local skilled workers so that there will be more local firms producing under OEM contracts, or even under their own brandnames in the future.

All in all, the limited technological capabilities of local small computer firms make it difficult for them to run an OEM plant on their own. The possibility of joining with MNCs to obtain OEM contracts is also constrained by the lack of own capital and technological embodiment. However, it is possible for local large firms with the available capital to have joint-ventures with MNCs because they are in a better position to employ highly-skilled and well-experienced personnel form everywhere.

5.4 KEY ISSUES & PROBLEMS FOR THE INFORMATION EQUIPMENT INDUSTRY

FDI has contributed significantly to the recent economic boom in Thailand and still can be one important factor of considerable benefit to the Thai economy. For FDI not only generates employment and provides capital, it can also be a source of foreign technology acquisition and export market opportunities.

Had it not been the favorable internal and external conditions that led to the recent influx of FDI into Thailand in the mid to the late 1980s, the information equipment (telecommunications and computers products) and related industry would still remain as an insignificant segment of the electronics industry with only a handful of local Thai firms.

Two key problems and issues are seen as impediments that have prevented the realization of fuller benefits possible from these FDI. The first is caused by the inadequacy of technical manpower, both in quantity and in quality, while the second is a general lack of linkages between the parts/components including various other supporting industries and the equipment and

finished products industry. These are important ingredients for the transfer and diffusion of technology (both production and design technologies) and management skills from foreign investments, whereby substantially increases the benefits the country can gain from FDI in addition to just exports earning and employment generations.

Moreover, increasing linkages and subcontracting would lead to less reliances on parts and components imports (currently at a high level of over 70 percent) as well as encourage more establishments of local Thai suppliers. In turn, a stronger presence of Thai firms would generate larger extent of technological spillovers. Otherwise, the information equipment industry in Thailand is likely to become no better than what it had been for almost three decades if and when the FDI decide to pull out.

The sudden surge in the foreign investments into the country had created a number of problems however. Notable among these are bottlenecks in the country's physical infrastructure like transportation, power supply, ports facilities, and telecommunications services; as well as the unmet demands in technical human resources, engineers in particular.

While a highly qualified technical workforce is certainly essential for absorbing technology transfer from foreign investments, an adequate supply is also necessary to meet the increasing demand and maintain efficient production and quality product outputs. Another important element to ensure quality control and diffusion of technological knowledge is an adequate technological infrastructure which involves, among others, basic metrology, standards, certification and product testing capabilities, and a good information system on technology and market trends, for example. Though low production cost and high quality are certainly major factors of international competitiveness, another important factor has emerged as a result of rapid technological changes and shortening product life cycle, and that is for rapid delivery times. This certainly calls for a good support infrastructure such as efficient transportation, customs procedures, and telecommunications services. Thus the third impediment identified is a prevailing poor technological and support infrastructure (government administrative procedures included).

Although the products of the computer industry involve high technology, most of the activities in Thailand still entail only the assembly of imported

parts and components, using large numbers of local unskilled workers. The remaining activities include testing, using highly-automated machines attended by a handful of operators. Technology acquisition, engineering and management capabilities, even the plant layouts of some MNC subsidiaries, are obtained from the headquarters. Almost no design or R&D activities are carried out by local subsidiaries or joint-venture firms. Likewise, public sector (government R&D institute) R&D is also lacking or inadequate. Therefore, except for some training of local engineers and head technicians, it is difficult to see how technology could be transferred effectively to local entrepreneurs. Worse yet, since engineers will still be in short supply for some time to come, the production technology and knowledge obtained by transferring new products and models from the parent companies to be produced locally will take longer to introduce. This implies that the technology transfer entailed in new product and model introduction to local engineers and technicians will likely be slow or limited.

The various key issues considered are generally not confined to only the information equipment (computer and telecommunications) industry, but to the whole electronics industry and even most other industries. One other main issue remains to be included that is specifically relevant to the telecommunications equipment industry. And that concerns government regulations and policies. On one hand is the tight control of telecommunications services and equipment market, though the latter has been partly liberalized. On the other is a lack of clear and firm sectoral policy and planning, not only in the information equipment industry, but in almost all industries as well.

In sum, five key issues have been identified as major impediments to the development of the information equipment industry in Thailand. They are:

1. a weak domestic parts & components and other supporting industries,
2. an inadequate technical human resource base,
3. a poor technical and support infrastructure,
4. a haphazard technology development,
5. government regulations and lack of focused industrial policies.

We will discuss a number of possible strategies in the next and last chapter that may help lessen impediment to development arisen from the various key issues as well as other possible issues not specifically covered here, which may also help to improve the weak state of technological capability and embodiments among most local firms for the machinery and the information equipment industries in Thailand.

CHAPTER 6: STRATEGIES AND POLICY RECOMMENDATIONS

This concluding chapter presents a number of short-term, medium-term and longer-term strategies useful in removing or at least lessening some of the impediments to the present and future development of the four industrial sectors under study. While the proposed strategies are primarily aimed at the four sectors in particular, they are equally useful and applicable to the development of all manufacturing in general. The main essence of the strategies is to strengthen the industries and their technological bases over time to be able to enlarge the manufacturing value-added chain (of Figure 6.1).

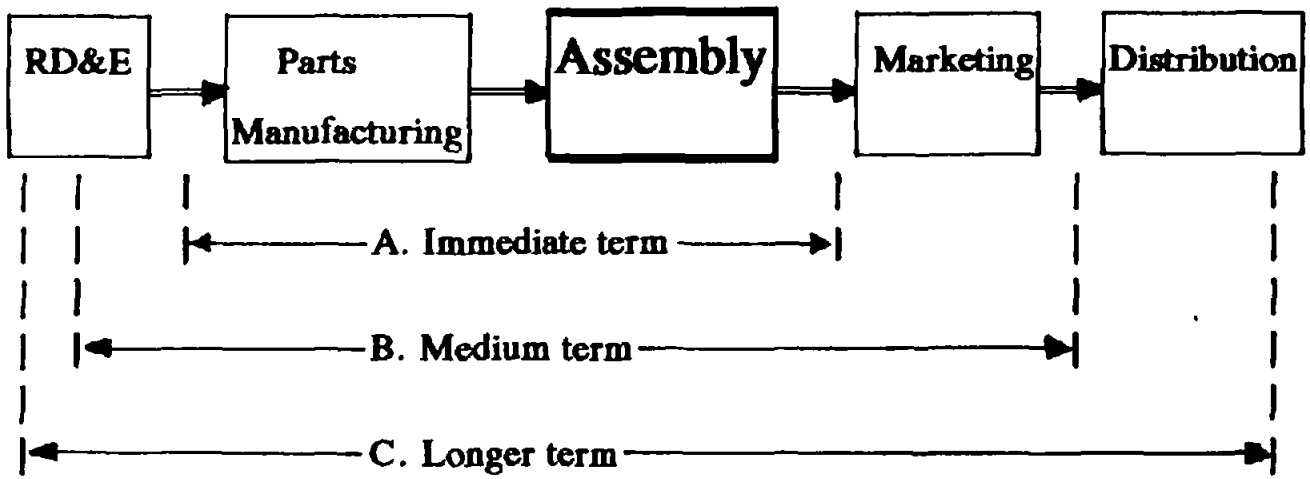
In short, over the near term, the strategy is to create strong supporting industries. Medium-term strategy would be one of intensifying design and basic fabrication (upstream) activities. Ultimately over longer-term, the strategy is necessary one of (downstream) own-brandname manufacturing to complete the whole value-added chain. It is almost always the case that the greatest value-added tend to occur at both extreme ends of the chain, viz the R&D and the marketing/distribution part of chain activities. Section 6.1 will discuss various strategies in detail.

Lastly, the study will propose a number of policy recommendations. Supply-side recommendations entail investment promotion, industrial linkage development, technological infrastructure building, and technical human capital development. Demand-side recommendations involve government procurement, incentives for training, social status for technicians, and tax rationalization. These are discussed in Section 6.2 to conclude this study.

6.1 STRATEGIES

The general policy trend of the Thai government is currently toward liberalization of industry and reduction of protection to prepare the country for greater integration with the world economy in line with the GATT Uruguay Round Agreements. As evident by the reduction of import tariff on production machinery by the Chartchai government in October 1990, and on automobile and computer by the Anand government in July 1991 as well as the lifting of bans and restriction on establishment and expansion of 21 types of industries, we

Figure 6.1 The Manufacturing Value-Added Chain



have every reason to believe that such trend will continue in subsequent governments.

While we are in general agreement with such a present policy trend, we are also of concern that free competition or market force alone may not be the most efficient way to develop industries. In a World Bank report [World Bank, 1990], it suggested four key roles a government can play in the development of electronics industry which should also be generally applicable to other industries as follows:

1. Develop technical human capital
2. Strengthen the basic technological infrastructure such as information, technical services, R&D etc.
3. Provide incentives to improve technological levels
4. Provide an environment for flexible adjustment to production structure

The present Thai government policy has tried to address the fourth role suggested by the World Bank but has by and large ignored the first three. In lifting economic protection, subsequent adverse effect may be so acute that instead of nursing production structure to be stronger by introducing competition, many Thai manufacturers established in response to the import substitution policy may lose their business owing to their weak technological bases.

The first two roles, namely, developing technical human capital and strengthening the basic technological infrastructure should not be seen as a form of government intervention. In fact, we feel that these roles are part of the obligations that a government should provide to society in order to facilitate the development of a country. Due to their characteristics of long lead time, large investment and low initial return, market force alone is therefore insufficient to adequately ensure viability.

The current acute technical manpower shortage especially, engineers and skilled technicians has negatively affected productive efficiencies, project expansion, and product development programs and is therefore in need to be urgently addressed. The strategy should address short term, medium term and long term solutions to ensure that technical manpower will not be a

bottleneck impeding the development of the country into a better society [Sripaipan, 1991].

Modern businesses and industries also have found Thailand inadequate in basic technological infrastructure. Services such as calibration, testing, inspection, contract R&D, consultancy, information and training are insufficient and sometimes non-existent prompting firms, both local and foreign, to seek overseas services. This incurs long lead time and high expenses and at the same time presents a big stumbling block against deepening the industrial structure.

The third key role on the provision of incentives to improve technological levels can be seen as a form of government interventions. However, interventions are sometimes necessary and justifiable for specific purposes provided that attention be paid to minimize possible distortion on the macroeconomic scene. In the above World Bank study into the role of government in the development of the electronics sector in four developed economics (U.S., U.K., France, and Japan) and seven developing economics (Brazil, China, India, Korea, Taiwan, Singapore and Hong Kong), nine of the 11 countries (with exception of Singapore and Hong Kong) have made extensive use of government procurement guarantees for specific products. What we are proposing are much less interventionistic than successful examples of Japan and the NICs in Chapter 3. Furthermore, the role at government may change as the industry matures. We propose as follows a set of short-term, medium-term and longer-term strategies.

Phase I (0 to 5 years) : creating a strong support industry

For machine tool industry, the basic support industry is the metal-working industry. Without good supporting metal parts, quality machine tools in terms of both accuracy and repeatability will never be met. In addition the metal-working industry is also a basic support industry to all machinery and metal-based industries ranging from electrical and electronic to automotive industry.

The mold and die industry needs casting, machining, heat treatment and electroplating which are metal-working industries as its support industry. Availability of standard parts is another important supporting service. In

turn, the mold and die industry is itself a support industry to the fabrication of metal, plastic and metal parts. It is, therefore, important to develop the mold and die industry in Phase I along with other support industries.

For the telecommunications and the computer and peripherals industries which, at present, are engaged in assembly of final products or intermediate goods with heavy reliance on imports of parts and components. From our study, it is found that mechanical parts, for example, aluminum casted parts, sheets metal stamped parts, machined parts and plastic molded parts are the first group to be localized. These parts again need strong support from the metal-working including mold and die industries. As for electronics industry-specific processes, we find a particularly weak link in the area of printed circuit board etching.

Despite a large influx of foreign investment in electronic component industry, there is still a lack of breath in coverage. Even if all the locally manufactured electronic components are made easily available to final product assemblers, quite a number of components still need to be imported.

The proposed strategies in Phase I are, therefore:

1. to continue the promotion of foreign direct investments, joint-ventures and technology licensing in the machine tool, mold and die, telecommunications equipment, and computer and peripherals industries particularly in their support industries as a first step in enlarging the value-added chain (Fig. 6.1).

2. to promote greater backward linkages as well as OEM manufacturing for foreign firms. Up to now, spill-over effects from FDI, if any, is largely limited to production-management and process technologies, and practically no design capability, marketing know-how, subcontracting, or establishment of new local firms by former managers, engineers, or technicians.

3. to strengthen the basic technological infrastructure provided by government agencies as well as private organizations providing such services as calibration, standards, testing, information, consultancy and training. Access to foreign expertise and technology should be emphasized.

4. to use government procurement as a mean to nurture local firms, promote backward linkages, access and acquire foreign technologies, diffuse and adapt technologies. An example, though not of direct government purchase, is the contract condition imposed on CP Telecom Co., Ltd. to install 2 million telephone lines for the Bangkok Metropolitan to buy 50 percent of the equipment locally. However, it was estimated by one of our researchers that the feasible local value-added was only about five percent based on the current state and the weak technological base of the local electronics industry. It is, nevertheless, a good starting point with better prospect for subsequent projects.

Phase II (5 to 10 years) : intensifying design and fabrication activities.

As industries mature, comparative advantages will gradually be shifting from low cost of production workers to low cost of engineers (based on engineering and design capability) and managers (based on marketing and management skills), development strategy over the medium term (5 to 10 years) should focus on expanding the value-added chain's activities upstream to RD&E (research, development and engineering) as well as downstream to cover marketing function. Having accrued sufficient experiences and built up good support industries, both local firms and foreign subsidiaries alike should be encouraged to develop their own product design and marketing capability locally. Domestic firms should shift from subcontracting to more OEM manufacturing based on their own design, or form joint-ventures with foreign distributors or manufacturers with leading-edge technologies to gain a foothold in the world market.

For machine tool industry, after good metal parts are widely available in the country, assembly and fabrication activities become more feasible. If quality metal parts are not available, even the government pushes hard to promote assembling and fabrication firms, the result would still be limited. The assembly and fabrication activities could be led by prominent international machine tool firms to create market and skills.

For mold and die industry, the emphasis should shift from mold and die making to mold and die design. More knowledge on working material and products to be produced by molds or dies as well as production process will be

required. More attention should be paid to small-size and high precision molds and dies for the electronics industry like stamping die for IC package connector-pins.

For the telecommunications industry, some target products could be selected based on market needs as well as indigenous capability. Based on our study, potential targets could be: feature phones, cellular telephones, pagers, PABX and facsimile.

The microcomputer industry may feature more sophisticated hardware and software design to enhance competitiveness. Design of peripherals such as keyboards and monitors should be possible.

The strategies of Phase I on investment and backward linkages when achieving their objectives can continue on their own momentum. The technological infrastructure needs to be continually upgraded to maintain its usefulness. RD&E activities of the public sector should now be linked to those of the private sector. The government procurement policy is still applicable but measures should be carefully designed so as not to over protect the domestic firms to the point of being uncompetitive internationally. Such privilege should be coupled with demanding improved performance proven by export capability.

Phase III (over 10 years) : Own brandname manufacturing

For longer term strategies of over 10 years, domestic firms should finally aim for own brandname manufacturing and look out for opportunities in forming strategic alliances with suitable foreign companies. Targeting makes more sense at both firm (private) and national (public) levels due to the high investment cost and long lead time of R&D.

6.2 POLICY RECOMMENDATIONS

The policy recommendations may be divided into two categories on supply side aspects and on demand side aspects

6.2.1 Supply Side Aspects

a) Investment Promotion

The industries under study, namely, machine tool, mold and die, telecommunications equipment, and computer and peripherals, and particularly parts and components manufacturing and support industries and services should be kept on the promoted list of the Board of Investment (BOI). Special attention should be paid to their activities in relation to the time frame of the strategies in section 6.1.

b) Industrial Linkage Development

BOI Unit for Industrial Linkage Development (BUILD) can provide information on available local supporting industries to large firms seeking subcontractors as well as on investment opportunities created by the need of large principals. Technical assistance to small and medium firms attempting to become sub-contractors may be provided by government agencies like MIDI or by large principals. The recent move by the Board of Investment to permit promoted investors in support industries to sell up to 20 percent of their output in the domestic market will help establishing more linkages.

c) Technological Infrastructure Building

Technological infrastructure includes metrology, standards, calibration, testing, information, consultancy support industries and services, research and development and training. The first group including metrology, standards, calibration, and testing is needed to ensure that the products meet the quality requirement of customers both domestic and overseas. The government has the duty to provide metrology, standards, and secondary standards calibration and the private sector may provide some services in working standards calibration and product testing. From the point of view of manufacturers, most of the services needed are product testing to comply with international standards and quality inspection so that their products are acceptable to major world markets. Although it is impossible to offer testing services to every product in compliance with a variety of international standards, some priorities should be agreed upon in view of the limited resources. It is felt that the process of issuances of documentary standards

should be speeded up, while a wider range of new products should be covered and a national system of traceability of standards should be set up. For the four industries under study, testing requirements may include but not necessarily be restricted to verification of accuracy of second-handed or reconditioned machine tools, standards for basics parts of molds and dies, electromagnetic interference of microcomputers and peripherals and spurious electromagnetic emissions of telecommunications equipment.

At the very least, the excellent facilities of the Industrial Metrology and Testing Service Centre and the Industrial Standardization and Testing and Training Centre in the Bangpoo Industrial Estate about 40 kilometers south-east of Bangkok built with the donation from JICA of Japan in 1991 should be well maintained and fully utilized. The government should support in devising a scheme to attract qualified personnel in sufficient number, to train young and promising staff by providing scholarships and training courses, and finally to provide sufficient operating fund for consumable and repair and maintenance of the equipment.

Information, consultancy, support industries and services, research and development services and training may belong more to the private sector, but this certainly does not preclude the public sector in initiating and promoting these activities as well as operating some of them. An investment opportunity study on science and technology services in Thailand by the Board of Investment is a first step to make potential investors aware of such opportunities [BOI, 1992]. With the exception of training, the market of these services are still small since not many potential users fully realize their significance as yet. Therefore, the government has a role in convincing industries especially small and medium ones regarding the benefits of accessibility to good information, of engaging a consultancy, of the economic of subcontracting and even research and development services in the future. The Singaporean government had a very successful scheme to upgrade small and medium industries by linking them with available infrastructure through provision of initial subsidies. Other countries also have or going to have similar programs of assistance.

d) Technical Human Capital Development

To alleviate the present manpower shortage and to achieve sustainable development of the country in the future, we feel that a number of actions need to be taken with strong commitment from top administrators.

In the short run, there is no alternative but to launch massive short-course programs making full use of foreign industrial experts already residing in the country. The Office of the Board of Investment may act as the coordinating body for organizing training courses in a number of institutions such as the Technological Promotion Association (Thai-Japan), the Metal-working and Machinery Industries Development Institute, the National Institute for Skill Development plus a number of educational institutions located in industrial areas around Bangkok like Samut Prakarn, Thonburi and North Bangkok. To alleviate shortage of technical personnel, foreign engineers and technicians in areas of shortage should be allowed to work in Thailand. The Office of the Board of Investment is willing to assist any companies with or without BOI promotion to bring in relevant foreign experts.

In the medium term, it is expected that new private sector educational institutions can provide significant contribution. Public sector educational institutions undergoing current reform will have more flexibility in responding to market needs. However, the key seems to be the availability of teachers. Private universities still rely heavily on lecturers from public universities. The present pay scale for university lecturers is very low, and even in private universities the pay is not competitive to private industries. Unless remuneration for teachers can be significantly improved to attract the best people into teaching career, it is impossible to resolve this bottleneck. This would need a strong government intervention to succeed.

In the longer run, a clear vision of the future manpower needs of Thailand must be developed by public sector policy makers to adequately reflect all perspectives so that, measures for manpower development can be effectively carried out.

In addition, all levels of technical human resources need to be retrained and upgraded from time to time to keep abreast with rapid

changes in technologies and avoid falling into obsolescence and technologically incompetency.

6.2.2 Demand Side Aspects

a) Government Procurement

To use government procurement as an instrument to promote local industry, one should be aware of its interventionistic nature and be careful not to create a protected vested-interest group. However, in the telecommunications equipment and computer industries where public sector market is very significant, there are some opportunities to exercise such a role. Apart from the example of CP Telecom Co., Ltd. undertaking the installation of 2 million telephone lines, there are many other possibilities for subsequent telecommunications projects.

As for computers or rather microcomputers, a possible project is the use of public sector market including education, to boost the local microcomputer manufacturers. Since microcomputers are being locally designed and peripherals like monitors, disk drives, keyboards and printers are being locally assembled, the benefits should be much greater than the 2 million telephone lines' example. In addition, like the telecommunications infrastructure, microcomputers should not be seen as an end by itself. Its wider usage will also enhance productivity in all sectors.

b) Incentives for Training

It is shown in a recent study [Poapongsakorn, 1991] that Thai firms spend too little resources in training. The government should encourage more training investment through provision of incentives. In our opinion, the success story of the Skill Development Fund in Singapore should be closely studied to find relevant lessons for implementation in Thailand.

c) Social Status for Technicians

Apart from initiatives to accelerate the training of the technical manpower, from skilled craftsmen to technicians and university graduates, the country should consider schemes to institutionalize an ap-

propriate certification systems in technical skills and proficiency rankings of workers. This is to raise the social standing of skilled craftsmen up to a similar social level as scientists and engineers in order to encourage more Thais to pursue this career path. This could be done by proclaiming a "National Technical Qualification Law" similar to the successful examples of Taiwan and South Korea.

d) Tax Rationalization

The proposal by the Department of Customs to reduce import duties to a maximum of 30 percent with only five classifications (ie. 0, 5, 10, 20 and 30 percent) is a welcome move worthy of support. Together with the value-added tax (VAT), the overall tax structure should be on a more rationalized footing and should help increase the competitiveness of Thai industries. It is, of course, not appropriate to suggest any tax rate for the four industries under study here. However, we feel that raw materials should have lower tariff than parts and components, and parts and components in turn should have lower tariff than machinery or finished goods. In particular, these parts and components that Thailand has been exporting successfully, whereby proving their international competitiveness should not be subjected to any tariff protection. Moreover, special tariff privilege provisions for the import of CKD kits for computers should be abolished to attract more manufacturers into the arena.

ACRONYM	
AI	Artificial Intelligence
AT&T	American Telephone and Telegraph
AIST	The Agency for Industrial Science and Technology, Japan
ASIC	Application Specific Integrated Circuits
BIOS	Basic Input-Output System
BOI	The Board of Investment, Thailand
CASE	Computer-Aided Software Engineering
CIM	Computer Integrated Manufacturing
CNC	Computerized Numerical Control Machine
CPT	Color Picture Tube
DRAM	Dynamic Random Accessed Memory
EDB	The Economic Development Board, Singapore
EDM	Electrical Discharge Machine
EDP	Electronic Data Processing
EIAJ	Electronic Industry Association of Japan
EIAK	Electronic Industry Association of Korea
ERSO	The Electronics Research and Service Organization, Taiwan
ETRI	The Electronics and Telecommunications Research Institute, Korea
FA	Flexible Manufacturing
FAX	Facsimiles
FDI	Foreign Direct Investment
FM	Flexible Manufacturing
HDD	Hard Disk Drive
HDTV	High Definition TV
IBM	International Business Machines
IC	Integrated Circuit

ACRONYM	
ICOT	Institute for New Generation Computer Technology, Japan
III	The Institute for Information Industry, Taiwan
ISDN	Integrated Service Digital Network
ITRI	The Industrial Technologies Research Institute, Taiwan
JICA	Japanese International Cooperation Agency
JMTBA	The Japan Machine Tool Builders' Association
KAIST	Korean Advanced Institute of Science and Technology
KIAS	Korean Institute of Advanced Science
KIST	Korean Institute of Science and Technology
MIRL	The Mechanical Industry Research Laboratories
MITI	The Ministry of International Trade and Industry, Japan
MNCs	Multinational Corporations
MIDI	The Metal-working and Machinery Industries Development Institute
MTI	The Ministry of Trade and Industry, Korea
M&I	Machinery and Information Equipment
NC	Numerical Control Machine
NCB	The National Computer Board, Singapore
NEC	Nippon Electric Corporation
NESDB	The National Economic and Social Development Board, Thailand

ACRONYM	
NICs	Newly Industrialized Countries
NSTB	The National Science and Technology Board, Singapore
NTT	Nippon Telegraph & Telephone, Japan
OA	Office Automation
OEM	Original Equipment Manufacturer
OS	Operating System
OSI	Open System Interconnection
PABX	Private Automatic Branch Exchange
PBX	Public Branch Exchange
PC	Personal Computer
PCB	Printed Circuit Boards
PCBA	Printed Circuit Boards Assembly
POS	Point-of-Sales
R&D	Research and Development
SISIR	Singapore Institute of Standards and Industrial Research
SMEs	Small and Medium Enterprises
SMT	Surface Mount Technology
S&T	Science and Technology
TAMI	Taiwan Association of Machinery Industry
TOT	Telephone Organization of Thailand
VCR	Video Cassette Recorder
VAN	Value-Added Network
VLSI	Very Large Scale Integrated Circuit

APPENDIXES

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APPENDIX I: STATUS OF THAI ECONOMY

1. THAI ECONOMIC GROWTH RATE

Since 1970's Thailand has been in the process of transforming her economy from mainly an agricultural economy to a more industrialized economy. Economic development of Thailand has been a success story particularly in recent years, with a double-digit high growth rate in GDP for three consecutive years from 1988 to 1990 (See Table A1.1). The projected rate for 1991 is likely to be less certain in the aftermath of the Gulf crisis. Nonetheless, a strong 7 to 8 percent growth is possible.

The spectacular expansion during the past recent years has however over-heated the economy causing a number of side-effects like the manpower shortage problem and infrastructural constraints. Thus, it could be said that the slow down of the economic growth rate is not a great shock, as it presents a good chance to adjust the Thai economic development policy for more balanced economic growth.

2. SOME FACTORS OF THE HIGH GROWTH RATE

Several factors supported the high growth rate of Thai economy during the recent years. Relatively speaking, the stability of Thai politics and economy as compared to other developing countries has made Thailand an attractive choice for foreign direct investment. The influx of foreign direct investment, particularly from Japan and the Asian NIEs as well as many western countries in search of lower cost production bases, is one of the main contributing factors.

Statistics of foreign direct investment inflows from the Bank of Thailand indicate that net foreign direct investment inflows during 1980-1989 were 125.8 billion baht which were 7.7 times of the net foreign direct investment inflows in the 1970's. In particular, inflows from Japan also increased significantly in the 1980's. Japanese net direct investment accounted for about half of the total net inflows [Tambunlertchai, 1991].

The statistics on project applications for promotion from the Board of Investment of Thailand (BOI) also show a dramatic increase in foreign investment in recent years (see Table A1.2). The number of Japanese projects applying for the BOI promotion increased from 53 projects in 1986 to 389 projects in 1988. However, the number of applications decreased to 233 projects in 1989 and 199 projects in 1990. At the same time, there was a higher proportion of foreign direct investment in the application of export-oriented projects. The number of export-oriented projects approved by BOI has increased from 483 projects in 1987 to 1,053 projects in 1988, but it slowed down to 791 projects in 1989 and 538 projects in 1990 (see Table A1.3). The share of export-oriented projects in the total approved projects was over 50% during 1987-1988. These foreign direct investment has greatly helped to speed up the pace of development of modern industries in Thailand [Surakanvit, 1991].

It should be noted also that domestic investment by Thai investors has dramatically increased in these recent years too. Thus, we could say that the expansion of both private and public investments has been the engine of economic growth for Thailand at present.

There are also some other internal and external factors which support the recent high growth rate of Thai economy. They include:

(1) The rapid expansion of Thai export since 1986.
(2) The increase in the number of tourists and foreign currency earnings from the tourism related activities.
(3) The expansion of domestic market as per capita income has greatly increased.
(4) The recovery of the world economy, and the rapid growth of the region in general.
(5) The effective macroeconomic management of the Thai government.

3. SECTORAL ECONOMIC PERFORMANCES

Economic development of Thailand has shown a good performance since 1987, with a significant structural change from the traditional production of agricultural product to manufacturing and services. As shown in Table A1.4 the share of gross domestic product by sector in 1989 was 15.2% for agricul-

ture, 25.4% for manufacturing and 40.1% for trade and services. However, the agricultural sector still accounted for approximately two third of labor employment. Thus, the agricultural sector is still crucial for Thai economic development.

The growth rate of the agricultural sector in 1990 is estimated to reduce to about 1.8% due to water supply shortage as well as a slow down in world demands. On the other hand, the industrial sector and the service sector in 1990 continued to expand at a relatively high rate of about 13.7% and 9.5% respectively (see Table A1.1).

According to the National Income Statistics of Thailand (Table A1.4), gross domestic product at current market price of the manufacturing sector in 1985 amounted to 224,456 million baht and it grew more than twofold to 535,396 million baht in 1990. The trade and services sector likewise doubled from 421,391 million baht to 854,853 million baht during the same period.

In the trade service and sector, the performance of banking, insurance and real estate was particularly strong. It increased about 3.5 times from 35,988 million baht in 1985 to 124,527 million baht in 1990. At the same time, wholesale and retail trade also increased strong by from 153,130 million baht in 1985 to 312,738 million baht in 1990.

Thus, the Thai industrial and service sectors are without doubt the leading sector in the Thai economic development.

As Thailand still has abundant labor supply, particularly of a large pool of unskilled labor in the rural sector, the pressure for a rapid wage rise will not be too strong in the immediate future. Thailand is thus still able to gain comparative advantage in labor-intensive industries though not for very long perhaps. Notwithstanding, Thai labors are considered to be diligent, cheerful and easily trained. Thus, the industrial and service sectors can be expected to grow steadily.

However, owing to the unexpected economic boom in recent years, the shortage of highly qualified manpower and over extended infrastructural facilities are serious constraints which may impede future development considerably. Already, investment continued to decline with a drop of 39% in the number of projects seeking BOI promotional privileges in the first 10

months of 1991 compared with the same period in the previous year. Of these, 467 projects involving a total investment of 148,456 million baht were approved representing a reduction of 40% over the same period in 1990. Majority of these projects were foreign investments with 119 from Japan, 54 from the E.C., 56 from Taiwan and 36 from H.K.

The Thai government is well aware of these problems and is now trying seriously to solve them. Nevertheless, these problems are expected to remain for some years to come as efforts to overcome them require massive investment, a considerable amount of time, and most importantly the will of a strong government in order to succeed.

4. INTERNATIONAL TRADE RELATIONS

The structural changes in the economy since the mid 1980s have resulted in a significant change to the trade structure of Thailand as well.

On the import side, the share of consumer goods has decreased from 10.1% in 1987 to 7.8% in 1988 and increased to 9.0% in 1990. In contrast, the share of capital goods has risen significantly from 31.7% in 1987 to 39.2% in 1988 and 38.8% in 1990. While the share of intermediate goods has been about 35.5% in average during 1987 to 1989, decreasing somewhat to 33.3% in 1990. The rising share of capital goods in total imports in recent years is the result of the investment boom which requires increased import of capital goods such as machinery and equipment. The total amount of imports increased from 501 billion baht in 1988 to 650 billion baht in 1989 and 815 billion baht in 1990 (see Tables A1.1 and A1.5).

On the export side, the export structure has undergone a significant change. The share of agricultural exports has decreased from 27.8% in 1987 to 23.0% in 1989. While the share of manufacturing products exports has increased from 62.7% in 1987 to 68.6% in 1989. Although the share of traditional exports products such as rice, rubber and tropical products is still high, the export of manufactured products has increased substantially. Many of manufactured products were non-existent or accounted for a very small part of total exports in 1970's, but recently they became the major export items of this country. Those manufactured products include textile products, in-

tegrated circuits, precious stones and jewelry, footwear, plastic products, and canned pineapple as well as canned fish.

It is expected that industrial exports will rapidly increase and becoming more diverse. Thus, the total amount of exports value has increased from 399 billion baht in 1988 to 510 billion baht in 1989 and 590 billion baht in 1990.

However, Thailand trade deficit has increased to the highest record of 239 billion baht in 1990.

Thai trade deficit with Japan since the end of the Second World War has been almost as large as the country's overall trade deficit. Despite the increase in export to Japan, import from Japan has grown even faster, mainly due to import of capital goods to support Japanese investment.

It is interesting to note that Thailand has been able to register trade surplus with the United States and the E.C. in recent years. Moreover, the United States is now the largest market for Thai exports. Therefore trade conflicts with the United States and the E.C. might be a problem in the near future. In fact, they are now restricting the imports from Thailand through various measures.

Therefore Thailand should attempt to increase export to Japan and diversify her exports to other markets as well.

Although the trade deficit tends to increase due to the import of capital goods and intermediate products to support the large amount of investment, it is expected that the trend will be slowed down as the investments in export industries start to bear fruit. The investment boom in export industries in recent years will contribute to strong export growth in the near future.

Thailand still has the transfer and services balance surplus. Thus, the current account balance deficit is not so serious comparing to other developing countries.

Table A1.1 : Revision of Thailand's economic forecast for 1991

	1989	1990	1991 Initial	1991 Revised
1. GDP Growth (%)	12.0	10.0	7.0	9.0
1.1 Agriculture	6.6	(1.8)	2.0	2.0
1.2 Manufacturing	14.9	13.7	8.5	10.5
1.3 Construction	21.3	22.7	9.0	11.2
1.4 Other	11.8	9.5	7.0	9.0
2. Expenditure Growth (%)				
2.1 Consumption				
- Private	10.9	9.1	5.5	8.0
- Public	(0.1)	2.9	3.0	3.0
2.1 Investment				
- Private	15.7	23.0	8.0	9.5
- Public	5.7	33.3	14.0	14.0
3. Consumer Price Index (%)	5.4	6.0	8.0	6.0
4. Exports of Goods (Bt bn)	509.9	590.0	670.0	690.0
Growth (%)	27.7	15.7	13.6	17.0
5. Imports of Goods (Bt bn)	650.7	815.0	940.0	940.0
Growth (%)	29.7	25.2	15.3	15.3
6. Trade Balance (Bt bn)	(140.8)	(225.0)	(270.0)	(250.0)
Trade Balance/GDP (%)	(7.9)	(11.0)	(11.7)	(10.4)
7. Current Account Balance (Bt bn)	(63.7)	(136.5)	(172.6)	(154.0)
Current Account Balance/GDP (%)	(3.5)	(6.8)	(7.6)	(6.4)
8. Income From Tourism (Bt bn)	96.4	111.7	112.0	124.0
9. Per Capita Income (Bt/yr)	32,094	36,399	40,016	42,000

Source : National Economic and Social Development Board March 8, 1991

Table A1.2 : Foreign Investment Application to BOI (Million Baht)

	Year 1986		Year 1987		Year 1988		Year 1989		Year 1990	
	Project	Amount	Project	Amount	Project	Amount	Project	Amount	Project	Amount
Total Investment	431	59,888	1,058	209,029	2,127	530,292	1,284	461,052	1,009	523,807
Total Foreign Investment	207	36,487	630	163,322	1,273	394,212	856	341,496	638	391,028
JAPAN	53	8,111	200	46,987	389	148,221	233	135,769	199	80,512
TAIWAN	31	2,957	178	14,642	400	54,287	207	30,273	131	14,267
U.S.A.	24	10,998	61	19,214	136	92,767	76	31,497	72	28,068
HONGKONG	17	1,934	46	7,035	126	20,108	106	36,172	76	180,616
SINGAPORE	9	330	37	5,129	90	16,954	45	18,483	39	12,190
MALAYSIA	7	201	13	771	39	4,299	30	4,608	15	5,081
KOREA	2	20	16	2,303	40	3,679	39	9,482	25	3,088
AUSTRALIA	6	528	22	7,331	30	29,851	9	380	11	1,852
EUROPE	42	16,292	110	33,131	148	73,569	134	53,862	110	45,299

Note: Project with foreign investment from more than one country are doubly counted

Source: Board of Investment of Thailand (BOI)

Table A1.3 : Foreign and Domestic Investment in Export-Oriented Projects (Million Baht)

	1984	1985	1986	1987	1988	1989	1990
Export	11,044.4	33,152.6	16,300.0	44,521.0	108,173.0	91,462.0	76,988.0
(Number of Projects)	114	124	168	483	1,053	791	538
Other	225,157.6	21,044.4	18,320.5	22,769.0	87,048.0	194,592.0	397,891.0
(Number of Projects)	152	86	128	142	397	379	368
Total	236,202.0	54,197.0	34,620.5	67,290.0	195,221.0	286,054.0	474,880.0
(Number of Projects)	266	210	296	625	1,450	1,170	906
SHARE							
Export	33.26	61.17	47.07	66.16	58.87	31.97	16.21
(Number of Projects)	43	59	57	77	73	67	59
Other	66.74	38.83	52.93	33.84	43.33	68.03	83.79
(Number of Projects)	57	41	43	23	27	32	41
Total	100	100	100	100	100	100	100
(Number of Projects)	100	100	100	100	100	99	100

Note: Export-oriented projects refer to projects which export 80-100% of their production output.

Source: Board of Investment of Thailand (BOI)

Table A1.4 : Gross Domestic Product at Current Market Price by Industry (Million Baht)

	1980	1985	1988	1989	1990
Agriculture	152,852	169,895	250,384	266,379	254,523
Mining & Quarrying	22,147	40,167	47,657	60,648	73,500
Manufacturing	139,936	224,456	373,326	453,258	535,396
Construction	34,764	56,824	84,791	112,283	146,817
Utilities	44,152	101,666	141,011	164,546	186,119
Electricity & Water Supply	6,289	23,590	34,315	41,499	47,367
Transportation & Communication	37,863	78,076	106,696	123,047	138,752
Trade & Services	264,658	421,391	609,808	718,864	854,853
Wholesale & Retail Trade	110,176	153,130	240,080	272,748	312,738
Banking, Insurance & Real Estate	19,926	35,988	64,979	87,845	124,527
Ownership of Dwelling	22,798	41,091	52,697	58,430	64,355
Public Administration & Defense	30,711	48,545	56,397	64,326	74,603
Other Services	81,047	142,637	195,655	235,515	278,630
Gross Domestic Product	658,509	1,014,399	1,506,977	1,775,978	2,051,208
SHARE (%)					
Agriculture	23.2	16.8	16.6	15.0	12.4
Mining & Quarrying	3.4	4.0	3.2	3.4	3.6
Manufacturing	21.3	22.1	24.8	25.5	26.1
Construction	5.3	5.6	5.6	6.3	7.2
Utilities	6.7	10.0	9.4	9.2	9.1
Electricity & Water Supply	1.0	2.3	2.3	2.3	2.3
Transportation & Communication	5.8	7.7	7.1	6.9	6.8
Trade & Services	40.2	41.6	40.5	40.6	41.6
Wholesale & Retail Trade	16.7	15.1	15.9	15.4	15.2
Banking, Insurance & Real Estate	3.0	3.6	4.3	5.0	6.1
Ownership of Dwelling	3.5	4.1	3.5	3.3	3.1
Public Administration & Defense	4.7	4.8	3.7	3.6	3.6
Other Services	12.3	14.1	13.0	13.3	13.6
Gross Domestic Product	100.0	100.0	100.0	100.0	100.0

Source : National Income of Thailand, Office of the National Economic and Social Development Board

Table A1.5 : Exports and Imports by Major Sectors
(Percentage)

Item	Year			
	1987	1988	1989	1990
Exports				
Agriculture	27.8	26.4	23.0	17.0
Fishing	6.1	5.2	5.5	5.5
Forestry	0.3	0.2	0.1	0.1
Mining	2.0	1.9	1.6	1.3
Manufacturing	62.7	65.4	68.6	74.7
Samples and other	0.9	0.7	1.0	1.2
Re-exports	0.3	0.3	0.2	0.3
Imports				
Comsumer goods	10.1	7.8	8.4	9.0
Intermediate Products	35.8	35.4	35.5	33.3
Capital goods	31.7	39.2	36.6	38.8
Other imports	22.3	17.7	19.5	18.9

Source : Bank of Thailand

APPENDIX II: TECHNOLOGICAL ASSESSMENT

1. ASSESSMENT CRITERIA FOR EACH KEY COMPONENTS

In analyzing the technological capabilities, contents, and embodiments, of each surveyed firm, we assessed the operative capability and technological content on an ordinal scale as follow:

score 5	=	equivalent to world-class firms
score 4	=	comparable to internationally competitive firms
score 3	=	lower than internationally competitive firms, but higher than the average Thai firms
score 2	=	comparable to average Thai firms
score 1	=	lower than average Thai firms

The assessment for scoring was based on some observable characteristics and activities. These activities vary according to types of technological contents and capabilities as follows:

For Production Capability
- product quality
- cost effectiveness

For Design Capability
- quality of design
- variety of design
- sophistication of design

For Production Management Technology
- effectiveness of management with regards to cost control, quality control, time control and safety control

For Process Technology
- comparison against state-of-the-art process technology

For Product-specific Technology
- fineness of product specifications
- ability to utilize state-of-the-art technology
- ability to optimize designs

For Design Technology
- design rules
- design equipment

In contrast with the above production and design capabilities, and the four technological content components which render themselves more readily to quantitative ratings through observable activities and outcomes as in product quality and costs, assessment of each technological embodiment was made on a qualitative basis by comparison with a perfect type embodiment. This is because the research team did not see how one can devise a set of guidelines that can uniformly fit across the wide spectrum of firms, nor be sufficiently objective in the rating exercise. Such rating attempts are not likely to be very meaningful. It is believed that a better methodology would be to assess the strength and weakness where possible and to make an attempt to find out the reasons behind such strength or weakness. In order to do this, a perfect type for each embodiment was specified. Then the deviations of each firm's embodiment from the perfect type were identified. This was followed by an investigation into the possible effect of deviations on the firm's technological content and operative capability. The specifications of the perfect type for each embodiment were made according to the following considerations:

For Machinery and Equipment
- comparison was made with state-of-the-art machinery and equipment

For Manpower
- range of specialization
- qualification of specialists
- average level of skills of workers

For Organization
- effective management of resources
- sound organizational structure
- coordination among departments and communications within department

For Information
- extent of acquiring and assessing information
- extent of digesting information
- extent of maintaining information
- extent of disseminating information
- extent of creating information
- extent of synthesizing information

The acquisitive capability was assessed with respect to modes of acquisition, frequency of acquisition, intensity of effort used in acquisition (measured by expenditure and time spent, if possible) and the sophistication of the acquired technologies. Data limitations many affect the accuracy of assessments.

Assessment of adaptive and innovative capabilities was based on past achievements and current efforts on adaptation and innovation.

2. ASSESSING THE PERFORMANCE

The analysis of technological performance of the various surveyed firms was made by comparing scores given to the firms. The discussion was also separated by firms with different types of ownership, firm size, and market orientation.

Measures of center are used to indicate a value that typifies or is the most representative of a set of numbers. The three most commonly used measures are the mean, the median, and the mode. The mean (arithmetic mean) is what most persons think of when the word "average" is mentioned. A second kind of measure is the median. Its key feature is that it divides an ordered set into two equal groups. The choice of using the mean or the medium as the measure of center depends on several factors. The mean is sensitive to, or influenced by, every value in the set, including extremes. The median, on the other hand, is relatively insensitive to extreme values. However, the mode is the measurement which represents the value that occur most often in a set.

As compared to the mean and the median, the mode is the least commonly used for most statistical problems because it does not lend itself to mathematical analysis in the same manner that the other two do. However, from a

purely description standpoint, the mode is indicative of the "typical" value in terms of the most frequently occurring value of a sample set. The mode is most useful when one or two values, or a group of values, occur much more frequently than other values.

Since the measurement of the level of technology in this study is mainly aimed at qualitative analysis, therefore the measurement of the center in terms of the mode is most appropriate. In other words, the study aims to describe the most typical case of surveyed firms' technological level whether it is one of a world-class, internationally-competitive, or average Thai firm.

Scores of production-management technology, process technology, product-specific technology and design technology for technological content, and production capability and design capability for technological capability are tabulated in Tables A2.1 and A2.2 respectively for the machinery industry and the information equipment industry classified by ownership, size and market-orientation.

3. FINDINGS FROM THE SCORE TABLES

From Tables A2.1 and A2.2, salient findings of firms' technological contents and capabilities by sectors are:-

1. In the machine tool industry foreign firms have higher or at least the same levels of production-management, process, and product-specific technology content than the locally-owned firms. They also have a similar level of production capability compared with local firms. However, local firms have higher levels of design technology content and capability.

Most machine tool firms are small-or medium-sized. Large firms have higher levels of production-management and process technology content and production capability than small-and medium-sized firms.

While export firms' production-management technology content is better than that of firms producing for the local market, their design technology is lower, however.

2. In the mold and die industry joint-venture firms have higher levels of all the technological contents and technological capabilities than local firms. Interestingly, the only foreign firm in the sample shows lower or at best equal levels of all types of technological content and technological capability than most local firms, except process technology and production capability, which are just about the same as those of the local firms.

The level of process technology and production capability of the small and medium sized firms is greater than that of the large firms, whereas the level of other technological contents and technological capabilities is the same for firms of all sizes.

Most mold and die firms produce for the domestic market, the only sampled export-oriented firm was not found to have higher technological content nor capability level than the firms producing for the domestic market.

3. In the telecommunications equipment industry, foreign firms have higher or equal level of all types of technological contents and capabilities than those of the local firms, except for design technology and capability.

Except for design technology alone, large firms also have higher or equal levels of all types of technological contents and capabilities.

Similarly, except for design technology and capability, export-oriented firms also have higher or at least equal levels of all types of technological contents and capabilities.

4. In the computer industry, most locally-owned firms are small or medium scale, and produce largely for the domestic market. The majority of computer peripheral firms are, on the other hand, large scale foreign or joint-venture firms, producing for the export market. Except for design technology and capability, the foreign and export-oriented firms have higher levels of all the other types of technological content and capability than those of local firms.

Table A2.1 : Technological Assessment in the Machinery Industry by Characteristics

Characteristics	Production Management Technology	Process Technology	Product-Specific Technology	Design Technology	Production Capability	Design Capability
Machine Tools:						
Thai	2	2	3	2	3	3
Foreign	3	3	3	1	3	1
Joint-venture	2	3	2	1	3	1
Large	3	4	3	2	4	3
Medium/Small	2	3	3	2	3	3
Export	3	3	3	1	3	1
Local	2	3	3	2	3	3
Molds and Dies:						
Thai	2	3	3	3	3	3
Foreign	1	3	2	1	3	1
Joint-venture	4	4	4	4	4	4
Large	3	3	3	3	3	3
Medium/Small	2	4	3	3	4	3
Export	1	3	2	1	3	1
Local	4	4	3	3	3	3

Table A2.2 : Technological Assessment in the Information Equipment Industry by Characteristics

Characteristics	Production Management Technology	Process Technology	Product-Specific Technology	Design Technology	Production Capability	Design Capability
Computer & Peripheral:						
Thai	2	4	3	2	3	2
Foreign	4	5	4	1	5	1
Joint-venture	2	2	3	1	2	1
Large	4	5	4	1	5	1
Medium/Small	2	2	3	2	3	3
Export	4	5	4	1	5	1
Local	2	3	3	2	3	3
Telecommunications Equipment:						
Thai	2	3	3	3	2	3
Foreign	4	4	3	1	4	1
Joint-venture	3	4	3	1	4	1
Large	4	4	4	1	4	1
Medium/Small	3	4	3	3	2	1
Export	4	4	3	1	4	1
Local	2	3	3	3	2	3

APPENDIX III: LISTS OF PERSONS AND FIRMS OR AGENCIES INTERVIEWED

Table A3.1 : Firms Surveyed in The Machinery Industry

Name of firm	Interviewee	Address
1. Burapa Steel Co., Ltd.	Mr. Somkiat Sakao-ratananon Managing Director	715 Moo 1 Suksawasdi 48, Bangkok 10140 Tel. 427-0035/8
2. Charoenpol Engineering Co., Ltd.	Mr. Prapon Trakanrungroj Managing Director	3/32 Soi Ruampalung (Chan Sret 2), Bangkok 10150 Tel. 428-0726/7, 427-7450
3. Driessen Aircraft Interior System (Asia) Ltd.	Mr. Apiluk Lohachitkul Director	139/6 Moo 17 Bangplee Industrial Estate, Samut-Prakarn 10540 Tel. 315-1157/9
4. Jeng Jih Machinery Co., Ltd.	Mr. Boonchai Tia General Manager	63/10 Thonburi-Paktho Road, Samut-Sakorn 10600 Tel. 211-8591
5. Kamol Trading Co., Ltd.	Mr. Kamol Surangsuriyakul Managing Director	53/19 Soi Srimuang-Anusoon, Bangkok 10310 Tel. 277-0589, 277-2750
6. Kao Hong Industrial Co., Ltd.	Mr. Se-Nan Tseng General Manager	115/1 Moo 4, Lat Krabang Industrial Estate, Bangkok 10520 Tel. 326-0280/1
7. Kyodo Die-Works Co., Ltd.	Mr. Teryo Yoshimura Managing Director	60/3 Navanakorn Industrial Estate, Pathum-Thani 12120 Tel. 529-0945/6
8. MDA (Thailand) Ltd.	Mr. John Kosten Quantity Control Manager	140 Bang Plu New Town 3, Bangsoatong, Samut-prakarn 10540 Tel. 315-1005/6
9. Okamoto (Thai) Co., Ltd.	Mr. Wiboolyos Amatyakul Factory Manager	174 Moo 2, Chamaeb, Wang Noi, Ayuthaya 13170 Tel. (035) 271-187/90
10. Pricision Tools Co., Ltd.	Mr. Somchai Charnwiwat Product Manager	60-62 Soi Prajaksil, Bangkok 10250 Tel. 314-4801, 318-9693/4

Table A3.1 : Firms Surveyed in The Machinery Industry (cont.)

Name of firm	Interviewee	Address
11. Sek Kee Engineering Co., Ltd.	Mr. Boonyarit Wangkamhaengharn Managing Director	213 Moo 4 Soi 34, Suksaward Road, Bangkok 10140 Tel. 427-1283, 427-3130
12. Siam Technic Industry Co., Ltd.	Mr. Sema Amphankao Factory Manager	B 9 Moo 14, Bangchan Industrial Estate, Bangkok 10510 Tel. 517-0040/1
13. Sodick (Thailand) Co., Ltd.	Mr. Yoshio Omura Managing Director	60/84 Moo 19, Navanakorn Industrial Estate, Pathum-Thani 12120 Tel. 529-2450/7
14. Srithai Miyagawa Co., Ltd.	Mr. Chairath Suvitayakit Product Manager	539 Soi 8 B, Sukhumvit Road, Samut-Prakarn 10280 Tel. 324-0425, 324-0426
15. Taksin Steel and Equipment Co., Ltd.	Mr. Tossaporn Damrongkul Product Manager	32/1 Taksin Road, Bangkhunthian, Bangkok 10150 Tel. 468-0285, 468-1521
16. Thai Engineering Product Co., Ltd.	Mr. Alongkot Chutinan Managing Director	101/90 Moo 19, Navanakorn Industrial Estate, Pathum-Thanee 12120 Tel. 529-3518/22
17. Thai Iron and Steel Co., Ltd.	Mr. Somchai Factory Manager	1-3-5 Krabi Road, Amphur Muang, Phuket 83000 Tel. (076) 216-287
18. Thai OKK Machinery Co., Ltd.	Mr. Yongyot Lowkanjanarat Factory Manager	9/23 Suksawad 78, Praphadaeng, Samut-Prakarn 10130 Tel. 462-7598, 463-2436/7, 463-6185
19. Thai Precision Manufacturing Co., Ltd.	Mr. Chalee Rungruang General Manager	621/4 Moo 5 Sukla-Piban 8 Nongkham, Sriracha, Chonburi 20110 Tel. (038) 322-506, 311-069

Table A3.1 : Firms Surveyed in The Machinery Industry (cont.)

Name of firm	Interviewee	Address
20. Thai Rung Union Cars Co., Ltd.	Mr. Chairat Kitpanich Factory Manager	28/6 Petchkasem 81, Bangkok 10160 Tel. 420-0076, 420-1328
21. Thai Tech Mutsuda Co., Ltd.	Mr. Kiyoto Saito Production Manager	60/53 Moo 19 Navanakorn Industrial Estate 2 Pathum-Thanee 12120 Tel. 529-3306/12
22. Union Itoh Mould Co., Ltd.	Mr. Paotap Chotinuchit Managing Director	11 Sukla-Piban 2 Road, Bangchan Industrial Estate, Bangkok 10510 Tel. 517-0109, 517-0114

Table A3.2 : Firms Surveyed in The Information Equipment Industry

Name of firm	Interviewee	Address
1. Chicony Electronics (Thailand) Co., Ltd.	Mr. Kenneth Chou Operation Manager	82 Mu 4 Takham, Bangpakong, Chachoengsao Tel. 212-0027
2. Chinteik Electronics Systems Co., Ltd.	Mr. Chaiyapong Chiarapatanakorn V.P. Finance	5 Sukhumvit 3, Bangkok 10110 Tel. 529-0036
3. Ei-En	Mr. Grant Jiang Managing Director	628 Moo 12, Santikam Soi 5, Sukhumvit 109, Samutprakam 10270 Tel. 393-0385, 393-9146
4. Elcom Research Co., Ltd.	Mr. Gowit Jira Vice President	2540 Sukhumvit Road, Bangna, Bangkok 10260 Tel. 3986952-5
5. Electro-Ceramics (Thailand) Co., Ltd.	Mr. Satoshi Tomikawa Managing Director	65 Moo 4 Tumbol Ban Klang, Amphur Muang, Lamphun 51000 Tel. (053) 581-036-8
6. Fujitsu (Thailand) Co., Ltd.	Mr. Y. Kodera Director	60/90 Phaholyothin Rd., Klongluang, Pathumthani 12120 Tel. 529-2630, 529-2597
7. Intronics Co., Ltd.	Mr. Chaiyasit Thampeera Managing Director	1547/6-7 Oscar Center, New Petchaburi Road, Bangkok 10310 Tel. 251-1426, 251-5470
8. KSS Electronics (Thailand) Co., Ltd.	Mr. Sompot Teachatrisorn General Manager	89 Moo 4, Highway No. 11, Amphur Muang, Lamphun 51000 Tel. (053) 581-201
9. Larp Viboonkit Ltd., Part	Mr. Paiboon Jerdjumraskoon Manager	426/7-9 Suthisan Rd., Huai Khwang, Bangkok 10400 Tel. 276-1023, 276-1914
10. Melco Manufacturing (Thailand) Co., Ltd.	Mr. Pongsak Navapradit Acc. & General Affairs Mgr.	86 Moo 4 Bangna-Trad K.m. 23, Bangplee, Samutprakam 10540 Tel. 316-6191-4

Table A3.2 : Firms Surveyed in The Information Equipment Industry (cont.)

Name of firm	Interviewee	Address
11. Murata Electronics (Thailand) Co., Ltd.	Mr. Tobinaka Administration Manager	63 Moo4, Tambol Banklang, Amphoe Muang, Lamphun 51000 Tel. (053) 581-158, 581-166
12. NEC Communication Systems (Thailand) Co., Ltd.	Mr. Masaaki ABE Deputy Managing Director	60/76 Paholyothin Rd., Klongluang, Pathumthani 12120 Tel. 529-2460
13. Nitsuko Thai Ltd.	Mr. T. Kumamoto General Manager	60/81 Moo 19, Klongluang, Pathumthani 12120 Tel. 529-2112-4
14. Northern Telecom (Thailand) Co., Ltd.	Mr. Lee Meng Chong Enginerring Manager	9/1 Moo 2, Tumbol Ko-kaow, Amphoe Muang, Phuket 83000 Tel. (076) 214-679, 213-260
15. Phuket Electro Mechanics Co., Ltd.	Mr. Vichit Limsakoon Managing Director	262/13 Yaowaraj, Amphoe Muang, Phuket 83000 Tel. (076) 213-655
16. Samart Satcom Co., Ltd.	Mr. Twatchai Wilailuk Managing Director	59 Moo 2, Klong Luang, Pathumthani 12120 Tel. 516-8785
17. Srithai Goldstar Co., Ltd.	Mr. Lak-Cheon Kim Executive Vice President	71/12 Moo 5 Bangna-Trad Rd., K.m.52, Chachoengaso 24130 Tel. (038) 513-061-3
18. Tavon Computer Co., Ltd.	Mr. Jira Jiriyasin Manager Director	316/2-3 Sukhumvit 22, Bangkok 10110 Tel. 258-9863, 258-1099
19. Teletech (Thailand) Co., Ltd.	Mr. Pungpej Boonliang General Manager	105 Moo 3, Bangna-Trad Rd., K.m.52, Chachoengaso 24130 Tel. (038) 631-419, 531-340

Table A3.2 : Firms Surveyed in The Information Equipment Industry (cont.)

Name of firm	Interviewee	Address
20. Tiger Engineering LTD., Part.	Dr. Krayim Santrakul Managing Director	367/1-3 Chatchai Rd., Amphoe Muang, Lampang 52000 Tel. (054) 225-456/8
21. Thai N.J.R. Co., Ltd.	Mr. Satoshi Iwai Director & Production Manager	79/1 Moo 4, T. Banklang, A.Muang, Lamphun 51000 Tel. (053) 581-260

Table A3.3 : List of Agencies Interviewed

Name of Agency	Interviewee	Address & Telephone
1. The Office of Industrial Economics	Ms. Orapin Werawut Deputy Director	Ministry of Industry Rama VI Road, Payatai, BKK.10400 Tel. 245-6659 Fax: 245-6658
2. The Metal-Working and Machinery Industrial Development Institute	Dr. Damri Sukhotanang Director	Department of Industrial of Promotion Ministry of Industry Soi Trimit (Kluay Nam Thai), Rama IV Phrakhanong, BKK.10110 Tel. 381-1051/6
3. National Centre for Metal and Material Technology	Dr. Harit Sutabutr Director	Ministry of Industry Rama VI Road, Payatai, BKK.10400 Tel. 247-1455 Fax: 247-1455
4. Government and Private Co-ordination Division	Mr. Chakramon Phasukvanich Director	Office of the National Economic and Social Development Board (NESDB) 962 Krung Kasem, BKK. 10100 Tel. 280-0889 Fax: 281-9263
5. Office of the Board of Investment (BOI)	Mr. Chackchai Panichapat Deputy Secretaries General	555 Vipavadee Rangsit Road Bangkhen, BKK. 10900 Tel. 270-1400, -1410 Fax: 271-0777
6. The Industrial Estate Authority of Thailand	Dr. Somchet Thinaphong Governer	618 Nikhom Makkasan, Ratchathewe, BKK. 10400 Tel. 253-0561
7. The Industrial Development Support Section	Dr. Nit Chantramanklasri Deputy Director	Office of The Science and Technology Development Board (STDB) 6 th Floor, Charan Insurance Bldg., Ratchadapisak Road, BKK. 10310

Table A3.3 : List of Agencies Interviewed (cont.)

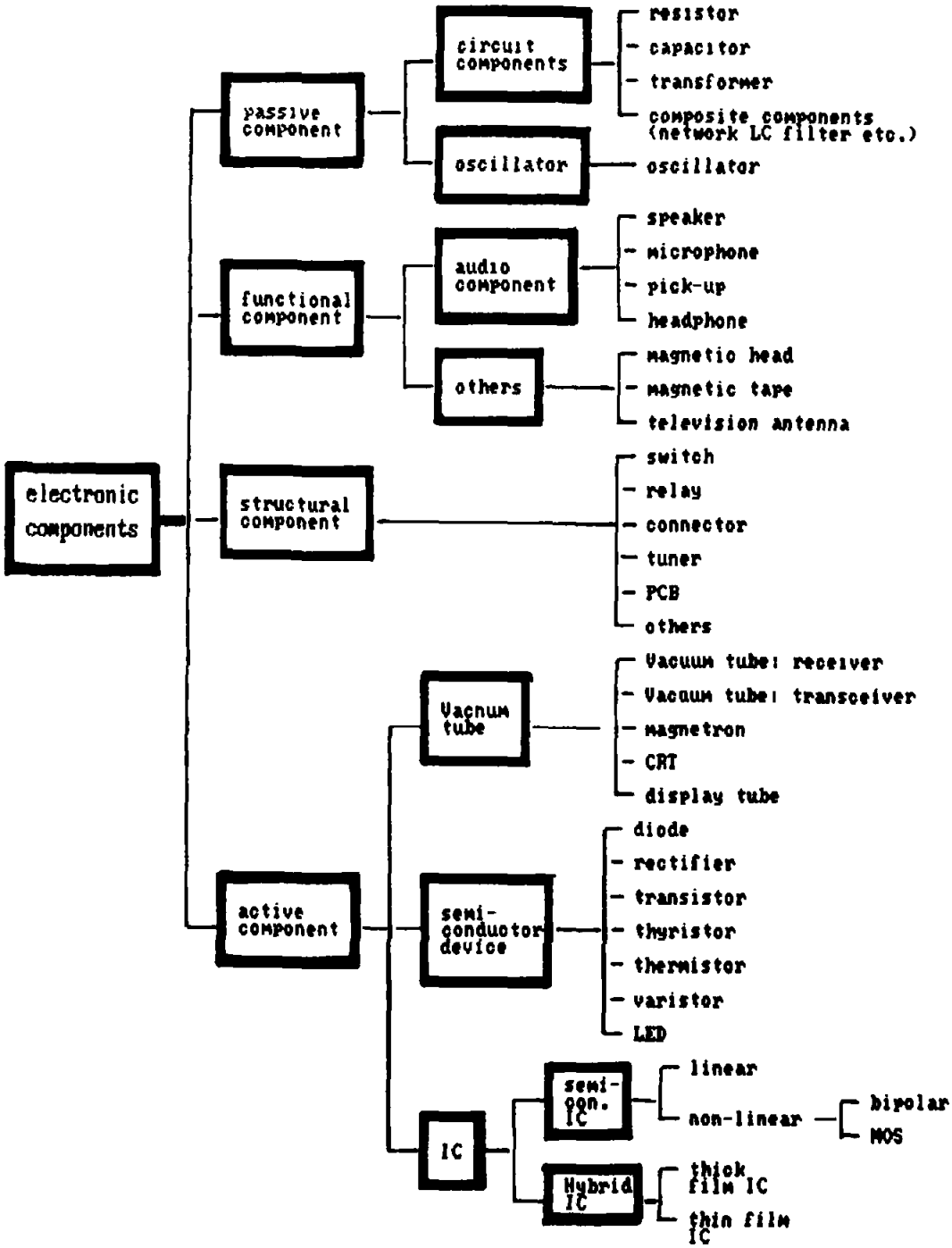
Name of Agency	Interviewee	Address & Telephone
8. Technology Transfer Centre Technology	Mr. Narong Rattana Director	Ministry of Science, and Energy Rama VI Road, Payatai, BKK. 10400 Tel. 245-9032 Fax: 246-8106
9. King Mongkut's Institute of Technology, Lat Krabang	Assoc. Dr. Kosol Petchsuwan Rector	Chalongkrung Road, Lat Krabang, BKK. 10520 Tel. 326-9157, -9964 Fax: 326-7333
10. The Communications Authority of Thailand	Mr. Somlak Sachapinan Deputy Governer	12/46-48 Chaengwattana Road., Bangkhen, BKK. 10002 Tel. 573-0099

Table A3.4 : List of Panel of Experts Consulted

Name of Expert	Organization	Address & Telephone
Ms. Orapin Werawut Deputy Director	The Office of Industrial Economics	Ministry of Industry Rama VI Road, Payatai,BKK.10400 Tel. 245-6659 (Fax: 245-6658)
Dr. Damri Sukhotanang Director	The Metal-Working and Machinery Industrial Development Institute	Department of Industrial of Promotion, Ministry of Industry Soi Trimit (Kluay Nam Thai), Rama IV, Phrakhanong, BKK.10110 Tel. 381-1051/6
Dr. Pairash Thajchayapong Governer	National Electronics and Computer Technology Centre	Ministry of Science, Technology and Energy Rama VI Rd., Payatai,BKK.10400 Tel. 247-1465 (Fax: 247-1335)
Dr. Harit Sutabutr Director	National Centre for Metal and Material Technology	Ministry of Science, Technology and Energy Rama VI Rd., Payatai, BKK.10400 Tel. 247-1455 (Fax: 247-1455)
Mr. Chakramon Phasukvanich Director	Government and Private Co-ordination Division	Office of the National Economic and Social Development Board 962 Krung Kasem, BKK. 10100 Tel. 280-0889 (Fax: 281-9263)
Mr. Chackchai Panichapat Deputy Secretaries General	Office of the Board of Investment	555 Vipavadee Rangsit Road, Bangkhen, BKK. 10900 Tel. 270-1400, -1410 (Fax:271-0777)
Mr.Khemadhat Sukondhasingha Chief Executive Office	C.M. Industry Co., Ltd.	255 South Sathorn Road, Yannawa BKK. 10120 Tel. 211-8623, -8692 (Fax: 212-7703)
Mr. Adisorn Thumaprudit Managing Director	Ayutthaya Metal Co., Ltd.	33 Group 3, KM.11 Rojana Rd., Bang-Pa-In, Ayutthaya Tel. (035) 330-103 (Fax: 271-2507)
Mr. Fungpej Boonliang Vice President	Teletech (Thailand) Ltd.	105 Moo 3 Bangna-Trad KM.52, Bangpakong, Chachoengsao 24130 Tel. (038) 631-419
Dr. Vallobh Vimolvanich Senior Vice President	CP Telecommunication Co., Ltd.	27 th Floor, 313 CP Tower, Srilom, Bangluk, BKK.10500 Tel. 231-0221/50 (Fax: 231-0190)

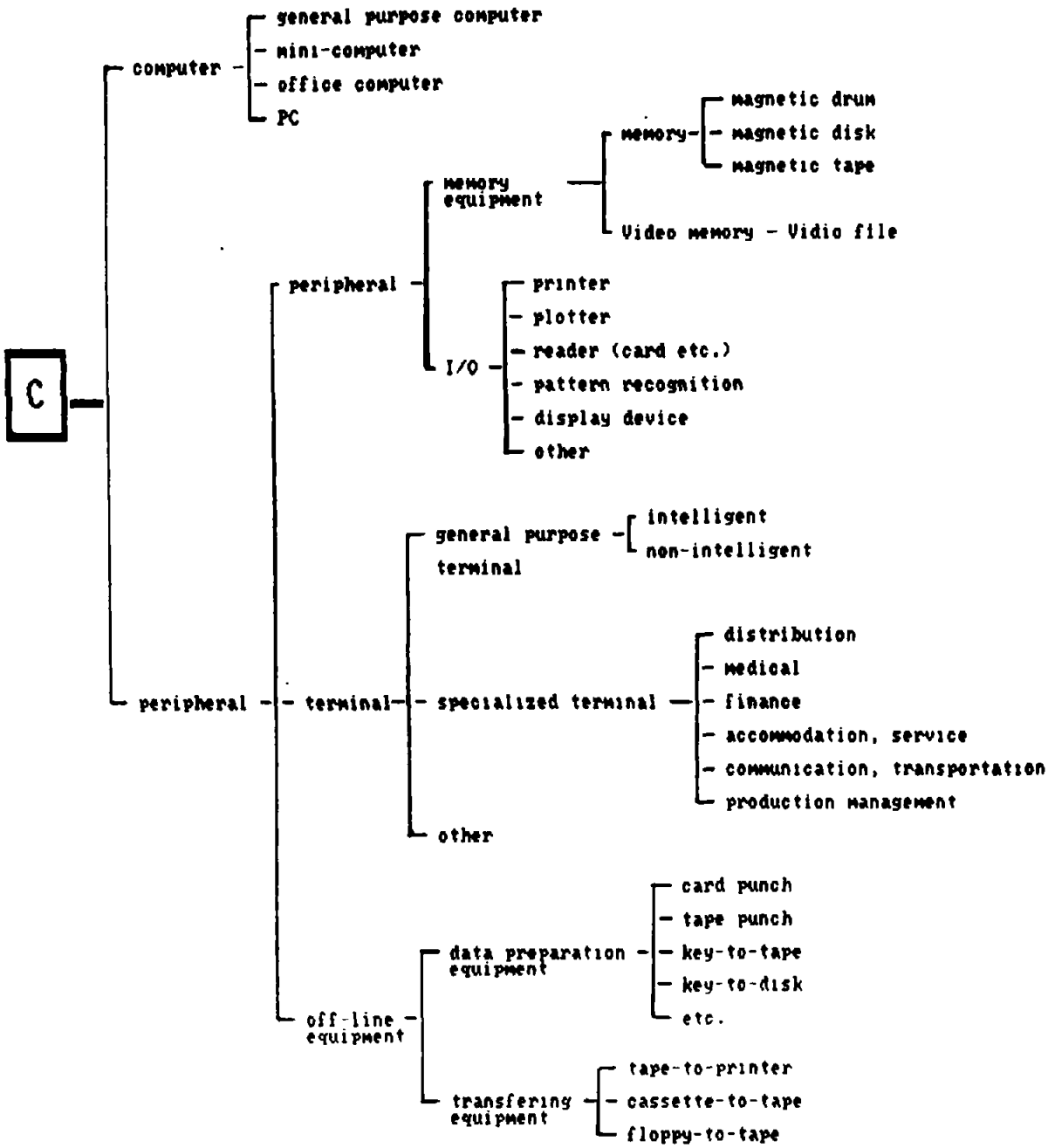
APPENDIX IV: PRODUCT TREES OF THE JAPANESE ELECTRONICS INDUSTRY

A. PRODUCT TREE OF PARTS & COMPONENT



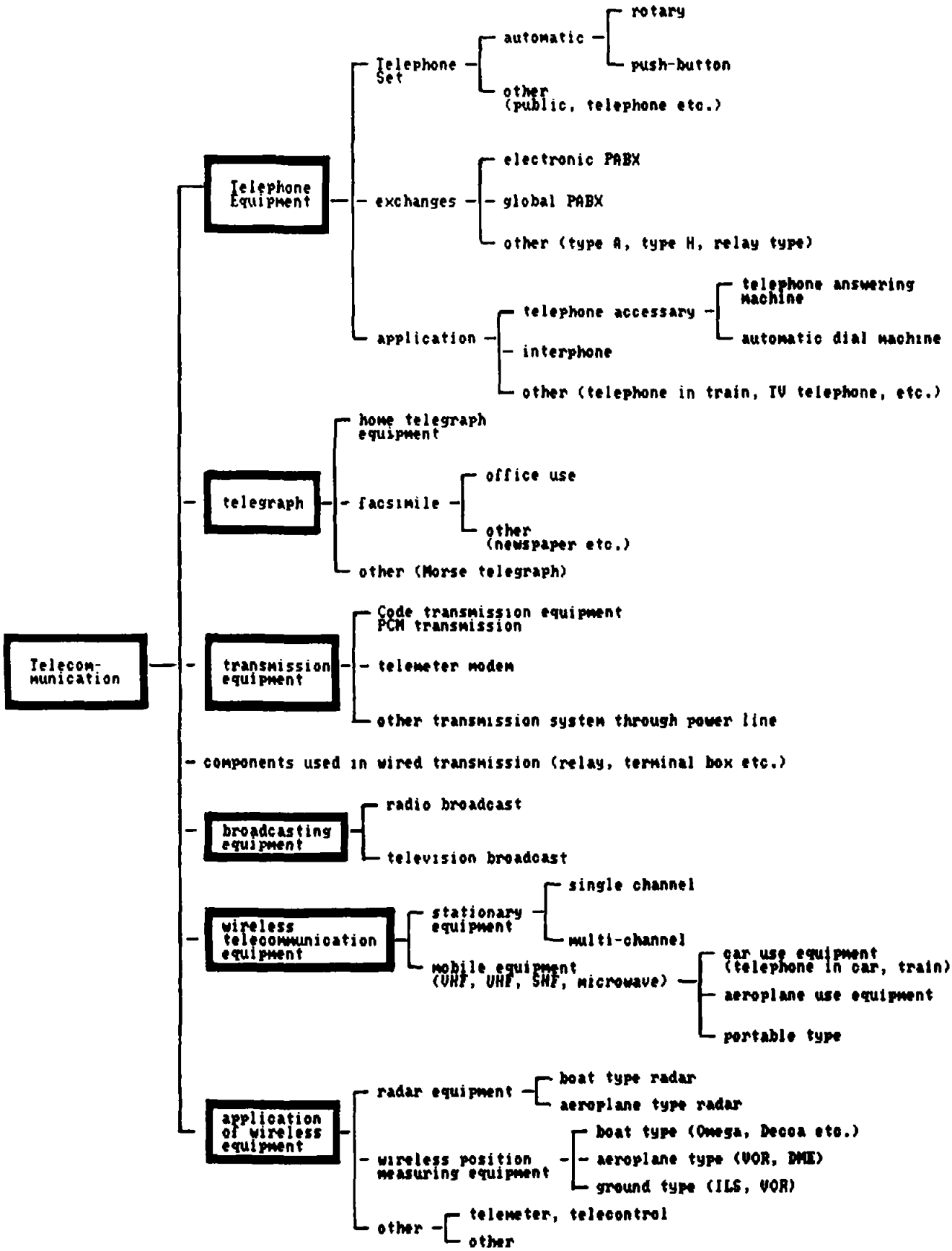
(Source) NIRA (1984) p.38 (in Japanese)

B. PRODUCT TREE OF COMPUTER



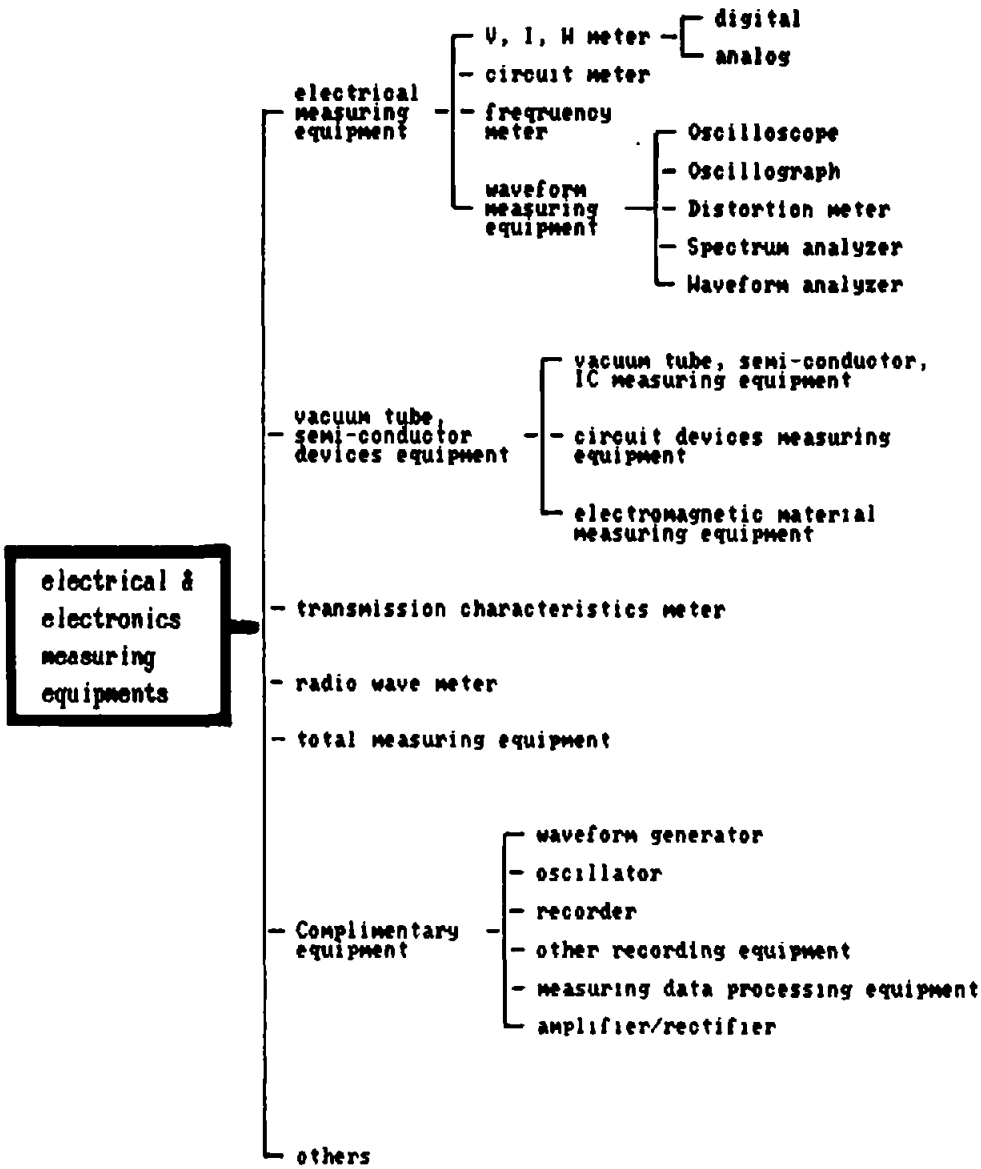
(Source) MIRA (1984) p.42 (in Japanese)

C. PRODUCT TREE OF TELECOMMUNICATIONS EQUIPMENT



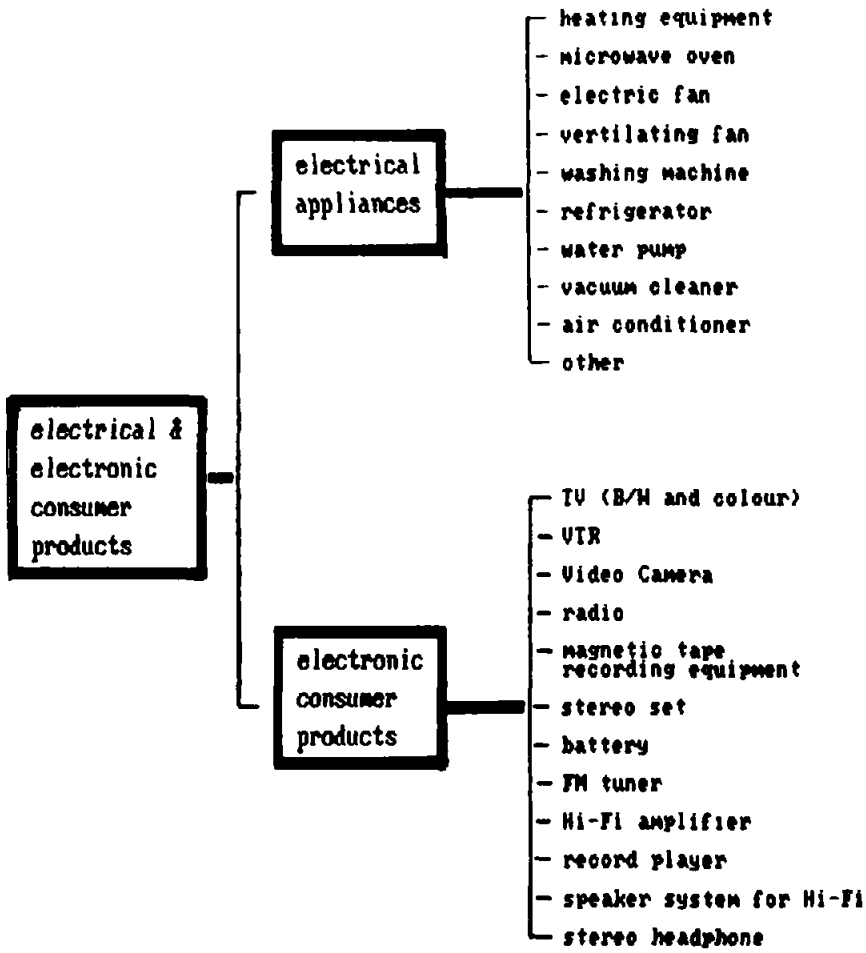
(Source) MIRA (1984) p.43 (in Japanese)

D. PRODUCT TREE OF MEASURING EQUIPMENT



(Source) NIRA (1984) p.45 (in Japanese)

E. PRODUCT TREE OF ELECTRICAL & ELECTRONIC CONSUMER PRODUCTS



(Source) MIRA (1984) p.47 (in Japanese)

APPENDIX V: DEVELOPMENT MODELS AND IMPLICATIONS FOR POLICY OPTIONS FOR THE COMPUTER INDUSTRY

1. COMPARING THE INDUSTRY IN THAILAND WITH THE ASIAN NICs

We may want to compare the structural changes in Thailand's electronics industry from consumer electronics to computers and peripherals with those in the newly industrialized countries such as Korea, Taiwan, and Singapore. In these NICs the electronics industry started with the assembly of consumer electronics catering to the domestic market in the early 1960s. By the 1970s assembly of parts and components increased rapidly and these electronics products were ready for the foreign markets. By 1980 the share of consumer electronics accounted for 40 to 50 percent of total electronics production, with most of the remainder being the production and export of parts and components.

The industrial and export structures had greatly changed from the early 1980s. In Korea, consumer electronics exports still had large share, but declined from 50 percent in 1980 to 36 percent in 1987. Parts and component exports fluctuated in the range of 45 to 50 percent. Interestingly, computer and peripheral exports increased from 6 percent in total electronics exports in 1980 to 18 percent in 1987. In Taiwan, consumer electronics export declined from 47 percent in 1980 to 27 percent in 1985. Parts and components fluctuated in the range of 45 to 50 percent and the share of computers and peripherals in total exports increased from 4 percent in 1980 to 30 percent in 1985. In Singapore, consumer electronics declined from 40 percent to 20 percent; parts and components declined from 50 percent to 35 percent; and computers and peripherals rose from nil to 30 percent [Ota, 1989].

With the computer and peripheral industry expanding at the most rapid rate worldwide in the late 1980s, it is quite likely that the share of this industry in total exports in each of the NICs has grown further. As presented earlier, these countries captured the market niches with lower end personal computers or variations of standardized products developed in the U.S., Japan, or Europe.

However, the characteristics of the industry in Thailand and the three countries differ. Computer firms in Korea are large, mostly local with some

being joint investment with Japanese MNCs, to produce personal computers and peripherals in large quantities for export to the U.S. market. These large firms normally have OEM agreements with MNCs of established brandnames to manufacture products using their designs and production technology. In fact, in Korea, a survey found that in 1986 about 40 percent of total computer exports are from the MNCs, 44 percent from OEM subcontracts; and only 16 percent from local firms exporting the products under their own brandnames [Levy, 1991].

In Taiwan, the industry started when MNCs located their plants to assemble consumer electronic goods using the low cost Taiwanese labor force in the 1960s. Later, with a higher number of skilled workers available, engineers or entrepreneurs who previously worked for the MNCs had enough capital to set up their own business or joint-ventures with foreign firms to produce imitation or standardized products at lower prices. At the beginning they may have jointly invested with foreign firms to produce brandname products on an OEM basis. By supplying products to well-known firms and letting them distribute the products under their own brandnames, these local firms can concentrate on production, leaving marketing and maintenance services to firms they supply. This is a way to overcome entry barriers due to scale economies and product differentiation. As more technological capabilities are accumulated, particularly in the areas of production and management technology and design capability, many local firms are able to develop and export their products under their own brandnames through marketing linkages with local and foreign traders.

In fact, the industry in Taiwan has many more small-sized and medium-sized local firms than does Korea and the number is increasing. Taiwanese exports of personal computers and peripherals from MNCs declined from 50 percent of total exports in the mid-1980s to 40 percent in the late 1980s. Of these, only 22 percent are exported on an OEM basis, and about 28 percent are exports from local firms using their own brandnames [Levy, 1989].

It has been documented that the computer industry in Taiwan has a higher proportion of engineers and technicians in total employment and a larger share of R&D expenditures in total sales than in any other segments of the country's electronics industry. These factors may enable Taiwanese firms to have more flexibility in adapting and designing products than their Korean counterparts. Besides, they are more capable of exporting using their own brandnames.

Korean firms merely produce at high volumes according to specifications and designs under OEM agreements. Although Korean firms' production technology is generally higher, Taiwanese firms are more innovative and their product range is much wider from various models of personal computers and peripherals, such as keyboards, monitors, and various add-on cards to key components like ASICs.

In terms of technological acquisition, Korean firms emphasize process technology to increase assembly productivity. In contrast, smaller Taiwanese firms acquire technology that allows them to produce or design new products quickly for supply to the market, and then to diversify to other products before the market is saturated with the existing standardized products or designs. Thus, by the end of the 1980s, Taiwanese firms were able to capture 15 percent of the world's personal computer production; 50 percent of world monitor production; and 40 percent of world keyboard production; and over 30 percent of world terminal production [San, 1990]. With the unit labor cost increasing in their country, Taiwanese producers will continue relocating their plants producing labor-intensive parts to various lower wage countries such as Thailand.

The industry in Singapore is completely different relying almost entirely on direct foreign investment [Lim, 1991]. Both the U.S. and the Japanese electronics MNCs relocated their plants to manufacture parts and components to gain from low wages in Singapore in the 1970s. But when Singapore adopted a high wage policy in the early 1980s, MNCs responded by moving their plants to lower wage neighboring Malaysia and Thailand. The MNCs were induced to change the assembly operations in Singapore to higher value-added and higher technology content products. In fact, by the end of the 1980s Singapore became the world's largest MNC base for the production and exports of various disk drives. However, the extent of technological capability transferred to local personnel is normally limited to production and management technology, with little design and product specific-technology.

Although it is possible for engineers or managers who had worked for a long while with the MNCs to accumulate adequate capital and technological capability to start their own operations, the number of domestic firms in the computer industry is still surprisingly limited. This is in contrast to Taiwan where there were spin-offs of local entrepreneurs in the computer and other supporting industries after having to rely mostly on electronics MNCs

for almost the whole decade of the 1960s. Taiwan now has local subcontractors and supporting industries to turn out both components and finished products. Indigenous traders capable of finding export markets for many small-sized and medium-sized manufacturers are also plentifully available [Levy, 1991].

In Singapore supporting industries are available but in relatively small number because MNCs or joint-ventures can import cheap parts and components from all parts of the world under the country's free trade system. Indigenous traders are numerous but they engage more in importing activities than marketing locally produced products for export [Lee, 1990]. Furthermore, both unskilled and skilled workers are few in number and costly in Singapore. This explains why there are not many local firms in Singapore. In fact, the Singaporean government seemed to have greater success in inducing MNCs to use automation to increase productivity than in increasing the number of small-sized and medium-sized local firms.

Furthermore, Singapore's exports under OEM agreements with foreign firms are not significant either. However, the country has the potential of increasing outward investment to neighboring ASEAN countries or China by combining their capital and skills with the region's cheap labor and to form OEM agreements with brandnames exporters. Otherwise, Singapore can supply parts to MNCs located in these countries. Thailand should prepare for receiving this kind of outward investments from the NIC countries by increasing the country's supply of skilled workers in order to attract them. By having more engineers, and skilled workers, firms in Thailand can also obtain product engineering know-how from the OEM contractors (sharing both capital and skilled labor employment with foreign investors). When capital and technological capability are finally greatly accumulated, Thailand will be in a better position to easily follow the example of the NICs.

2. POLICY OPTIONS FOR FUTURE DEVELOPMENT OF THE INDUSTRY

After comparing the development of the computer industry in Thailand with the development experience in Korea, Taiwan, and Singapore, there are at least three industry development models for Thailand to follow or make evaluations from. The Korean model relies on large firms that have joint-ventures with MNCs to assemble large quantities of micro-computers on an OEM basis. Over time, as assembly productivity increases, these firms aim to

undertake more in-house activities such as product design (circuit design for PCs) and component fabrication. In Taiwan, the industry consists of a large number of small-sized and medium-sized firms producing a wide range of computers and peripherals under both OEM agreements and their own brandnames. Local firms, in fact, dominated the industry, but all have both technological and marketing links with foreign firms. Connections with foreign firms are through being joint ventures, joint research partners, previous employees, to simply being former distributors. Due to Taiwanese firms' emphasis on improving design and marketing capabilities, Taiwan is destined to become a world producer of various low price computer peripherals and standardized PCs under their own brandnames.

The ownership structure of the computer industry in Singapore is completely different in that it is largely dominated by MNCs, with a small number of firms manufacturing personal computer and peripherals under OEM contracts. Meanwhile, local firms producing and marketing products under their own brandnames are almost non-existent. As the country's wages rose MNCs were given incentives to shift from investing in labor-intensive products to investing in more capital-intensive and technology-intensive items, to better utilize workers with higher skill levels. In addition, both foreign and local firms are inclined to take advantage of Singapore as a free trade port to diversify their investment activities so that the country can become a regional center for electronics trading and complementary maintenance and services.

To be sure the strategies and measures for developing the computer industry in the three countries are distinct. Although all countries give priority to developing human resources to increase the supply of skilled labor, the emphasis on technological acquisition and development is rather different in each country. Korea relies the least on foreign investment as a channel for technology transfer and obtaining export market access, and has, in fact, restrictive measures on direct foreign investment. The country mostly obtains foreign technology through technology license purchases, and has an international trading network through OEM contracts.

By having OEM agreements with foreign buyers, local firms as well as joint-ventures can avoid the problems of seeking computer export markets, which are currently influenced greatly by existing producers of brandname products. Firms can instead focus their activities on production and assembly

of products to meet standard requirements of the world market. In fact, foreign buyers also supply local firms with product specifications and designs. In Korea, foreign firms provide additional consultancy on import of inputs and technical assistance on installation of machinery and equipment. Frequently they arrange in-service training courses for local workers in such activities as production, testing, and even using and maintaining production equipment. They occasionally send engineers to help with trouble-shooting to ensure that production is done to standards and products are delivered on time.

Apparently Korean firms tend to invest relatively less of their own resources on product design, adaptation, and marketing activities compared to Taiwanese firms. However, they actually have very high production and assembly capabilities [Bloom, 1989]. Furthermore, since Korean firms' activities are concentrated on assembly of imported parts and components using local low-cost skilled and unskilled workers, it is necessary for them to easily obtain imported raw materials and capital equipment from the cheapest source in order to deliver low-cost and good quality products without delay. This implies that Korean trade policy must be such that these export-oriented firms with OEM contracts are able to get access to inputs or factors of production from all countries at a competitive price level.

Thus, it seems that by following the Korean computer industry development model, firms can spend relatively less on product design and innovation because the technology is widely available through foreign partners, licensers, or the foreign firms that have OEM agreements with local firms. However, local firms need to operate under such a trade policy environment that they can obtain raw materials and machinery and equipment from the cheapest source. Moreover, supply of well-trained skilled and unskilled workers should be abundantly available. Finally, firms' production or operative technological capability should be accumulated to a high level.

In Taiwan computers and computer peripherals are exported through many channels, including direct foreign invested firms, local and joint-venture OEM firms, and local firms producing products under their own brandnames. However, the number, production and exports of local small-sized and medium-sized firms are the largest among the three NICs. Taiwan's development strategy for the industry is different from the others in that the government allocates expenses and efforts on education, R&D, and innovation activities

more than in the other two.

On human resource development, the Taiwanese government's formal education system ensures that the country's supply of engineering graduates adequately meets demand. At the same time the government recruits overseas Taiwanese science and technology personnel in industry, research institutes, and academic institutions to return home. The government also encourages employers to conduct in-service training for engineers and technicians. Employees are requested to sign a contract agreeing to continue service after training and the government, in turn, strictly enforces such contract. In areas where the private sector lacks instructors, teaching materials and instruments, and infrastructural facilities, the government sets up public training institutes to provide needed services. For example, the government provides technical and productivity enhancement training programs for middle-level personnel.

To promote innovation the government sets up public-sponsored institutions to do research for small-sized and medium-sized local firms which usually lack capital to invest in long-term R&D activities. Research results are disseminated to local firms in various ways. These public research institutes can be R&D technology suppliers for private firms in order for them to reduce R&D costs and, at the same time, encourage more new product or technology development adoptions. Alternatively, research institutes can develop and license new products or technology to private firms. Private firms will only have to pay royalty fees which are lower than the cost of developing technology on their own. Finally, these institutes can set up joint-venture research programs with the government and domestic or foreign firms [San, 1990].

In addition, the government establishes science-based industrial parks for private science and technology-intensive firms to conduct R&D in order to generate new designs, new products, and if possible, new production processes. In science parks, the government finances infrastructural overhead, providing incentives and an environment conducive to innovation. Essentially the government provides physical infrastructure such as buildings, transportation, and communications. Science parks are intentionally built near research institutes or universities to foster interactions between industrial firms in the parks and nearby researchers and engineers. Firms in science parks also obtain various fiscal incentives, such tax and tariff

exemptions, similar to the incentives given to firms in export processing zones. The difference is that firms in science parks concentrate their activities on technology development.

Finally, the government attempts to boost domestic demand for computers and peripherals by training high-level personnel of both government offices and private sector firms to use automated machines so as to increase productivity and at the same time avoid the problem of rising labor cost. As such, the government's efforts to promote the computer industry and technological development are both active and comprehensive. In fact, the available large supply of highly-educated engineers and well-trained technicians, together with an environment favorable for self-conducted R&D and technology development also enable local firms to easily and more effectively absorb technology diffused or transferred from foreign firms or research agencies.

In Singapore both production and technology development strategies for the computer industry are at the other extreme. The industry is greatly dominated by multinational corporations (MNCs). In fact, it is the government's policy to attract as much direct foreign investment as possible; and in some cases also to provide extra incentives for investing in specified sectors which correlate with the country's overall development objectives. Overall both the trade regime and investment policy environment are quite liberal and neutral. Both local and foreign investors are treated equally in this free port city-state. Trade barriers are almost nil and there are no limitations on equity ownership, foreign exchange controls, or local content requirements imposed on foreign investors. Only those seeking additional investment and fiscal incentives from the Economic Development Board may be subjected to some special demand such as in production technique, technology level, and investment in R&D activities.

In addition, the government tries hard to ensure a stable political and economic situation so that foreign firms can enjoy low risks of operating in Singapore. The government also invests heavily in education to increase the supply of skilled workers, and in constructing modern infrastructural facilities, such as housing, sea and air ports, and telecommunications, for foreign firms to benefit from the convenience and efficiency. Essentially the government aims at attracting further foreign investment so that its economy can gain from high export earnings. Developing domestic technological capabilities and supporting industries seems to be secondary, and has only

until recently been given more attention.

Although the R&D to GDP ratio in Singapore has long been lower than that of Taiwan and Korea, a science park was built near a leading academic institution in the early 1980s to strengthen the collaborative research efforts between private firms and universities, and for them to benefit from exchanging staff and sharing equipment. The science park was built to provide an environment where foreign firms could invest in more R&D activities in Singapore. Since unskilled labor was in short supply and many MNCs relocated their labor-intensive activities to neighboring countries with lower labor costs, the government has tried to induce more foreign investment in technology-intensive industries and services.

Backward linkages for computer MNCs with local supporting industries are not yet widespread and so far have been confined to clean rooms, membrane switches, circuit boards and subassemblies, mother boards, and input-output boards. The government tries to promote these by providing the facilities for firms to grow and improve product quality in a competitive environment, rather than imposing local content requirements on foreign-invested firms. For instance, first, the government actively collects and provides information on available local supporting industries and acts as a broker to MNCs to link or even form joint-ventures with local firms in the supporting industries. Thus local firms have a better chance of obtaining technical guidance to produce products with satisfactory quality. Second, local skill level is upgraded and entrepreneurship is promoted so that highly skilled workers or former MNC personnel can set up firms to supply parts to MNCs. Lastly, firms providing in-service training courses are subsidized, and they enjoy the benefits of the free trade regime to import various tools and equipment used for testing or controlling product quality to meet the required standards [Lim, 1991].

Thailand thus has the options of following any of the above industrial and technological development models, derived from the development experiences of different countries. Different options are in turn associated with different policy measures and institutional arrangements. All the countries have experienced high growth in the industry, although the levels of technology and technological capabilities may vary among countries. In fact, the differences in the technological capabilities among these countries can be viewed as both the prerequisites for adopting the corresponding development strategies, or the results of using different development approaches.

In using the Taiwanese model for developing the computer industry the requirements are the most comprehensive. Skilled human resources, capital, international trading networks, supporting industries, public research institutes, and also a wide range of technological capabilities are all needed for firms to be successful in developing the industry to rely mostly on its own resources. Meanwhile, under the Taiwanese development strategy, firms are more likely to accumulate greater range of technological capabilities.

The Korean model requires a large supply of skilled labor, capital, and high production and operative capabilities, with less of other requirements stated above compared to the Taiwanese model. As a result, although production technology level in the Korean industry may be higher (due to her larger and more capital-intensive local firms or joint-ventures) than the level in Taiwan, the design and innovative technological capabilities are likely to be lower than those of Taiwan.

Finally, under the Singaporean model, development requirements for skilled labor and capital are less intensive than the Taiwanese and the Korean models, but the demand is rapidly increasing. Meanwhile, the prerequisites for technological capabilities, including the rest of the supporting activities are relatively less urgently needed. On the other hand, this particular development model would lead the country to capitalize on the industry's high growth, export earnings, increased employment, and rising real wages. However, the least technological transfer and development results should be expected.

Taking into consideration Thailand's present resource endowment, with limited skilled labor supply and technological capabilities, the prerequisites for the Singaporean model seem to be the most appropriate (for Thailand to develop in the short-run) in that they are the least demanding. The necessary supplementary economic policy measures are also similar to those which Thailand already has and is trying to improve. However, given that Thailand is also abundant in the supply of entrepreneurs and has a large domestic market (albeit with still too low purchasing power and per capita income) the ambition of following the Taiwanese and the Korean models in a more distant future should not be totally discouraged. Instead, the government should provide support, by creating a liberal, informative, competitive, and rewarding environment to encourage private firms to use their own initiatives and capability. Of course, the greater and more effective additional government

support to increase skilled labor supply and their technological capabilities, the sooner individuals or private firms will be able to seize market opportunities.