The Development of Thailand's Technological Capability in Industry

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List of Abbreviations

AI	--	Artificial Intelligence
AIT	--	Advanced Information Technology
ASIC	--	Application Specific Integrated Circuit
ATM	--	Automatic Teller Machine
BOI	--	Board of Investment
BOT	--	Bank of Thailand
CAD	--	Computer-Aided-Design
CAE	--	Computer-Aided-Engineering
CAM	--	Computer-Aided-Manufacturing
CAT	--	Communication Authority of Thailand
CCD	--	Charged-Coupled Device
CCCN/BTN	--	Customs Cooperation Council/Brussels Tariff Nomenclature
CD	--	Compact Digital Audio Disk
CD-V	--	Compact Video Disk
CIM	--	Computer-Integrated Manufacturing
CNC	--	Computer Numerical Control
CRT	--	Cathode Ray Tube
DAT	--	Digital Audio Tape
DSP	--	Digital Signal Processing
DOSS	--	Department of Science Services, MOSTE
ECRC	--	European Computer-Industry Research Center
EEAIC	--	Electrical, Electronics, & Allied Industries Club
EIBI	--	Electronics and Information Technology-Based Industry
EIT	--	Engineering Institute of Thailand
FGCS	--	Fifth Generation Computer Systems
FMS	--	Flexible Manufacturing System
FTI	--	Federation of Thai Industries
GaAs	--	Gallium Arsenide
GDP	--	Gross Domestic Product
GNP	--	Gross National Product
HDTV	--	High-Definition Television
IC	--	Integrated Circuit
ICOT	--	Institute for New Generation Computer Technology

List of Abbreviations (continue)

IEEE	--	Institute of Electrical and Electronic Engineers
IFCT	--	Industrial Finance Corporation of Thailand
INS	--	Information Network System
ISDN	--	Integrated Services Digital Network
ISIC	--	International Standard Industrial Classification
JICA	--	Japan International Cooperation Agency
JPPSCC	--	Joint Public Private Sector Consultative Committee
KMITL	--	King Mongkut Institute of Technology - Lad Krabang
KMITN	--	King Mongkut Institute of Technology - North Bangkok
KMITT	--	King Mongkut Institute of Technology - Thonburi
LA	--	Laboratory Automation
LAN	--	local-Area Networks
LCD	--	Liquid Crystal Display
LED	--	Light Emitting Diode
LSI	--	Large Scale Integrated Circuit
MAP	--	Manufacturing Automation Protocol
MIDI	--	Metal-working Industries Development Institute
MIPS	--	Million Instruction Per Second
MCC	--	Microelectronics & Computer Technology Corporation
MITI	--	Ministry of International Trade and Industry
MOC	--	Ministry of Commerce
MOE	--	Ministry of Education
MOF	--	Ministry of Finance
MOI	--	Ministry of Industry
MOPH	--	Ministry of Public Health
MOSTE	--	Ministry of Science, Technology and Energy
MUA	--	Ministry of University Affairs
NC	--	Numerical Control
NECTEC	--	National Electronics and Computer Technology Center
NESDB	--	National Economic and Social Development Board
NIC	--	Newly Industrialized Country
NSO	--	National Statistical Office
PABX	--	Private Automatic Branch Exchange
PCB	--	Printed Circuit Board

List of Abbreviations (continue)

PLA -- Programmable Logic Array
PLC -- Programmable Logic Controller
PSTN -- Public Switching Telephone Network
QC -- Quality Control
R&D -- Research and Development
RAM -- Random Access Memory
RD&E -- Research, Development, and Engineering
RISC -- Reduced-Instruction-Set Computer
ROM -- Read Only Memory
SKD -- Semi Knocked-Down
S&T -- Science and Technology
SMT -- Surface-Mount Technology
SO -- Small Outline
STDB -- Science and Technology Development Board
TDRI -- Thailand Development Research Institute
TIAC -- Technical Information Access Center
TISTR -- Thailand Institute of Scientific and Technological Resear
TPA -- Technological Promotion Association
TSIC -- Thailand Standard Industrial Classification
TTC -- Technology Transfer Center
TOT -- Telephone Organization of Thailand
VAT -- Value-Added Tax
VLSI -- Very Large Scale Integrated Circuit
VTR -- Video Tape Recorder

CHAPTER 1

INTRODUCTION

1.1 Prologue

1.1.1 Introduction

The technological development of the electronics industry has been extremely rapid and has had tremendous impacts on the way in which society functions. Recent advances have led to electronics components being incorporated in an increasing number of consumer and industrial products, greatly enhancing their efficiency and reducing the cost. Nowhere has this revolution been so keenly felt as in the computer industry. The cost of computing power has fallen drastically over the past two decades so that almost every activity from the home to the office to the factory can now afford to avail themselves of the so-called power of the computer.

These trends have ushered in a new phase in the history of human evolution that is commonly referred to as the "information age". Information is now assuming the center stage and the linkages between the information industry defined broadly and the rest of the economy are becoming stronger and more complex. As such, the importance of the manufacturing part of the electronics industry stretches far beyond its contributions to value-added in a limited sense. Furthermore, the ability of the firms in the manufacturing sector to acquire and use more effectively the new developments in the technology will have wide repercussions on the society's ability to obtain the maximum benefits from the advances.

Accordingly, this study aims to place the electronics and information-based industry in Thailand into its proper perspective by evaluating the technological capabilities of the industry and examining its linkages with other industries and institutions. In this way, we hope to be able to demonstrate to policy-makers and the population in general the importance of a coherent industrial and technological strategy to create an environment within which the electronics and information-based industry can grow and play the supporting role that it has already achieved in many developed countries as well as the newly industrialized countries (NICs) of East Asia.

1.1.2 Scope and Outline of the Study

Following a summary of global trends in production and technologies in the electronics and information technology-based industries (EIBI), chapter 1 presents an analysis of the structure of the EIBI in Thailand and its role in generating output, employment, and exports. The conceptual framework for the analysis of technological capabilities is then discussed, summarizing some major contributions to the literature and defining some of the terms that will be frequently used throughout the remainder of the study.

Chapter 2 details the policy environment within which the industry has been developing, covering both policies which implicitly affect technological decisions including trade, investment, and fiscal policies, and those which explicitly deal with technical matters including technology transfer, research and development, and science and technology manpower policies. Before summarizing the major weaknesses and strengths of the present environment, a comprehensive picture of the science and technology support infrastructure is presented.

Chapter 3 contains an analysis of the present profile of the various types of technological capability possessed by firms in the EIBI. Following a brief description of the survey process and the firms surveyed, the chapter analyses the present profiles of the various types of technological capabilities at the firm level. A number of firm-level characteristics such as ownership, size, type of industry, and export orientation are used to examine differences in technological capability levels between various groups of firms.

Chapter 4 examines in more detail the processes by which firms in the electronics industry acquired the various technological capabilities. The types of firm-level behavior or strategies that influence the development of technological capability and the determinants of such behavior is examined in order to identify the kinds of market and policy failures that need to be addressed. Special consideration is given to the nature of foreign involvement in the electronics industry and to the role of human capital formation.

Chapter 5 proceeds to examine the likely scenarios in the development of the various components of the EIBI in Thailand and identifies the types of technological capabilities and supporting infrastructure that will be necessary in order to ensure that they grow in the most efficient and beneficial way. The important linkages between the EIBI and many other industrial sectors play an important role in the analysis of this chapter.

Chapters 6 and 7 present the policy conclusions of the study. The former discusses a number of strategies that will be necessary to ensure that the existing technological gaps are filled and that the future required technological capabilities as outlined in chapter 5 are acquired. The latter summarizes the policy conclusions of chapter 6 in a more concrete way by outlining a detailed list of policy recommendations for the major institutions involved in the implementation of policies that directly or indirectly affect the acquisition of technological capability.

1.1.3 Definition Of Electronics and Information Technology-Based Industry

Electronics technology is a discipline which deals primarily with small amplitude electrical signals in contrast with the large amplitude, large power signals in the case of electrical technology. Electrical energy supplied to electronics products is used basically to process the signal into an energy form that we can perceive. These include such processes as driving a speaker to make sound and stimulating a cathode ray tube to make visible images. The power consumption of electronic products such as radios, televisions, microcomputers, and transceivers is accordingly much lower than that of electrical products such as refrigerators and air conditioners.

With the technological progress in digital technology and the emergence of electronics components such as microprocessors, electronics technology became able to process not only small electrical signals but also information in digital form. Developments in microprocessors make it possible to combine two important functions - information processing and information transmission - in one single item of equipment. This greatly extends the scope of electronics technology to cover the so called information technology industry.

Accordingly, the electronics and information technology-based industry comprises activities which manufacture products whose functions are made possible primarily through the use of electronics and information technology.

1.2 A Global View of the EIBI

1.2.1 A Global View of the Impact of Electronics Industry and Technology

The world production of electronics products has grown more rapidly than other industrial categories over the last several decades. In the United States, for instance, the electronics industry is growing one and a half times faster than the rest of the economy (Electronics Business, Jan. 1988). It is expected that, globally, the growth rate of the electronics industry for the next five years should continue to be at least 8-10% per annum (World Bank, 1988) In the case of the United States, electronics products comprised 15% of the total manufacturing sector in 1986, and the figure is expected to increase to 16.3% by 1988 and 17.2% by 1991 (Electronics Business, Jan. 1988).

In the case of Japan, the annual average growth rate of the electronics industry in the late 1970s was 16.7%, almost twice as fast as the 9.8% growth rate of GNP (Hayano, 1983). This amazing performance has turned electronics into the country's leading industry. In 1982, electronics industry output comprised 4.55% of total Japanese manufacturing, while the industry value added accounted for 8.78% of total manufacturing value added. In terms of employment, almost 900,000 people worked in the industry, placing the electronics sector at the top of the employment league, even ahead of the automobile industry. Furthermore Japan's exports of electronics products comprised 15.7% of her total manufacturing exports (World Bank, 1986, and Hayano, 1983).

As a result of this growth, the electronics industry is quickly becoming one of the largest manufacturing industries. By the year 2000, the annual output value of electronics products is expected to exceed one trillion US$ (World Bank, 1988).

Table 1.1 shows the number of corporations in three of the major industry groups listed by Fortune magazine as the world largest industrial corporations, their total sales, and their shares in the total sales of the top 50 corporations. From the table, the steady growth of the electronics industry is evident as can be seen from number of the largest firms which increased from 7 in 1982 to 9 in 1986. Total sales of the largest electronics corporations rose from 141 billion US$ in 1982 to 244 billion US$ in 1986. This helped to increased the electronics industry share in the total sales of the 50 largest corporations to 18.6% in 1986.

Table 1.1

Contributions of Various Sectors to the Total Sales of the World's 50 Largest Industrial Corporations

Year	Industry	No. of Corporations listed	Total sales per industry ('000 $)	Percent of sales of top 50 corporations (%)
1982	Petroleum	21	669,991,950	54.0
	Auto	9	205,032,953	16.5
	Electronics	7	141,002,493	11.4
1984	Petroleum	22	651,815,000	50.3
	Auto	9	256,366,400	19.8
	Electronics	8	194,024,270	15.0
1986	Petroleum	15	419,112,853	31.9
	Auto	11	362,640,212	27.6
	Electronics	9	244,012,978	18.6

Source: Compiled from Fortune magazine (Aug. 1983, Aug. 1985, Aug. 1987)

Market estimations for the major electronics products for 1988 are shown in Table 1.2. Products are classified into two groups, namely equipment and components. Equipment comprises a wide range of items including consumer products, communications products, computer-aided-design equipment (CAD), industrial electronics, data processing, testing and measuring equipment, and software. Components comprise discrete and integrated semiconductor devices, opto-electronics devices and so on.

From Table 1.2, we can see that data processing and communications equipment have grown into the largest items. When combined, they comprise more than half of the whole market for electronics products. The most important reason for this phenomenon is the development of electronics technology in general and the integrated circuit (IC) technology in particular. This is because technological changes in IC design and production have helped to increase the scale of IC integration which upgrades speed, reliability, function options, and cost performance. These changes, combined with rapid development in digital technology, have facilitated the development of new communication and data processing related products such as: key telephones, facsimiles, telephone switching equipment, computers, and so on. Furthermore, as electronics technology has proceeded towards the "programmability" of components and equipment, software has emerged rapidly into a billion dollar business comprising almost 10% of the total market.

Table 1.2

Market Estimations for Major Electronics Products for 1988

(unit: million US$)

Market / Product	Total Value	Total %	United States	Japan	Europe
<u>Equipment</u>	390,157	79.1	167,824	128,272	94,061
Consumer products	68,267	13.8	23,460	26,479	18,328
Communications	61,898	12.5	26,784	13,807	21,307
CAD/CAE	3,613	0.7	1,705	849	1,059
Indust. Electronics	19,440	3.9	6,029	6,666	6,745
Data processing	186,177	37.8	83,058	58,748	44,371
Power supplies	3,140	0.6	n.a.	2,506	634
Test and measuring	9,744	2.0	6,622	1,505	1,617
Software	37,878	7.7	20,166	17,712	n.a.
<u>Components</u>	103,082	20.9	40,241	45,508	17,333
Discrete semi device	6,642	1.3	2,094	3,319	1,229
IC	33,091	6.7	13,127	15,586	4,378
Opto-electronics	3,391	0.7	384	2,629	378
PCB	10,374	2.1	5,135	3,065	2,174
Others	49,584	10.1	19,501	20,909	9,174
Grand Total	493,239	100	208,065	173,780	111,394

Source: Electronics Business, January 7 and January 21, 1988

In addition to its own growth, the development of the electronics technology and industry has significantly influenced the course of development of many other industries and, in some cases, even helped to open up new ones. In the field of production machinery, for example, the fast evolving IC technologies have helped to create a new industry to manufacture semiconductor production equipment. World wide sales of such equipment was estimated to be around 7.2 billion US$ in 1988 (Electronics Business, Jan. 1987). Robots, computer numerical control (CNC) machinery are some major products made possible as a result of introducing electronics technology into machinery manufacturing. As a result, it becomes possible to have machinery controlled by sophisticated electronic controllers that can perform very high precision jobs with sub-micron level accuracy. The emergence of these products also helps to upgrade high precision technology and opens up many new possibilities to be explored.

The various impacts of changes in electronics technology on industrial development can be summarized as follows:

1) Impacts on product technologies

- on electronic products: the increasing scale of integration in ICs brings about similar miniaturization trends in other passive and functional devices. These support the trend for electronic equipment to become smaller and lighter while increasing the number of functions, the speed, the reliability, and the cost performance.

- on other products: the replacement of mechanical mechanisms by electronic ones such as electronic watches and numerical control machinery or the introduction of electronic mechanisms to improve the functions of products such as the automobile.

- impacts on design, production and research and development activities: the application of computer to support activities such as CAD, computer-aided-engineering (CAE), computer-aided-manufacturing (CAM), and laboratory automation (LA).

2) Impacts on production technology

- photolithography: the application of this technology in production of crystal oscillators, light filters, etc.

- gas phase growth technology: application in optical fiber production.

- ultra pure water, clean room technology, applications in medical supplies production and also in development of biotechnology.

3) Impacts on and interaction with other technologies

- material development: the need for new materials to use in areas where silicon is relatively weak brought about new research and development in compound materials such as gallium arsenide (GaAs). The development of this material is an essential step towards the realization of optical ICs.

- sensor technology: the role of this technology is growing due to the need to detect physical and chemical information for electronics equipment. For example, microprocessor-based microwave ovens use thermostats and ceramic sensors to detect temperature and humidity within the oven.

- artificial intelligence technology: this new discipline is a result of various developments in interrelated areas such as pattern recognition, automatic machine translation, and expert systems.

1.2.2 The NICs and the Electronics Industry

The electronics industry has been contributing significantly to the social, economic and technological development of the Asian NICs : Korea, Taiwan, Singapore, and Hong Kong. The following discussion will try to briefly explore the industry's role in three major areas: foreign currency earning, job creation, and as an engine for economic growth.

Foreign currency earning. Table 1.3 shows the values of electronics products exported from Korea, Taiwan, Singapore and Hong Kong compared to that from Thailand. It can be seen that the export values of electronics products from the Asian NICs are sizable, and even the island economy of Hong Kong managed to export electronics products with values five times larger than Thailand. In the case of Korea, about 59% of total electronics production in 1983 was exported accounting for about 13 percent of total manufactured exports (ADB, 1985, and World Bank, 1986). In Taiwan, exports of electronics products in 1987 increased by 53.6% over 1986 to a value exceeding 10 billion US$, accounting for about 20% of the country's total exports (DKB, 1988).

Job creation. Contrary to the general perceived view of the electronics industry as a highly capital intensive industry, electronics employment in the NICs is high both in relative and absolute terms. Table 1.4 shows figures of electrical and electronic industry employment and their shares in total manufacturing employment and total employment in the Asian NICs. Employment in electrical and electronics industries in these countries as a percent of manufacturing employment ranged from about 12% in the case of Korea to as high as 45% in the case of Singapore.

Table 1.3

Exports of Electronics Products from Asian NICs and Thailand in 1981

(unit : million US$)§

Country	Computers & Calculator	Telecommunication Equipment	TVs & Radios	Active Electronic Comps.	Sound Recorder	All Electronic Products
Korea	38,965	272,708	845,308	524,556	161,760	1,843,297 4,204,000 (1)
Taiwan	n.a.	n.a.	n.a.	n.a.	n.a.	10,579,200 (2)
Singapore	84,949	320,691	916,692	1,093,055	143,444	2,558,831
Hong Kong	74,296	151,845	730,195	228,982	117,605	1,302,923
Thailand	1,208	1,929	6,215	283,824	24	293,200

Notes : (1) 1984 figures, (2) 1987 figures.

Sources: UNCTC (1987), DKB (1988), World Bank (1986)

Table 1.4

The Employment Situation in the Electrical (ISIC 383) and the Electronics (ISIC 3832) Industries in the Asian NICs

	ISIC Code	Korea (1981)	Taiwan (1983)	Singapore (1981)	Hong Kong (1981)	Thai (1981)
1. Employment	383	211,800	n.a.	85,470	124,800	
	3832	151,100 (1)	250,000	65,770	93,800	41,628
2. Employment as % of manufacturing employment	383	7.37	n.a.	25.79	13.78	-
	3832	5.26 (2)	13.50	19.46	10.35	2.0
3. Employment as % of total employment	383	1.51	n.a.	7.68	6.05	
	3832	1.08	7.00	5.91	4.55	0.8

Note : (1) and (2): World Bank (1986) gave these figures for the year 1983 as 187,628 and 8.33 respectively.

Sources: UNCTC (1987), p.9., APO (1984), p.7.

<u>An engine for economic growth</u>. The volume of electronics production in Taiwan amounted to 5.5 billions US$ in 1983, accounting for almost 12% of total manufacturing output. In the case of Korea, the average growth rate of electronics industry output between 1970 & 1980 was 45.5% in compared with 18.5% for the whole manufacturing sector in the same period. Some important statistics of electrical and electronics production for the Asian NICs are summarized in Table 1.5. It can be seen that the share of electronics industry value added in total manufacturing industry value added is relatively high, ranging from 5.79% in the case of Korea to 14.94% in the case of Singapore.

From the statistics cited above, we can conclude that the electronic industry in the Asian NICs has been playing an important role in their rapid development and economic growth.

Table 1.5

Contribution of Electrical (ISIC 383) and
Electronics (ISIC 3832) Industries in the Asian NICs

	ISIC Code	Korea (1981)	Taiwan (1983)	Singapore (1981)	Hong Kong (1981)
1. Value of output (millions of US dollars)	383	5,479.9	n.a.	3,208.7	4,062.6
	3832	3,732.6	5,522 (1)	2,940.7	2,240.2
2. Value added (millions of US dollars)	383	1,936.8	n.a.	953.3	1,193.5
	383	1,936.8	n.a.	690.1	598.4
3. VA as % of mfg. VA.	383	8.56	n.a.	20.64	16.62
	3832	5.79	n.a.	14.94	8.34
4. VA as % of GDP	383	2.82	n.a.	7.02	5.15
	3832	1.91	n.a.	5.08	2.58

<u>Note</u> : (1) 1983 figure.

Sources : UNCTC (1987), p.9., APO (1984), p.7.

1.2.3 Strategies for Electronics Industry Development

Detailed investigations of the experiences of certain advanced developing countries allow three broad types of private sector strategies for electronics development to be identified. The major electronics firms in these countries have generally pursued a mix of these strategies with some differences in emphasis.

The first is generally known as the "leapfrog" strategy. Its rationale is that the nature of technological change in the electronics industry is such that firms are able to bypass certain intermediate stages of technological development and move directly to the mass production of certain high technology products. Brazil's direct move to tackle digital telecommunication technology, a frontier technology, by bypassing the previous stage of analog technology is one conspicuous case of this strategy. The recent case of the Korean semiconductor manufacturers moves to bypass the intermediate levels of circuit integration and directly produce very large scale integrated (VLSI) circuits provides another striking example.

The second strategy is to capitalize on the advantages of being the latecomer by moving into areas of electronics industry where most industrialized countries are losing their comparative advantage, either because of high labour costs, the loss of the technological edge, or both. Many Korean firms have moved in to produce simple computer terminals, telephone instruments, black and white picture tubes, and other discrete transistors and managed to capture a sizable share of the world market. Similar cases can be seen in Taiwan and Hong Kong.

The third strategy is to focus more on market niches rather than on high volume markets for standardized products. The approach is an attempt to fully utilize the advantages of a developing country, including its cheap but competent manpower, in production areas where massive investments in equipment is not required. However, a relatively high level of technological capability is required for firms to develop in this direction. Design capability is probably the most essential part of this requirement. Such a strategy would, in the case of electronics component production, focus on semi-custom and custom ICs instead of the high volume standardized ICs.

In Taiwan, the owners of firms specialized in market niche production are generally engineers or technicians who used to work with "hi-tech" multinational corporations operating in Taiwan. After gaining sufficient technological capability and in a conducive environment created by the government, they resigned and set up their own firms. This approach is beneficial in two aspects. Firstly it is a very efficient way to transfer technology. Secondly, such small firms with technological capabilities would gradually form into a solid base for the future development of indigenous "hi-tech" industries. In sum, this strategy is an attempt to utilize the human capital of the developing country as opposed to the physical capital of the multinational corporation.

All these strategies have their own strengths and weaknesses. It may be possible for an individual firm to focus on a particular strategy, but it would potentially be disastrous for a country to do so. In order to develop on electronics industry with sufficient technological capabilities, policy makers have to intelligently utilize an appropriate mix of these approaches to steer the electronics industry to the desired goal.

1.3 Technological Trends in Electronics and Information-Based Industries

In this section, the major technological changes and trends in EIBI are briefly described. In order to do this, the technologies to be discussed will be classified into: the material level (the most basic and fundamental); the component level; the board level; the equipment and systems level; and the computer system and software level.

1.3.1 Material Level

The most important basic material used in EIBI is silicon crystal. Changes in technology in the material level involve two major trends. One is to increase the diameter of the silicon wafer. The other is to substitute silicon with other prospective material, gallium arsenide (GaAs). The standard wafer diameter being used by the industry in the 1970s was three inches and improvements in crystal growing technology make it possible to produce a larger diameter wafer. A survey of 42 American firms engaged in microlithography operations in late 1983 showed the distribution of wafer sizes actually in production and planned within the next 12 months (see Table 1.6).

Table 1.6
Distribution of Wafer Sizes Used in American Firms

	Wafer sizes in production (%)	Wafer sizes planned in next 12 months (%)
3 inches	34	5
4 inches	56	21
5 inches	10	37
6 inches	-	34
not specified	-	3

Source: Semiconductor International, November 1983, quoted in UNCTC (1986)

Another trend in technology at the material level is to look for other materials to substitute for silicon, for both economic and technical reasons. This is because the cost of silicon (per square inch) after decreasing steadily for many years levelled off in 1978 and has remained more or less constant since then. On the technical side, there are certain physical limits to the operational speed and the level of integration obtainable with silicon. *Gallium arsenide* is considered to be one of the most promising new materials given its high speed compared to silicon as well as its high prospects in opto-electronic devices due to its compatibility with visible electromagnetic wave.

It is reported that sample production of a commercial gallium arsenide on silicon wafer was announced in late 1987, uniting the high speed and opto-electronic capability of gallium arsenide with the low material cost and superior mechanical and thermal properties of a silicon substrate (IEEE *Spectrum*, Jan. 1988).

1.3.2 Components Level

Electronic components are the basic parts that make up electronic equipment and systems which are discussed below in section 1.3.4. Components are usually considered to be either "active" or "passive". Active components are mainly semiconductors which amplify or modulate electrical signals, or rapidly switch voltages and currents to generate signals that can be stored (memory), added to or subtracted from other signals (logic), and transmitted. Semiconductor components make up almost 50% of the total value of the world production of components. However, cathode-ray tubes, which provide the pictures for television sets and the screens for computers, are also considered to be active components, as are electro-optical devices such as photo-cells and power tubes used in broadcasting and radar.

Passive components, often called electronic parts, are those which do not contribute to the electrical signals, but simply carry them from one active component to another (wire and cable, and connecters); or which store electrical energy (capacitors and coils), raise from lower voltages (transformers), or limit current flow (resistors).

The two major technological trends in the electronic components are miniaturization and surface-mount technology (SMT).

Miniaturization is not confined to just making individual components smaller, although this trend continues. Miniaturization also includes: the substitution of tiny integrated circuits for much larger passive components such as capacitors and resistors; the substitution of individual ("discrete") semiconductors for much larger power tubes; and the replacing of discrete semiconductors with integrated circuits. Surface-mount technology also can contribute to the reduction in size and weight of as much as 30% to 40%.

As future information systems will become more intelligent and broadband, and will incorporate light wave networks to enhance integrated communications capabilities, components are also being researched and developed that will contribute to these developments. Electronic devices will become more photonic (i.e. photon + ic as against the present electron + ic) for high-speed digital transmission and switching.

1.3.3 Boards Level

Most electronic equipment have their circuit mounted on a printed circuit board (PCB). The PCB is a copper-clad insulator sheet where the copper is chemically etched into patterns to provide connections between components. Components have their leads or legs wired through holes drilled on the board to be connected to the copper pattern on the other side of the board by soldering.

When a high density of components on the board is required, more than one layer of copper pattern for interconnection can be used. Such multi-layered boards of up to 30 layers have been produced. Plated-through-hole PCBs are used for interconnection between copper patterns on various layers of the board.

Recently, the SMT has become more and more popular. Component legs are soldered to the copper on the same side of the board. Therefore, no hole needs to be drilled for component legs although some are needed for interconnection between the patterns of both sides. Components are mounted on both side of the board resulting in a higher density. The component industry has also produced a new set of components called surface mount devices (SMD) which are much smaller. ICs have also been produced in a new set of packages with smaller outline (SO).

In the design of interconnection pattern, computer-aided-design is being extensively used both at microcomputer and minicomputer level to memorize the pattern, to provide a library of packages, and to find a suitable connection path. In mass production, numerically controlled machines are used to drill holes, and components are placed in the PCB using automated insertion machines.

The IC packages on the board are becoming larger, resulting in fewer components and very few discrete components. The circuit itself is increasingly changing from analog to digital. Complex circuits are microprocessor-controlled with a steady movement towards real time digital signal processing (DSP).

1.3.4 Equipment and Systems Level

Electronic equipment and systems provide home entertainment in the form of radios, televisions, video cassette recorders, CD players, cameras, audio equipment, and personal computers as well as telephone services and television broadcasts; and which supply offices, industry, and commercial establishments with typewriters, computers, copying machines, measuring and control devices, robots, and cash registers. The military is one of the largest users of electronic systems, for radar, for search and detection equipment, and for navigation and guidance systems. Other uses for electronics products range from watches to traffic lights to microwave ovens to electric eyes that open doors or set exposure for cameras. In the medical field, the use of electronics has now gone far beyond just X-ray machines. Ultrasonic imaging enables us to see a few weeks old fetus in vivo and computer tomography provides sectional images of the human body. The new cars of today are incorporating electronics to replace carburetors and distributors, and to provide anti-lock brakes and cruise control.

The equipment itself consists of a group of circuits which performs certain functions of signal processing with or without the input and output for human interfaces. Examples of equipment are televisions, telephones, X-ray machines, radar equipment, and so on. Traditionally, most of the processing is done using analog technology. With the advent of ICs and microprocessors which make digital computing power cheaper and cheaper, digital circuits are increasingly used in equipment to replace their mechanical or electrical counterparts. This process adds features such as programmability, replaces analog electronic components, or creates a new type equipment that was not possible before. Examples of such applications are timers, washing machines, audio compact disks, and personal computers.

Another development is in power electronics where solid-state devices are used to handle high power levels. A variable-frequency inverter can control the speed of an induction motor over a very wide range at a power level of several hundred kilowatts.

A collection of equipment can be interconnected to form a system to provide certain functions or services. The best known is the telecommunication system where any pair of the over 100 million telephones worldwide can be linked up with each other. Smaller systems include: the feedback control system of a factory; the automatic test and measurement system of manufacturing equipment; and the data acquisition system of a process. Nowadays these systems invariably contain digital circuits and microprocessors, and computers and certain system software are required to enable them to function. The language used may be low level assembly language for smaller systems or a high level language such as C for large systems.

1.3.5 Computer Systems and Software

At this point of time, computers have already gone through four generations of evolution and attempts are now being made through various R&D organizations to push the computers towards their fifth generation by the end of the 1980s (see Figure 1.1).

The mechanism of the previous four computer generations has been based on the so-called von-Neumann architecture which is characterized by features such as stored-programs, addressable memory, sequential processing, and numerical calculations. The realization, development, and improvement of such machines has evolved mainly around their hardware structures: 1st generation - vacuum tubes; 2nd generation - transistors; 3rd generation - ICs; 3.5th generation - LSIs; and 4th generation - VLSIs.

The 1980s will see the continued existence of the present von-Neumann computers that are excellent for algorithmic processing (for such purposes as accounting, computing, modeling and the like) as well as a new generation of intelligent machines that are ideal for pattern recognition, expert judgement, automatic programming, and natural language translation.

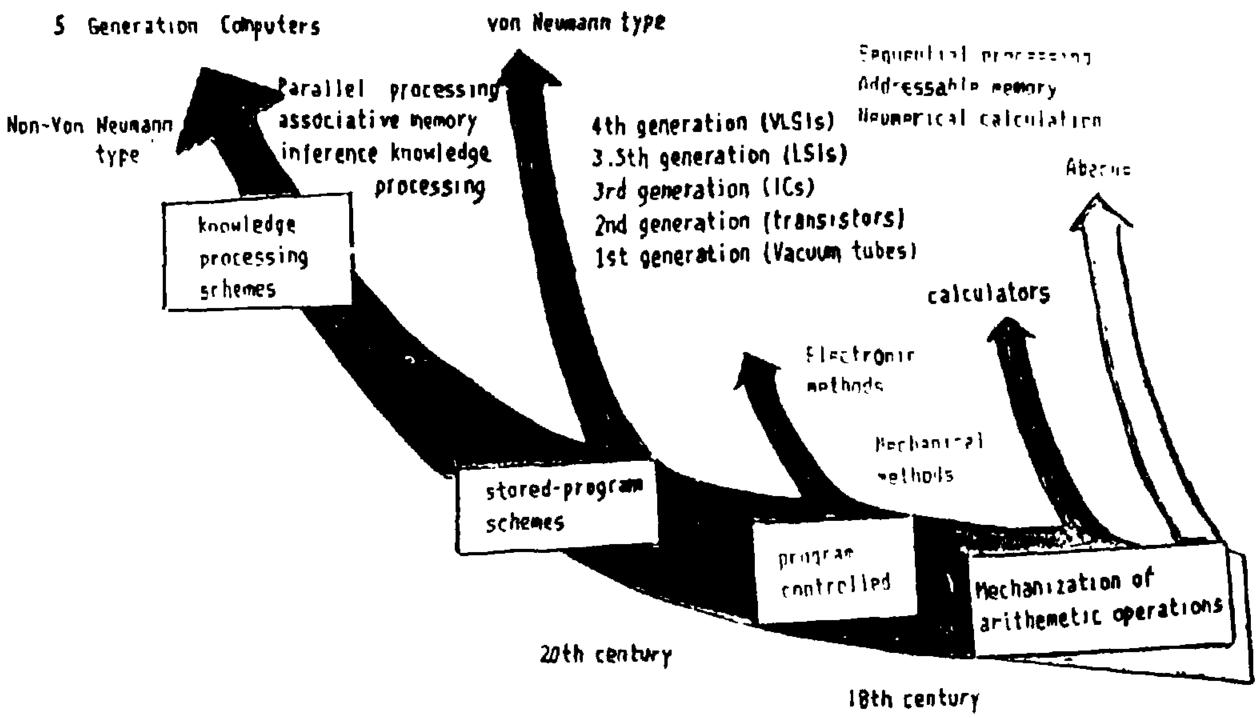
The fifth generation computer is being developed based on a technological scheme drastically different from those that have gone before. It is a non-von-Neumann machine characterized by such features as parallel processing, associative memory, and inference knowledge processing that is similar to that of a human being (see Figure 1.2).

Table 1.7 summarizes the major international R&D projects on advanced computer systems.

The classical hardware/software cost trend as demonstrated by Boehm (1983) and shown in Figure 1.3 indicates a cost ratio of 10:90 between the software development and software maintenance. The technology for zero-defect software has been sought after and will continue to be the main topic (Hamilton, 1986). The productivity and quality of the software industry will then improve accordingly, supported by R&D in three main areas, namely the use of methodology, the use of development tools/aids, and the use of intelligent processing (see Figure 1.4).

The Fifth Generation Computer Project of Japan has a main objective of developing an automatic programming technology using the artificial intelligence concept. To increase productivity, the American MCC software group will focus on developing the best computer-aided environment for software design teams (Fischetti, 1986).

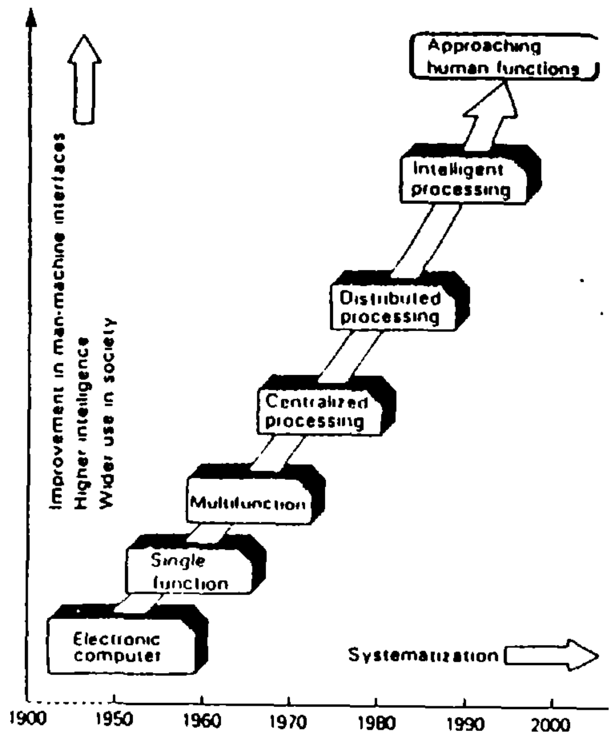
Figure 1.1
Computer Evolution



Source : A Ishikawa, Future Computer and Information System
pp.79, Praeger 1986

Figure 1.2

Computer Technology Development towards Human Intellgence



Source : K.Kobayashi : Computer and Communications, MIT Press, 1986

Figure 1.3

Hardware/Software Costs

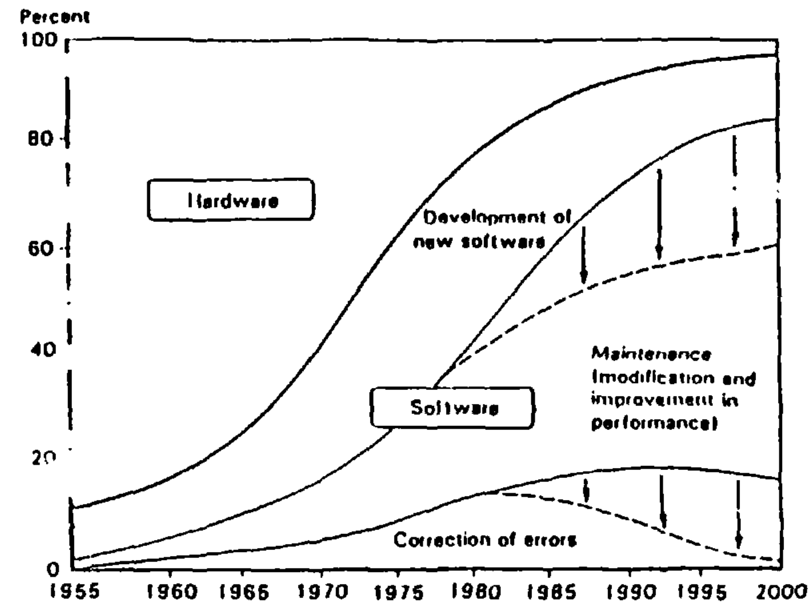


Figure 1.4

Development of Software Production Methods (K.Kobayashi)

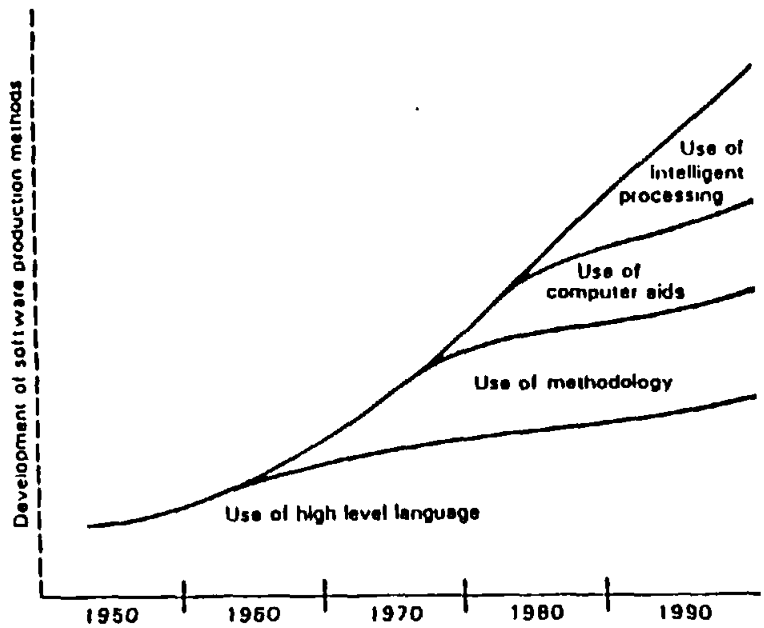


Table 1.7

Major International R&D Projects on Advanced Computer Technology

United States	DARPA (Defense Advanced Research Project Agency) of the department of defense has initiated a program called the Strategic Computing and Survivability Project. Development will be carried out over a ten year period beginning 1984 under a charter from the U.S. government (AI, expert system, parallel processing architecture, etc.). A joint research project (on computers and semiconductors) by private firms is also underway. A Consortium called MCC (Microelectronics & Computer Technology Corporation) was established, whose work is to be performed over approximately 10 years starting in 1983 in the areas of CAD, CAM, AI, new architectures, advanced IC packaging, etc.
Japan	The Fifth Generation Computer Systems (FGCS) Project was initiated in 1982 by Japan's Ministry of International Trade and Industry (MITI). The Institute for New Generation Computer Technology (ICOT) was established in April 1982 as the central organization responsible for promoting the FGCS. The project spans 10 years; divided into three stages, the initial (1982-84), the intermediate (1985-88), and the final (1989-91). The R&D areas are parallel inference machine, knowledge base machine, natural language processing, intelligent programming, etc.

Table 1.7 (continue)

Great Britain	The Ministry of Commerce and Industry has initiated a project for advanced information technology (the AIT project). A steering committee was established within the Ministry in June 1983, and research and development on knowledge based systems, man-machine interfaces, software engineering, and LSIs began in April 1984.
France	Committees of experts within national research organizations are presently studying possible projects corresponding to the FGCS project of Japan and will make recommendations to the Government in the areas of AI, knowledge base management, intelligent interfaces, etc.
W. Germany	The Government has initiated a policy for the comprehensive promotion of improvements in the information industry through a five-year sector research on semiconductors and next-generation computers (main areas are AI, expert systems, and parallel processing architecture).
European Countries	With the development of more advanced information technology as its goal, the EC Committee recently approved plans for software technology, VLSIs, CAD, and so on. The ECRC (European Computer-Industry Research Center) was established in January 1984 by Bull, ICL and Siemens. Major areas include next generation computer architecture, man-machine interfaces, etc.

Source: Ishikawa (1986)

1.4 Structure of the Electronics Industry in Thailand

Following a discussion of the classification system that will be used for the remainder of the study and a brief survey of previous studies, this section will examine the evolution of the electronics and information technology industry in Thailand and evaluate its contribution to the economy in terms of output, trade, and employment. This will be followed by an examination of the ownership structure of the industry and the existence or absence of linkages between the various components, both of which are frequently critical in determining the nature of technology transfer and the extent to which it is disseminated within the economy.

1.4.1 The Classification of the EIBI

In this study of the EIBI in Thailand, the activities in the industry will be classified into the following broad groups:

(1) Consumer Electronics which includes products that are generally used for entertainment or home uses including radios, televisions, cassette players, home stereos, and microwave ovens.

(2) Communications Equipment which includes items that are used in the telecommunications industry and range from telephone systems to switching equipment and facsimile machines.

(3) Computer Hardware which includes computer systems and other finished components of such systems such as hard disks, computer terminals, and printers.

(4) Industrial Electronics Equipment which includes industrial instrumentation equipment, medical equipment, and other electronic equipment such as solar cell systems and power line conditioners.

(5) Electronic Components which covers a wide range of constituent parts which support the production of groups one to four and includes transistors, capacitors, integrated circuits, printed circuit boards, other electronic components and parts, and electronic wire and cable.

(6) Computer Software which covers the production of the programs that are necessary to enable the productive use of computer systems to perform a wide variety of business or personal related tasks.

Table 1.8 summarizes the major products that are produced or assembled in Thailand at the present time classified according to the above groups (excluding software). The table also provides an indication of the new products of projects that have already been approved by the Board of Investment (BOI) but which have not yet started up.

The first five groupings are essentially compatible with those used in recent studies of the electronics industry in Thailand and in other countries, with groups 2, 3, and 4 frequently being aggregated into an overall industrial electronics category (see World Bank, 1986 on Korea and Sripaipan et al., 1987, on Thailand for example). Group 6 which covers the computer software side of the industry is becoming more and more important in terms of systems work and a wide variety of applications, although software activities in Thailand are still in a very nascent stage of development. Indeed, this obvious weakness in the Thai information sector is one that will be carefully addressed in this study.

1.4.2 Past Studies on the Electronics Industry in Thailand

Most of the early studies related to the electronics industry in Thailand such as IFCT (1981) and Jongtanasarnsombat (1982) tended to examine electronics as a subset of the electrical machinery industry, focussing on consumer electronics (televisions and radios) and taking a rather macro view of the industry. These studies generally emphasized the excessive protection given to the consumer electronics industry and the anomalies in the tariff structure whereby tariffs on intermediate products were frequently lower than those on the raw materials used to produce them. The reports accordingly recommended tariff restructuring in order to improve domestic production efficiency and remove the anomalies, with only moderate levels of success.

The first study to clearly differentiate electronic from electrical products was carried out by Sripaipan et al. (1982a). This study on the "Current Status of the Electrical and Electronics Industry in Thailand" which was used as an input for the Sub-Committee for the Restructuring of the Electrical and Electronics Industry also classified electronics products in a similar way as detailed above although they faced severe data constraints. The subsequent studies considered below built on the material presented in this report and examined more carefully issues specific to the electronics industry. At about the same time, TISCO (1982) presented background information on 5 electrical and 10 electronic products. The report concluded that the most promising investment opportunity lay in the production of cathode-ray tubes for black and white television sets.

In 1984, Coopers and Lybrand (1984) prepared a study which made a number of useful recommendations on how the government should promote the development of the electronics industry. The main suggestions involved: the organization of more effective promotional activities abroad; a restructuring of the existing tariff structure to promote domestic production of components; the improvement of domestic support services in the areas of metrology, technology transfer, and specialized training; and the establishment of an industrial estate that specialized in the production of electronic products.

On a somewhat different note, Petchsuwan et al. (1985) carefully examined the manpower situation in the electronics industry and indicated that there would likely be a shortage of electronics engineers although a large surplus of electronics technicians. The study concludes that the relatively low usage of technicians is due to the fact that the production of electronics consumer goods and components is still at the assembly level and ordinary workers can easily perform the required tasks. Engineers tend to be used mostly to control product quality. The study implies that the development of the industry away from the assembly stage into industrial electronics and telecommunications products will generate more demand for electronic technicians as well as increased value-added.

A comprehensive and complete set of investment opportunities was evaluated by Prapinmonkolkarn et al. (1986) which examined the potential for product development on the basis of employment creation, market prospects, and importance for the growth of other domestic industries and the technology advancement of the country. Market analyses and preliminary details of financial and technical aspects of production were presented for the following ten products: microcomputer assembly, cathode ray tube monitor assembly, computer keyboards, floppy disk drives, printers, radio cassette recorders, telephones, video cassette recorders, printed circuit boards, and integrated circuits. The estimated rates of return on these investments ranged from 24 percent to 200 percent indicating that all of the opportunities that were explored were profitable.

ADL (1986) presents recommendations to the BOI regarding the establishment of electronic contract manufacturing in Thailand which were used as a basis for preparing an industry master plan by the BOI. They propose a three phase approach beginning from relatively simple processes such as contract printed circuit board assembly and consumer electronic product assembly in the first phase, electronic component manufacturing and liquid display manufacturing in the second phase, and integrated circuit manufacturing and more complex industrial electronics equipment in the third phase. They emphasize the importance of establishing a design and engineering support center to support the contract manufacturers in technical areas, of setting up a national quality standards organization to ensure and guarantee the high quality of export products, of ensuring the development of supporting industries and infrastructure, and of establishing within the BOI a small but technically competent unit to deal with and monitor the development of the industry. The ADL study also presented mini-business plans along the same lines as Prapinmonkolkarn et al. (1986) for a number of products including printed circuit board production, light emitting diodes, and microcomputer parts and components.

In 1987 three main studies were produced, each one focussing on a different area. SRI (1987) identified computer peripherals and related components as being among the engineering products which offer significant investment potential in Thailand. They made a number of concrete recommendations including: easing the restrictions that peripherals manufacturers face in importing components; developing a cooperative investment program with the Economic Development Board of Singapore to promote investment in peripherals manufacturing in the two countries; and improving capabilities in specific areas such as printed circuit board fabrication through special training courses and similar programs.

Sripaipan et al. (1987) examined the overall development status of the electronics industry by carrying out numerous interviews, surveying 55 firms, and reviewing previous studies and secondary data. In addition to identifying a number of promising investment areas, namely printed circuit board fabrication, high precision parts, television parts, and microcomputer parts, the report summarizes a number of recommendations on the factors seen as hindering the growth of the electronics industry. First, the inadequacy of the direct and indirect supporting industries are pointed out. Second, problems in the tax structure, both in terms of import duty structure and the multiple taxation element of the domestic sales tax, are pointed out as being a major factor inhibiting both the development of a domestic component industry and the growth of linkages between the various types of electronics activities. Third, the importance of encouraging local firms to take advantage of export markets in order to benefit from economies of scale is emphasized. However, the study does not really identify concrete measures that should be taken by the government to address these problem areas.

On a more concrete note, Boonyubol et al. (1988b) review the present tariff structure on electrical and electronic products and make a number of recommendations regarding appropriate import tax reforms. These are discussed in more detail in section 2.1 below.

1.4.3 The Evolution of Firms and Products in the EIBI

According to a general survey and compilation of information on electronics products manufacturers (excluding software) carried out specifically for this study, there presently exist just over 100 firms in the industry as summarized in Table 1.9. The list of existing producers was compiled from BOI sources, previous studies, and a variety of other firm lists and directories. In addition to the firms selected for in-depth interviews, many of the other firms were contacted to obtain additional information and check for accuracy.

When examining the development of firms and products in the EIBI in Thailand, five major phases can be identified and are summarized in Figure 1.5:

The Consumer Electronics Phase - 1960-1970. The first main phase began in the early 1960s with the establishment of Tanin Industrial, a wholly Thai-owned firm, to produce radios and televisions. The company had in fact begun to assemble radios in the late 1950s but only moved into large-scale production in 1964 with a project promoted by the Board of Investment (BOI). The entry of Tanin into the consumer electronics industry was followed before the end of the 1960s by the so-called big five Japanese producers - National, Sanyo, Hitachi, Mitsubishi, and Toshiba - who all formed joint-ventures with Thai partners to exploit the well-protected domestic market for electrical and electronic consumer products. Although the scene was dominated by Tanin and the Japanese consumer electronics giants, several smaller, predominantly Thai firms producing telecommunication and industrial electronics equipment such as radio transceivers and transformers began to emerge.

In the telecommunications industry, ITT located a small subsidiary in Thailand to produce telephone sets and a local firm started up to produce radio equipment for the army and police.

The Integrated Circuits Phase - 1971-1974. The second phase of development which occurred in the first half of the 1970s took on a very different flavor. Three of the major US producers of integrated circuits - National Semiconductor, Signetics, and Data-General - located 100 percent American-owned assembly plants in Thailand exclusively to serve export markets.

The early seventies also saw several new firms entering the consumer electronics business. Tanin opened a new company exclusively to produce radios, cassettes, and B&W and color televisions for export although it never really succeeded in generating and sustaining significant export volumes. In addition, Phillips started up a joint-venture to produce televisions for the domestic market and a domestic company began to produce sound systems for the local automobile market.

The Consolidation Phase - 1975-1982. The third phase saw no major developments in the Thai electronics industry as around 12 predominantly Thai companies entered the domestic consumer electronics industry in a small way and an equal number of Thai and joint-venture companies began to produce a wider range of electronic components primarily for export markets. Foremost among the latter were two subsidiaries of the Tanin group producing electrolytic condensers for export, National Thai producing TV components principally for export, and another Thai firm producing electronic watch components also for export. It is interesting to note that the first of the Tanin components producers, Tanin Electronics, which opened in 1975 was a wholly Thai-owned firm which subsequently closed down while the second, Tanin Condenser, is a joint-venture with Elna of Japan and appears to be performing quite well. The latter is the only company of the Tanin group with foreign equity participation.

The Component Expansion Phase - 1982-1986. The fourth phase saw a rapid expansion of and diversification of firms in the electronic components industry. The period was dominated by the activities of two major players in the world electronics industry, one Japanese and one American. It began in 1982 with the decision of the Japanese ball-bearing producer, Minebea, to use Thailand as a base for the rapid expansion of its electronics component activities. The three 100 percent foreign-owned Minebea factories established between 1982 and 1986 presently employ more than 8,000 workers and produce a wide range of parts and components including small-size and miniature ball bearings, stepping motors, strain gauges, keyboards, speakers, and injection molded plastic parts. The second major company, Seagate Technology, entered Thailand in 1983 to carry out a number of sub-assembly processes to support their computer hard-disk assembly operations in Singapore.

This period also saw an expansion of the integrated circuit industry with four new companies entering the business, one of which being the first majority Thai-owned firm - Chinteik Electronic Industries. A number of printed circuit board producers and assemblers were set up and the Japanese electronic cable manufacture, Fujikura, formed a wholly-owned subsidiary to produce computer keyboard and flat cables.

In addition to the development of the component industry, additional small, Thai firms continued to enter the consumer electronics industry and a number of computer vendors began to play a more important role in developing software application packages for their customers, especially in the Thai language. These developments were accompanied by the production of reasonably effective Thai interface cards for monitors and printers. Up until 1985, the software industry was dominated by computer distributors that had established software sections to modify software for service the computer units that they sold. Several of these software units began to develop original applications and even entered the export market in a limited way. In 1985, the first and only two dedicated software houses were set up primarily to service industrial main frame users.

The Post-Yen Appreciation Phase - (1987 to present). The most recent phase of development is still rather difficult to assess since developments have been taking place so rapidly. Several existing companies such as Seagate and Minebea expanded rapidly in the last 18 months, both in existing product lines and new ones: the former into the assembly and testing of computer hard disk drives to accommodate their rapid growth, and the latter into ferrite magnets, the subassembly of magnetic recording devices, a wider range of electronic motors, and the steel balls used to produce ball-bearings. The latter activity marked the first time that Minebea had commercially produced steel balls in large volumes. Several other existing producers of integrated circuits, printed circuit boards, and other components also expanded their production operations substantially.

The most notable new entrant into the industry was Sharp which became the first major producer of a consumer electronic product, namely microwave ovens, to locate a factory in Thailand to serve primarily export markets. The company was sharply followed by several subcontractors from Japan which located close to the assembly plant to supply a number of microwave oven component parts. Another newcomer was one of the first companies to export fully assembled telephones, and has already expanded its factory to perform simple printed circuit board stuffing for other companies in Thailand. Several other export-oriented firms were also established to export printed circuit boards, floppy disk drives, and power line conditioners.

Although only 13 new firms could be identified that had started up factories in 1987 and 1988, the appreciation of the Yen and the NT dollar and generally favorable economic conditions in Thailand have led to a tremendous increase in international interest in investing in all types of electronics industries in Thailand. As shown in Table 1.10, which presents information regarding electronics projects receiving promotion from the BOI, the 53 electronics projects promoted in 1987 exceeded the total number of promoted projects before 1987. In 1988, the same is true for the first six months alone in which time 51 projects have been promoted. The majority of these projects (almost 70%) are in the electronic components industry for export with the remainder being distributed relatively equally among the other four groups, again mainly for export.

Major new companies to be established in the near future include a domestic-market oriented joint-venture with Mitsubishi to produce about one million color television picture tubes, a wholly-owned subsidiary of AT&T to produce telephones for export, and expansion projects by Sharp to produce office electronic equipment and portable stereos and by Fujikura (in cooperation with other Japanese companies) to produce components for electronic cables and flexible printed circuit boards.

1.4.4 The Output and Employment Contribution of the Industry

Sripaipan et al. (1987) estimated that the gross output of the consumer electronics industry in 1985 was about five billion baht of which about one half was accounted for by television sets. The activities in communications equipment, computer hardware, and industrial electronics equipment were estimated to be considerably lower at around 500 million baht.

The electronics components industry was found to generate in excess of 10 billion baht of gross output value, of which virtually all was exported. These figures correspond very closely to the export statistics presented below which indicate that gross output value of the component industry increased to at least 16 billion in 1986 and looks set to approach 20 billion in 1987, having already reached the 1985 total year figure by the end of June.

In order to provide an idea of the role of the EIBI in the Thai economy, the national accounts statistics from the NESDB are used to provide an indication of its contribution to total value-added. As shown in Table 1.11, the national accounts classify the electrical machinery industry group, code 383, into seven subsectors of which 38320 corresponds quite closely to the electronics industry as defined above. Subgroup 38320 includes: "the manufacture, assembly, and repair of radio and television transmitting and receiving sets, gramophones, dictating machines, tape-recorders and other sound recording and sound reproducing equipment; gramophone records and other similar sound records; telephone and telegraph equipment; radar equipment, radio signalling apparatus and other telecommunication equipment; and x-ray apparatus. Establishments primarily engaged in manufacture of parts and supplies specially used for electronic apparatus such as electronic valves and tubes, semiconductors, and fixed and variable electronic capacitors and condensers are also included in this group." However, the match is not perfect as it also includes repair activities and excludes a number of electronics components and industrial electronics activities which are included in other subsectors of code 383 or in other industry groups.

Overall, the contribution of the electrical machinery industry group has grown from just under 2 percent of manufacturing GDP in 1970 to 3.2 percent in 1987. The main part of this increase was accounted for by the growth of the electronics subgroup 38320 which increased its share of manufacturing GDP from a negligible 0.1 percent to 1.1 percent over the same period. This represented a real growth of more than 27 percent per year, more than three times greater than the 8 percent growth of overall real manufacturing GDP over the same period and more than four times the growth of overall GDP. Nevertheless, despite this rapid growth and the fact that certain product groups may be missing, the value-added contribution of the EIBI in Thailand in 1987 is still considerably below the 2.54 percent of Korea. This is largely due to the fact that the industries in Thailand still depend very heavily on imported inputs (see section 1.4.5 below).

In terms of the gross value of imports and exports, the electronic industry plays a much more significant role than in terms of value-added generation and the trends in the trade picture mirror very closely the evolution of the industry as outlined above.

On the import side of the trade equation (see Table 1.12), the overall share of electronics products in total imports has increased steadily from 3.5 percent in 1970 to 5.5 percent in 1987. The major structural shifts in import composition resulted in: the dramatic decline of consumer electronics from 27.4 percent of the total to less than 10 percent as the domestic production of consumer electronics substituted for imports; the expected increase in imports of computer hardware in recent years which now account for more than one-fifth of total electronics imports; and the periodic fluctuations in imports of telecommunication equipment (parts for broadcasting equipment) following the government's alternating policies to develop the telecommunications system or to conserve foreign exchange. Imports of components has hovered around 50 percent of the total for some years now while the import shares of communications equipment and industrial electronics have remained relatively constant around 13 percent and 15 percent respectively.

As expected, the change in the export picture since 1970 has been considerably more dramatic, increasing from virtually no exports in 1970 to over 7 percent of total exports in 1987 (see Table 1.13). The main jump occurred after 1975 when the integrated circuits companies reached full capacity and by 1980 electronics exports reached almost 5 percent of total exports and were dominated by that one commodity. The slump in the integrated circuit market in 1981 to 1983 caused electronics exports to stagnate. Since 1984, the production of electronic components diversified into electronic ball-bearings and other electronic components, largely due to the establishment of Minebea, Seagate, and some other smaller component exporters. This, combined with the recovery of the integrated circuit market and the entrance of the four new integrated circuit manufacturers, enabled electronics exports to recover and experience growth rates considerably higher than overall exports.

Up to 1987, the exports of the other electronics groups had been insignificant, accounting for less than 3 percent of electronics exports. The temporary attempts of Tanin International to export radios and televisions are reflected in the steady decline in exports of these products from 1980 to 1984 as they faced increasing competition in European markets from Korean producers.

On a more positive note, exports of computer parts (such as hard disks, stepping motors, and terminals) have already begun to grow, reaching some 160 million baht in the first half of 1987 alone. Furthermore, the investments already made and planned under phase 5 discussed above look likely to result in a significant increase in exports of consumer electronics, communications equipment, and computer hardware. The overall export structure would then become much more diversified and less subject to the vagaries of the integrated circuit market.

The net electronics balance of trade (compare Tables 1.12 and 1.13) which had been experiencing a surplus for several years prior to 1980 steadily declined since that time until entering a deficit position in 1983 following the stagnation of integrated circuit exports. The advent of the new components producers had reversed the trend by 1985 and the net balance experienced a surplus again in 1986. At the industry level, electronic components is the only sector that experiences net surpluses with all other sectors importing considerably more than they export. The picture is quite different from that of Korea in 1984 which experienced a huge surplus in the consumer electronics industry but almost balanced trade in the electronic components industry where significant imports were necessary to support the production of consumer electronics exports.

The contribution of the electronics industry to employment in the manufacturing sector is also quite significant. The total employment generated by the 102 firms that were identified in the general survey amounted to 41,628 persons (see Table 1.9) which accounts for some 2 percent of the two million or so workers in the manufacturing work force (see NSO Labor Force Survey, 1986).

More than two-thirds of the employment generated by the electronics industry is in components activities with consumer electronics accounting for another 25 percent and the remainder spread over the remaining three groups. While we were unable to estimate the employment generated by software companies, it is unlikely to exceed 1,000 persons at the present time.

The BOI data on investment project approvals indicate that project that received promotion in 1987 and 1988 will employ some 50,000 more workers. Even if not all projects actually start-up, indications from the interviews were that many of them would and the resulting demand for manpower at all levels would strain existing supplies even further. The pressures were expected to be especially severe at the engineer level since many of the new projects, especially those in the components field which constitute the vast majority, would demand increasing quantities of high-level staff to cope with increasing levels of production sophistication.

1.4.5 The Ownership and Size Structure of the Electronics Industry

One issue that has been important in discussions on the development of the electronics industry in Thailand concerns the role of foreign firms and the extent of their control. The issue is particularly relevant when examining questions concerning the acquisition of technology and the extent to which technological capability is transferred to the Thais working in the industry. Such spill over benefits of foreign firms, particularly as they relate to employment, were discussed in Sibunruang and Brimble (1988) although the lack of concrete data made firm conclusions impossible. As a result, for the remainder of the study, a clear distinction will be maintained between firms controlled by foreign interests and those controlled by Thais (see footnote on Table 1.14 for a definition of ownership). A further distinction that will be maintained is based on the size of the firm, which is seen in this section to be rather closely correlated to ownership.

Table 1.14 presents a breakdown of the firms in the electronics industry by ownership and industry group. It can be observed that overall, there are almost equal numbers of Thai and non-Thai firms (joint ventures and foreign owned firms). However, the distributions of the firms are very different. More than 60 percent of the non-Thai firms are concentrated in the higher technology electronic components industry with a further 20 percent in the upper end of the domestic consumer electronics business. In contrast, only 20 percent of the Thai firms are in electronics components while over 50 percent of the Thai firms produce or assemble relatively low technology, low end consumer goods for the domestic market.

The dominance of non-Thai firms becomes quite dramatic when one considers the total employment figures. Almost 85 percent of the total electronics labor force is employed in such firms and indications are that this percentage is even higher for engineers. Indeed, foreign owned firms in the electronic components sector employ more than 50 percent of the total electronics work force. The implications of this dominance of foreign firms in the higher technology sectors on the extent to which domestic electronics S&T manpower and capabilities are developed are potentially very important and will be carefully considered.

Table 1.15 summarizes the role of major country groups in the evolution of the electronics industry. With the exception of the "integrated circuits period - 1971-1974", the Japanese have played a consistently important role in the Thai electronics industry, from the consumer electronics to the electronic components sectors. European and American firms number the same, although the former tend to be more diversified while the latter are concentrated in relatively few, very large activities. The NICs have only recently begun to play a significant role in the electronics industry although, according to Table 1.16, they will be playing a more important role in the not too distant future.

Table 1.16, which shows the breakdown of BOI promoted firms by country, also indicates the declining role of Thai firms whose share in total approvals has dropped steadily since the early 1970s. In fact, they account for less than 3 percent of employment and less than 2 percent of investments thus far in 1988. Among non-Thai firms, the majority of which are 100 percent foreign owned, the Japanese are maintaining their share, the Americans increasing slightly, the Europeans declining further, while the NICs are storming ahead, increasing their share in total project approvals to 33 percent so far in 1988. Indications are that, as the export orientation of BOI promoted firms increases, so does the importance of 100 percent foreign owned firms.

In terms of the average size of firms by sector, electronics components firms are the largest, employing on average 673 workers, with consumer electronics, communications equipment, and computer hardware employing between 229 and 289 persons, and industrial electronics lagging far behind at 68 persons. When the ownership factor is introduced, foreign firms are by far the largest in all sectors, with the exception of consumer electronics where the large Japanese joint ventures play an important role. Thai firms employ on average 118 persons and, if one removes the three largest firms, this figure would drop substantially reflecting the fact that the Thai owned sector contains a number of very small workshop factories. As may have been expected, foreign firms on average tend to employ large numbers of workers while Thai firms employ substantially fewer.

1.4.6 Linkages and Input Structure in the Electronics Industry

The sources of inputs and linkages between domestic producers are also important issues when looking at technological aspects of development. Subcontracting in particular has frequently been shown to be a crucial way of transferring managerial and technical skills between firms. Although these issues will be dealt with in more detail in chapters 3 and 4, a summary of the present situation will be presented here.

In general, as shown by Sripaipan et al. (1987), the structure of the present electronics industry can be represented by the illustration in Figure 1.6. The consumer electronics and industrial electronics sectors presently import large percentages of their required inputs, with the exception of packaging, casing, and minor components, and sell the vast majority of the output on protected domestic markets. The electronic components and computer hardware sectors, on the other hand, also import all the technology and an even higher percentage of the inputs, but export all the output to world markets. The telecommunications industry falls in between the two extremes as it produces some products for the domestic market and some for export, although it also uses predominantly imported parts and components.

Although the picture has improved in recent years, with more linkages developing between component producers and the other sectors, the situation is far from ideal and the heavy reliance on imported inputs and technology and the inadequate domestic linkages are still very much facts of life in the Thai electronic industry.

Figure 1.5

The Development of the Electronics Industry in Thailand

	Number of Firms Established	Main Products of New Firms	Market Orientation of New Firms
Phase 1	11	Radios	Domestic
Consumer Electronics	(72.7%) [1/]	Televisions	Domestic
1960-1970		Electronic Cable	Domestic
Phase 2	10	Integrated Circuits	Export
Integrated Circuits	(70.0%)	Telephones	Domestic
1971-1974		Radio Tranceivers	Domestic
		Car Radios	Domestic
Phase 3	31	Consumer Electronics	Domestic
Consolidation	(41.9%)	Ferrite Devices	Export
1975-1981		Electrolytic Capacitors	Export
		Television Components	Export/Own Use
Phase 4	37	Mini & Small Bearings	Export
Component Expansion	(64.9%)	Stepping & Fan Motors	Export
1982-1986		Hard-disk Sub-assembly	Export
		Printed Circuit Boards	Export
		Custom Software	Domestic
		Thai Cards	Domestic
		Computer Cables	Export
		Integrated Circuits	Export
		Micro-computers	Domestic
Phase 5	13	Microwave Oven	Export
Post-Yen Appreciation	(100.0%)	Microwave Oven Parts	Export
1987-present		Telephones	Export
		Printed Circuit Boards	Export/Domestic
		Assembled Hard-disks	Export
		Floppy Disk Drives	Export
		Wide Product Range (see Table 1.3.1)	Mainly Export

[1/] Numbers in percentages represent BOI promoted firms in total established firms

Figure 1.6
Linkages and Inputs in the Electronics Industry

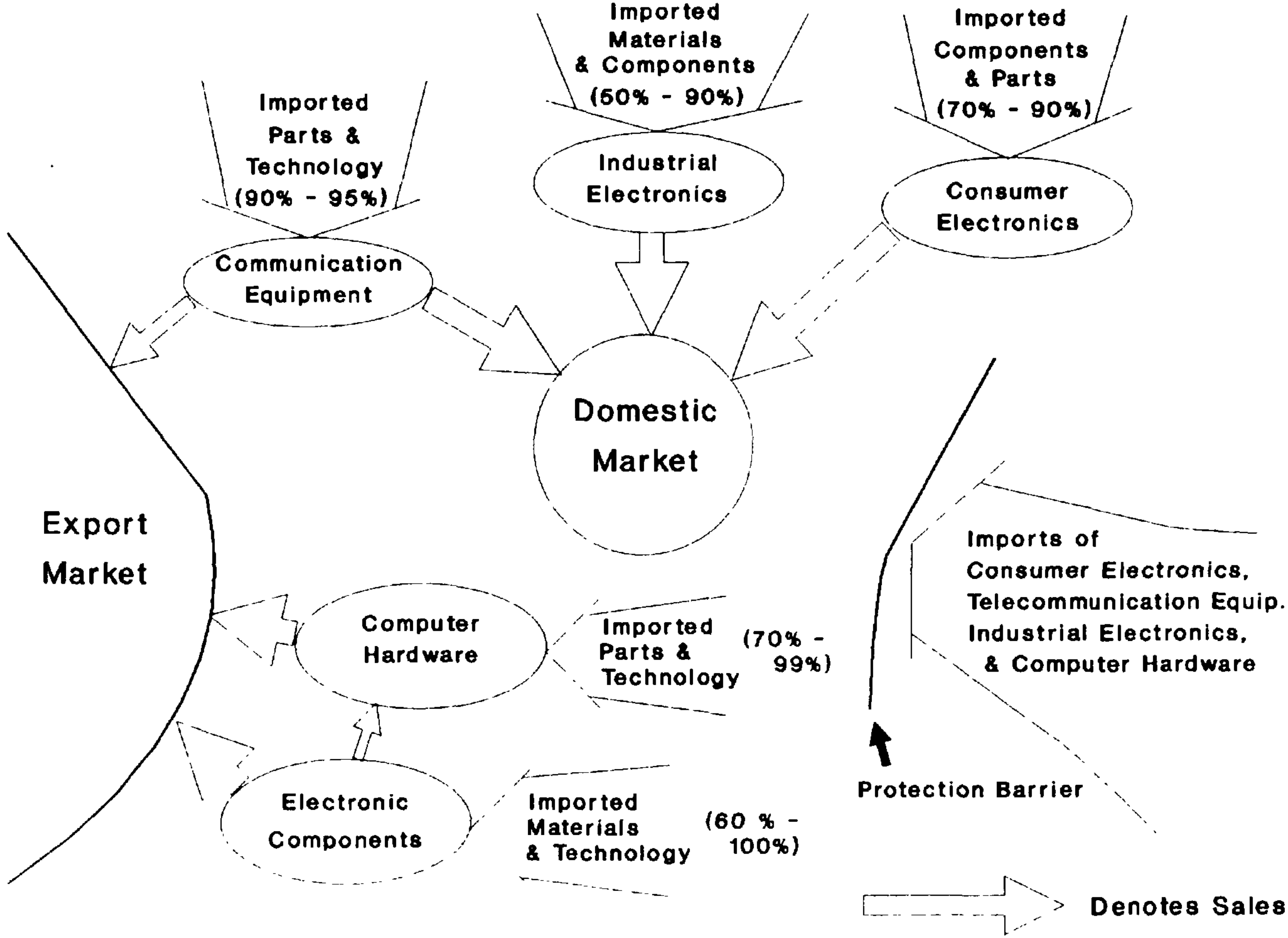


Table 1.8
Electronics Products and Processes in Thailand (Page 1)

Existing Products & Process	New Products & Processes that have Already Received BOI Promotion but Have not yet started Production
1. Consumer Electronics	
B&W Televisions	Automatic Cameras
Car Radios	Clock Radios
Car Tape Cassette-Radios	Clock & Alarm Clocks
Cassette Tapes	Compact Disc Players
Colour Televisions	Electronic Typewriters
Digital Watches	Equalizer Boosters
Electronic Calculators	Mini Stereos with Head Phone
Electronic Toys	Portable Stereos
Electronic Watches	Radio Controlled Toys
Home Stereos	Video Tape (VHS)
Microwave Ovens	Car Digital Audio Tape Recorders
Power Amplifiers	
Radio Cassette Recorders	
Radios	
Video Tape Recorders	
2. Communication Equipment	
Cordless Telephones	Facsimiles
Key Telephone Systems	Satellite Antennas
Paging Receivers	Satellite Receiver Sets
Radio Transceivers	Switching Equipment
Telephone Receivers	Telephone Answering Machines
Transponders	
3. Computer Hardware	
Computer Keyboards	Modems
Floppy Disk Drives	
Hard Disc Drive Components	
Hard Disk Drives	
Microcomputer Systems	
Paper Feeders	
Printers	
Thai Cards	
Computer Cases	
4. Industrial Electronics	
Coils & Transformers	Clamp Meters
Kilowatt-hour Meters	Electronic Cash Registers
Potentiometers	Multi Meters
Power Line Conditioners	Panel Meters
Solar Cell Panels	Servometers
Switching Power Supplies	Stroboscopes (Electronic Flash)
Uninterruptible Power Supplies	

Table 1.8

Electronics Products and Processes in Thailand (Page 2)

Existing Products & Process	New Products & Processes that have Already Received BOI Promotion but Have not yet started Production
5. Electronic Components	
Actuator & Parts Assembly	Car Radio Tuners
Analog Watch Components	Clock & Watch PCBs
Cabinets for Radio & TV set	Colour Picture Tubes (CRT)
Cable Harnesses	Condenser Discharge Ignitors
Ceramic Capacitors	Connectors
Coils for Electronic Watch	CRT Parts
Computer Cords	Electronic Ballast
Deflection Yokes	Fixed Resistors
Electrolytic Capacitors	Flexible Printed Circuit Boards
Electronic Control Devices	Gas Circuit Breakers
Electronic Watch Components	Head Gimbal Coil Winding
Electronic Wire & Cables	IC. Heat Radiation Panels
Fans & Ventilating	LED Numeric Displays
Ferrite Magnet	Light Emitting Diodes (LED)
Flat Type Cables	L-C Communication Filters
Floppy Disk Drive Heads	Magnetic Tapes
Head Gimbal Assembly	Microwave Oven Time Switches
IF Transformers	Multilayer Laminated Panels
Instrument Transformers	Peizo Transducer
Integrated Circuit Assembly	Polyethylene Variable Condensers
Interface Cords	Power Capacitors
Keyboard Cords	Reference Time Switches
Loudspeakers	Rectifiers
Magnetic Recording Heads	Small signal Transistors
Magnetic Relays	Thin Laminate
Metal Parts of Microwave oven	Transister Magnetic Ignitors
Micro Speakers	Tantalum Capacitors
Microwave Circulators & Isolators	
Microwave Transformers	Tape Mechanism
Mylar Capacitors	
PCB Assembly	
Plastic Electronic Components	
Power Supply Cord Assembly	
Power & Output Transformers	
Printed Circuit Boards (PCB)	
Printer & Disk Drive Components	
Quartz Crystal & Tuning Forks	
Small & Miniature Ball Bearings	
Stepping Motors	
Strain Gauges	
Transducers	
TV Tuner & Parts	
Variable Resistors	
VTR and Car Stereo Parts	
"E" Block Assembly	
Wiring Harness	

Source : Present Survey

Table 1.9
Electronics Producing Firms by Sector and Start-up Date

	Consumer Electronics 1/		Communications Equipment		Computer Hardware		Industrial Electronics Equipment		Electronic Components		Total Electronics	
Period	No. of Firms	Total Employ.	No. of Firms	Total Employ.	No. of Firms	Total Employ.	No. of Firms	Total Employ.	No. of Firms	Total Employ.	No. of Firms	Total Employ.
1960-1970	7	6,066	1	150	0	0	1	35	2	164	11	6,415
(share of period)	63.6%	94.6%	9.1%	2.3%	0.0%	0.0%	9.1%	0.5%	18.2%	2.6%	100.0%	100.0%
1971-1974	4	836	2	126	0	0	0	0	4	5,932	10	6,894
(share of period)	40.0%	12.1%	20.0%	1.8%	0.0%	0.0%	0.0%	0.0%	40.0%	86.0%	100.0%	100.0%
1975-1981	12	1,084	0	0	2	379	5	402	12	1,568	31	3,433
(share of period)	38.7%	31.6%	0.0%	0.0%	6.5%	11.0%	16.1%	11.7%	38.7%	45.7%	100.0%	100.0%
1982-1986	11	1,414	3	1,006	2	75	5	124	16	19,050	37	21,669
(share of period)	29.7%	6.5%	8.1%	4.6%	5.4%	0.3%	13.5%	0.6%	43.2%	87.9%	100.0%	100.0%
1987-Jun. 1988	1	700	1	320	1	600	2	320	8	1,277	13	3,217
(share of period)	7.7%	21.8%	7.7%	9.9%	7.7%	18.7%	15.4%	9.9%	61.5%	39.7%	100.0%	100.0%
Total	35	10,100	7	1,602	5	1,054	13	881	42	27,991	102	41,628
(share of total)	34.3%	24.3%	6.9%	3.8%	4.9%	2.5%	12.7%	2.1%	41.2%	67.2%	100.0%	100.0%

Notes: 1/ excludes three Thai consumer electronics firms for which no data existed on start-up or employment

Source: Compiled from a variety of sources and present survey

Table 1.10
Data on BOI Promoted Electronics Projects

Period	Consumer Electronics			Communications Equipment			Computer Hardware			Industrial Electronics Equipment			Electronic Components			Total Electronics		
	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.
1960-1970	5	4,035	1,611	2	189	29	0	0	0	0	0	0	0	0	0	7	4,224	1,640
(share of period)	71.4%	95.5%	98.2%	28.6%	4.5%	1.8%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%
1971-1974	3	929	410	0	0	0	0	0	0	0	0	0	5	6,562	1,878	8	7,491	2,288
(share of period)	37.5%	12.4%	17.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	62.5%	87.6%	82.1%	100.0%	100.0%	100.0%
1975-1981	0	0	0	0	0	0	0	0	0	0	0	0	6	1,645	175	6	1,645	175
(share of period)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1982-1986	1	433	639	2	196	25	1	587	262	4	422	135	21	22,145	10,840	29	23,783	11,901
(share of period)	3.4%	1.8%	5.4%	6.9%	0.8%	0.2%	3.4%	2.5%	2.2%	13.8%	1.8%	1.1%	72.4%	93.1%	91.1%	100.0%	100.0%	100.0%
1987	6	6,476	4,397	3	2,344	741	5	4,384	1,022	6	2,032	734	33	10,021	4,462	53	25,257	11,356
(share of period)	11.3%	25.6%	38.7%	5.7%	9.3%	6.5%	9.4%	17.4%	9.0%	11.3%	8.0%	6.5%	62.3%	39.7%	39.3%	100.0%	100.0%	100.0%
1988 (Jan-Jun)	3	2,329	899	5	2,181	1,660	2	161	16	1	163	35	40	20,084	12,953	51	24,918	15,564
(share of period)	5.9%	9.3%	5.8%	9.8%	8.8%	10.7%	3.9%	0.6%	0.1%	2.0%	0.7%	0.2%	78.4%	80.6%	83.2%	100.0%	100.0%	100.0%
Total	18	14,202	7,956	12	4,910	2,455	8	5,132	1,300	11	2,617	904	105	60,457	30,308	154	87,318	42,924
(share of total)	11.7%	16.3%	18.5%	7.8%	5.6%	5.7%	5.2%	5.9%	3.0%	7.1%	3.0%	2.1%	68.2%	69.2%	70.6%	100.0%	100.0%	100.0%

Note: Investment in million baht

Source: Board of Investment

Table 1.11
Contribution of Electronics to Gross Domestic Product
(1972 Prices - New Series)

TSIC Code 1/	Major Industry Group		1970	1975	1980	1981	1982	1983	1984	1985	1986	1987e	1970-87
383	Electrical Machinery	Share 2/	1.9%	1.9%	2.9%	2.7%	2.7%	3.1%	3.3%	3.0%	3.1%	3.2%	
		Growth	n.a.	10.65%	18.97%	-0.2%	1.6%	24.9%	13.3%	-10.6%	12.2%	14.4%	11.7%
38310	Electrical industrial machinery & apparatus	Share 2/	0.5%	0.5%	0.3%	0.3%	0.3%	0.3%	0.4%	0.4%	0.4%	0.3%	
		Growth	n.a.	7.4%	2.8%	1.5%	-10.2%	16.3%	35.6%	16.5%	-4.2%	-2.5%	5.7%
38320	Radio & television & communications equipment	Share 2/	0.1%	0.3%	0.8%	0.8%	0.8%	1.1%	1.3%	0.8%	1.1%	1.1%	
		Growth	n.a.	47.1%	31.8%	0.0%	11.8%	43.9%	22.6%	-32.9%	35.0%	20.5%	27.1%
38330	Electrical appliances	Share 2/	0.3%	0.3%	0.5%	0.5%	0.5%	0.5%	0.4%	0.5%	0.5%	0.5%	
		Growth	n.a.	11.5%	16.1%	8.9%	5.9%	7.8%	-1.8%	11.8%	8.5%	8.6%	11.0%
38391	Insulated wire & cable	Share 2/	0.3%	0.3%	0.5%	0.4%	0.4%	0.5%	0.5%	0.4%	0.4%	0.4%	
		Growth	n.a.	6.3%	23.3%	-12.7%	4.3%	34.3%	-0.5%	-5.4%	-8.5%	26.2%	10.1%
38392,3,9	Other Electrical	Share 2/	0.7%	0.6%	0.9%	0.8%	0.7%	0.8%	0.8%	0.8%	0.8%	0.8%	
		Growth	n.a.	6.2%	19.1%	1.2%	-7.2%	12.6%	9.8%	-2.7%	10.5%	12.2%	9.3%
	Total Manufacturing	Share 3/	16.0%	19.9%	21.7%	21.7%	21.4%	21.6%	21.5%	20.7%	21.5%	22.2%	
		Growth	n.a.	10.3%	9.8%	6.3%	2.5%	8.4%	6.8%	-0.6%	9.1%	10.2%	8.4%
	Total GDP	Growth	n.a.	5.6%	7.9%	6.3%	4.1%	7.3%	7.1%	3.5%	4.7%	7.1%	6.3%

Notes: e - estimate, 1/ Thai Standard Industrial Classification, 2/ of total manufacturing sector, 3/ of total GDP
Source: National Economic and Social Development Board

Table 1.12
Import Values of Electronic Products (Page 1)
(million baht)

Product Group	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987 1/
1. Consumer Products	263.1	186.5	427.5	980.6	1,024.6	1,524.1	1,380.1	1,271.4	1,143.1	674.3
(average annual growth rate)	n.a.	-6.6%	18.0%	129.4%	4.5%	48.8%	-9.4%	-7.9%	-10.1%	n.a.
(as percent of total electronics)	27.4%	12.9%	9.1%	19.2%	17.7%	15.5%	12.6%	10.6%	8.5%	8.1%
Televisions	133.3	35.4	66.9	263.1	319.3	271.3	235.0	120.1	88.7	59.4
Video Recorders	0.0	0.0	17.4	11.6	48.1	178.8	600.5	560.7	488.3	318.9
Radios	78.6	106.9	179.0	384.4	311.7	279.5	249.9	282.0	242.3	164.3
Stereos	8.5	6.8	21.1	52.7	46.6	72.7	72.5	92.8	116.3	51.0
Tape Recorders	35.5	30.9	134.1	230.8	276.3	689.5	185.8	155.9	124.6	62.5
Watch Movements	1.9	1.7	4.7	31.8	17.7	22.7	28.6	42.6	71.1	12.4
Others	5.2	4.8	4.2	6.2	4.7	9.5	7.9	17.1	11.9	5.9
2. Communications Equipment	126.3	216.7	721.9	512.0	883.1	1,132.6	1,409.0	1,878.8	1,798.6	1,046.2
(average annual growth rate)	n.a.	11.4%	27.2%	-29.1%	72.5%	28.2%	24.4%	33.3%	-4.3%	n.a.
(as percent of total electronics)	13.2%	14.9%	15.4%	10.0%	15.2%	11.5%	12.9%	15.6%	13.4%	12.6%
Telephones	45.1	103.3	438.2	282.5	390.8	489.3	596.7	1,284.4	621.6	281.2
Telegram Equipment	16.8	9.8	93.6	56.5	191.0	207.9	415.7	211.2	676.9	286.5
Radio Broadcasting Eq.	3.5	3.5	4.6	41.3	38.5	99.0	12.7	25.7	42.7	12.8
Television Broadcasting Eq.	6.8	23.9	24.3	21.0	28.5	92.9	46.4	70.7	77.0	49.7
Others	54.2	76.1	161.2	110.8	234.4	243.5	337.5	288.7	380.4	416.0
3. Computer Hardware	66.2	140.6	234.3	399.1	323.6	601.2	763.5	1,736.0	1,631.3	1,730.4
(average annual growth rate)	n.a.	16.3%	10.8%	70.3%	-18.9%	85.8%	27.0%	127.4%	-6.0%	n.a.
(as percent of total electronics)	6.9%	9.7%	5.0%	7.8%	5.6%	6.1%	7.0%	14.4%	12.1%	20.8%
For Office Use	61.0	79.3	109.9	116.1	89.1	80.8	103.9	104.2	68.5	928.8
Computers & Parts	5.2	61.4	124.4	283.0	234.5	520.3	659.6	1,631.8	1,562.8	801.6
4. Industrial Electronics	133.4	265.4	1,004.6	1,073.4	988.9	1,259.9	1,485.9	2,047.8	2,095.5	1,282.0
(average annual growth rate)	n.a.	14.8%	30.5%	6.9%	-7.9%	27.4%	17.9%	37.8%	2.3%	n.a.
(as percent of total electronics)	13.9%	18.3%	21.5%	21.0%	17.1%	12.8%	13.6%	17.0%	15.6%	15.4%
Electronics	24.4	70.9	293.0	139.3	82.5	138.2	202.6	279.7	167.2	212.0
Industry	63.1	113.9	466.0	574.4	604.6	647.6	790.3	1,206.7	1,162.1	604.3
Fisheries	0.2	0.4	3.8	11.5	33.4	21.1	15.1	24.3	52.2	38.6
Medical	1.5	0.3	24.6	26.1	31.4	30.0	36.2	50.3	156.0	76.8
Traffic Control	2.6	3.3	3.4	49.9	40.7	32.6	7.6	6.1	44.3	16.0
Load Protectors	37.0	71.1	108.6	145.4	99.7	269.2	304.6	263.6	261.0	163.8
Others	4.6	5.4	105.3	126.7	96.5	121.1	129.5	217.1	252.6	170.6

Table 1.12
Import Values of Electronic Products (Page 2)
(million baht)

Product Group	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987 1/
5. Electronic Components	369.8	640.5	2,293.3	2,140.8	2,571.6	5,335.9	5,907.8	5,080.4	6,798.8	3,600.5
(average annual growth rate)	n.a.	11.6%	29.1%	-6.6%	20.1%	107.5%	10.7%	-14.0%	33.8%	n.a.
(as percent of total electronics)	38.6%	44.2%	49.0%	41.9%	44.4%	54.2%	54.0%	42.3%	50.5%	43.2%
Passive	126.9	171.7	318.4	426.6	353.6	435.6	377.3	384.2	463.8	310.9
- Resistors & Relays	10.3	37.4	104.8	136.8	133.6	184.6	144.8	133.4	203.1	120.1
- Capacitors	27.7	67.5	167.9	185.7	151.9	171.0	173.0	219.4	228.7	171.6
- Transformers	88.8	66.7	45.2	103.6	67.7	79.3	49.0	27.4	30.4	18.7
- Other Photocells	0.0	0.1	0.5	0.5	0.5	0.7	10.5	4.0	1.7	0.6
Active	25.7	91.5	198.3	304.0	319.2	347.0	384.8	653.1	925.1	959.7
- Electronic Tubes	5.8	11.3	12.2	18.0	9.8	10.4	5.5	11.1	20.2	5.5
- Transistors	11.2	28.4	80.3	106.9	75.3	50.4	64.3	33.6	49.1	27.0
- Integrated Circuits	0.0	0.0	38.8	61.4	139.1	135.8	127.7	320.2	263.6	71.7
- Valves (crystal)	8.0	48.7	51.1	67.2	63.7	132.2	165.4	267.5	556.1	814.0
- Rectifiers	0.7	3.1	15.9	50.6	31.2	18.1	21.8	20.7	36.0	41.6
Other Parts	217.2	377.3	1,776.5	1,410.2	1,898.7	4,553.4	5,145.7	4,043.0	5,409.9	2,329.9
- Parts for Broadcasting Eq.	108.5	53.2	677.4	232.6	365.6	2,006.4	2,454.5	1,168.5	2,802.9	467.8
- Television Parts	15.5	96.4	210.9	181.5	414.6	980.5	1,223.8	1,670.0	1,742.3	1,277.8
- Radio Parts	23.7	59.2	83.1	72.1	85.1	412.5	376.7	395.0	223.7	174.6
- Cathode-Ray Tubes (CRT)	6.1	54.2	359.0	474.6	593.5	673.4	545.1	5.1	6.7	1.3
- Microphones	3.2	5.9	13.3	15.0	23.0	23.2	18.9	22.5	18.3	8.5
- Loudspeakers	25.8	62.0	125.3	148.6	125.7	165.2	158.1	174.9	129.8	84.6
- Microphone, Loudspeaker Parts	5.7	12.9	34.8	31.9	33.4	39.0	43.7	46.2	81.1	67.5
- Cabinets	0.0	0.0	142.2	107.3	92.4	90.0	42.2	11.3	0.7	0.6
- TV Camera Tubes	1.8	0.4	2.2	0.9	0.8	0.1	0.3	1.2	1.5	1.0
- Instrument Parts	26.6	31.9	119.1	135.1	156.2	146.4	215.6	286.6	234.1	150.3
- Electrical Goods Parts	0.3	1.1	8.6	8.9	7.0	16.2	15.3	134.4	25.8	20.1
- Medical Eq. Parts	0.1	0.0	0.5	1.7	1.5	0.6	0.8	2.5	6.7	4.1
- Computer Tape & Media	0.0	0.0	0.0	0.0	0.0	0.0	50.7	124.9	136.1	71.7
- Ball Bearings 2/	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Electronics Imports	968.8	1,449.8	4,681.6	5,106.1	5,791.7	9,853.6	10,946.2	12,014.3	13,467.3	8,333.4
(average annual growth rate)	n.a.	8.6%	26.4%	9.1%	13.4%	70.1%	11.1%	9.8%	12.1%	n.a.
(as percent of total imports)	3.5%	2.2%	2.4%	2.3%	2.9%	4.2%	4.5%	4.8%	5.6%	5.5%
Total Imports	27,009	66,835	193,618	219,026	196,616	236,609	245,155	251,169	241,358	150,924
(average annual growth rate)	n.a.	19.9%	23.7%	13.1%	-10.2%	20.3%	3.6%	2.5%	-3.9%	n.a.

Notes: 1/ Data from January to June only.
2/ Imports of bearings (mini and small) could not be obtained
Source: Department of Customs

Table 1.13
Export Values of Electronic Products (Page 1)
(million baht)

Product Group	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987 1/
1. Consumer Products	2.3	39.7	220.8	172.9	149.8	64.3	62.5	54.5	54.4	63.7
(average annual growth rate)	n.a.	76.9%	41.0%	-21.7%	-13.4%	-57.1%	-2.7%	-12.9%	-0.1%	n.a.
(as percent of total electronics)	99.5%	10.1%	3.4%	2.7%	2.4%	1.0%	0.7%	0.4%	0.3%	0.6%
Televisions	0.0	10.2	124.3	105.5	79.8	40.3	19.9	22.4	24.4	20.3
Video Recorders	0.0	0.0	0.1	0.3	0.2	0.0	5.7	4.5	3.1	13.6
Radios	2.3	27.5	33.8	29.7	65.9	20.2	33.2	21.7	10.5	9.6
Stereos	0.0	0.0	0.8	0.4	0.1	0.0	0.0	0.9	1.7	0.6
Tape Recorders	0.0	0.1	5.0	3.8	2.7	3.7	2.9	4.8	11.5	15.5
Watch Movements	0.0	0.0	56.9	33.3	1.1	0.0	0.8	0.2	3.3	4.0
Others	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2. Communications Equipment	0.0	0.1	3.6	0.6	5.3	3.0	3.1	23.7	68.6	28.8
(average annual growth rate)	n.a.	n.a.	89.0%	-83.9%	819.9%	-44.2%	6.0%	653.6%	189.4%	n.a.
(as percent of total electronics)	0.0%	0.04%	0.1%	0.0%	0.1%	0.0%	0.0%	0.2%	0.4%	0.3%
Telephones	0.0	0.0	0.8	0.1	1.1	0.5	0.1	0.2	18.9	8.6
Telegram Equipment	0.0	0.0	0.0	0.1	1.8	0.1	1.9	20.9	7.2	11.3
Radio Broadcasting Eq.	0.0	0.0	0.0	0.0	2.3	2.1	0.3	0.0	0.5	7.8
Television Broadcasting Eq.	0.0	0.0	0.1	0.0	0.0	0.0	0.1	0.6	1.1	0.3
Others	0.0	0.1	2.7	0.3	0.1	0.3	0.7	2.0	41.0	0.8
3. Computer Hardware	0.0	0.5	1.8	4.7	1.4	2.0	9.9	66.6	88.4	160.7
(average annual growth rate)	n.a.	n.a.	31.6%	156.9%	-70.6%	44.3%	397.2%	574.2%	32.8%	n.a.
(as percent of total electronics)	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%	0.5%	0.5%	1.5%
For Office Use	0.0	0.5	1.3	2.2	1.4	0.0	0.8	1.1	4.6	0.5
Computers & Parts	0.0	0.0	0.5	2.5	0.0	2.0	9.1	65.5	83.9	160.3
4. Industrial Electronics	0.005	0.1	5.9	1.1	5.0	8.4	17.1	24.4	54.3	44.6
(average annual growth rate)	n.a.	n.a.	108.3%	-81.2%	350.3%	70.2%	102.8%	42.2%	122.8%	n.a.
(as percent of total electronics)	0.21%	0.04%	0.1%	0.0%	0.1%	0.1%	0.2%	0.2%	0.3%	0.4%
Electronics	0.0	0.0	0.1	0.0	3.3	2.2	1.9	8.1	8.3	1.1
Industry	0.0	0.1	0.6	0.8	0.6	4.1	10.1	15.3	38.1	35.8
Fisheries	0.0	0.0	0.0	0.0	0.5	0.1	0.0	0.3	1.9	0.0
Medical	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	1.0	0.5
Traffic Control	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Load Protectors	0.0	0.0	0.5	0.0	0.6	0.1	0.1	0.4	0.5	1.1
Others	0.0	0.0	4.6	0.0	0.0	1.8	5.1	0.3	4.4	6.1

Table 1.13
Export Values of Electronic Products (Page 2)
(million baht)

Product Group	1970	1975	1980	1981	1982	1983	1984	1985	1986	1987 1/
5. Electronic Components	0.01	351.7	6,201.2	6,270.4	6,011.8	6,496.1	8,521.1	12,195.3	16,289.9	10,345.9
(average annual growth rate)	n.a.	780.8%	77.5%	1.1%	-4.1%	8.1%	31.2%	43.1%	33.6%	n.a.
(as percent of total electronics)	0.3%	89.7%	96.4%	97.2%	97.4%	98.8%	98.9%	98.6%	98.4%	97.2%
Passive	0.002	6.3	26.3	33.8	40.0	52.1	72.5	61.8	89.6	51.7
- Resistors & Relays	0.0	0.0	0.3	0.2	0.0	0.0	0.1	0.3	6.1	1.7
- Capacitors	0.0	5.9	25.8	33.6	40.0	52.1	72.3	61.5	82.9	48.1
- Transformers	0.002	0.4	0.2	0.0	0.0	0.0	0.0	0.0	0.6	1.9
- Other Photocells	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Active	0.0	344.2	6,155.9	6,193.0	5,929.6	5,829.1	7,353.7	8,256.4	11,655.3	6,730.6
- Electronic Tubes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Transistors	0.0	0.0	0.0	0.0	0.0	0.0	1.8	7.0	13.2	11.0
- Integrated Circuits	0.0	339.0	6,155.7	6,193.0	5,929.6	5,829.0	7,352.0	8,248.6	11,640.4	6,719.6
- Valves (crystal)	0.0	5.1	0.1	0.0	0.0	0.0	0.0	0.7	1.4	0.0
- Rectifiers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.1
Other Parts	0.004	1.2	19.1	43.6	42.2	615.0	1,094.9	3,877.1	4,545.0	3,563.5
- Parts for Broadcasting Eq.	0.0	0.0	5.5	3.0	1.9	2.3	4.5	2.9	17.5	9.7
- Television Parts	0.0	0.7	9.2	35.3	19.0	72.4	91.9	49.0	41.6	22.8
- Radio Parts	0.0	0.5	3.2	2.0	1.6	1.3	2.7	1.9	5.2	1.5
- Cathode-Ray Tubes (CRT)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1
- Microphones	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.4	0.5	0.4
- Loudspeakers	0.0	0.0	0.4	0.4	0.1	0.1	0.0	0.6	24.9	85.4
- Microphone, Loudspeaker Parts	0.0	0.0	0.0	0.1	0.0	0.0	1.0	0.2	1.3	2.1
- Cabinets	0.0	0.0	0.1	0.2	0.8	0.1	0.0	0.1	0.6	0.5
- TV Camera Tubes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
- Instrument Parts	0.004	0.1	0.3	2.0	5.5	358.3	131.5	97.3	18.8	11.1
- Electrical Goods Parts	0.0	0.0	0.0	0.8	0.0	0.1	1.9	2,028.1	3,568.3	2,560.6
- Medical Eq. Parts	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
- Computer Tape & Media	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.9	1.4	1.4
- Ball Bearings 2/	0.0	0.0	0.0	0.0	13.3	180.3	860.5	1,696.6	864.7	868.0
Total Electronics	2.3	392.1	6,433.3	6,449.7	6,173.3	6,573.8	8,613.8	12,364.4	16,555.6	10,643.7
(average annual growth rate)	n.a.	179.4%	75.0%	0.3%	-4.3%	6.5%	31.0%	43.5%	33.9%	n.a.
(as percent of total exports)	0.0%	0.8%	4.9%	4.3%	4.0%	4.6%	5.0%	6.5%	7.2%	7.7%
Total	14,250	47,505	130,406	148,962	156,039	144,322	172,076	191,613	229,937	137,903
(average annual growth rate)	n.a.	27.2%	22.4%	14.2%	4.8%	-7.5%	19.2%	11.4%	20.0%	n.a.

Notes: 1/ Data from January to June only
2/ Includes exports of all ball bearings since 1982 when NMB began producing mini-bearings for export
Source: Department of Customs

Table 1.14
Data on Electronics Producing Firms by Ownership

Period	Consumer Electronics 1/			Communications Equipment			Computer Hardware			Industrial Electronics Equipment			Electronic Components			Total Electronics		
	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.
Foreign Owned 2/	1	700	700	3	1,186	395	3	1,346	449	0	0	-	15	22,154	1,477	22	25,386	1,154
(share of total)	2.6%	6.9%		42.9%	74.0%		50.0%	92.1%		0.0%	0.0%		36.6%	80.3%		21.0%	61.0%	
Joint Venture 2/	9	5,609	623	1	122	122	0	0	-	3	615	205	16	3,893	243	29	10,239	353
(share of period)	23.7%	55.5%		14.3%	7.6%		0.0%	0.0%		23.1%	69.8%		39.0%	14.1%		27.6%	24.6%	
Thai-owned 2/	28	3,791	152	3	294	98	3	115	38	10	266	27	10	1,537	154	54	6,003	118
(share of period)	73.7%	37.5%		42.9%	18.4%		50.0%	7.9%		76.9%	30.2%		24.4%	5.6%		51.4%	14.4%	
Total	38	10,100	289	7	1,602	229	6	1,461	244	13	881	68	41	27,584	673	105	41,628	408
(share of total)	100.0%	100.0%		100.0%	100.0%		100.0%	100.0%		100.0%	100.0%		100.0%	100.0%		100.0%	100.0%	

Notes: 1/ Employment figures not available for 3 Thai-owned consumer electronics firms. Averages have been calculated accordingly.
2/ Foreign Owned - Foreign shareholding greater than 90 Percent
Joint Venture - Foreign shareholding between 10 percent and 90 percent
Thai-owned - Foreign shareholding less than 10 percent

Source: Compiled from a variety of sources and SP5 survey

Table 1.15
Data on Electronics Producing Firms by Country and Start-up Date

	NICS			Europe			USA			Japan			Thai			Total Electronics		
Period	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.
1960-1970	0	0	-	0	0	-	0	0	-	6	5,311	885	5	1,104	221	11	6,415	583
(share of period)	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		54.5%	82.8%		45.5%	17.2%		100.0%	100.0%	
1971-1974	0	0	-	1	156	156	5	5,988	1,198	0	0	-	4	750	188	10	6,894	689
(share of period)	0.0%	0.0%		10.0%	2.3%		50.0%	86.9%		0.0%	0.0%		40.0%	10.9%		100.0%	100.0%	
1975-1981	1	225	225	4	539	135	0	0	-	5	1,247	249	21	1,422	68	31	3,433	111
(share of period)	3.2%	6.6%		12.9%	15.7%		0.0%	0.0%		16.1%	36.3%		67.7%	41.4%		100.0%	100.0%	
1982-1986	2	932	466	4	2,660	665	6	6,314	1,052	5	9,056	1,811	20	2,707	135	37	21,669	586
(share of period)	5.4%	4.3%		10.8%	12.3%		16.2%	29.1%		13.5%	41.8%		54.1%	12.5%		100.0%	100.0%	
1987-Jun. 1988	3	683	228	2	620	310	0	0	-	7	1,894	271	1	20	20	13	3,217	247
(share of period)	23.1%	21.2%		15.4%	19.3%		0.0%	0.0%		53.8%	58.9%		7.7%	0.6%		100.0%	100.0%	
Total	6	1,840	307	11	3,975	361	11	12,302	1,118	23	17,508	761	51	6,003	118	102	41,628	408
(share of total)	5.9%	4.4%		10.8%	9.5%		10.8%	29.6%		22.5%	42.1%		50.0%	14.4%		100.0%	100.0%	

Notes: 1/ Employment figures not available for 3 Thai-owned consumer electronics firms

Source: Compiled from a variety of sources and SP5 survey

Table 1.16
Data on BOI Promoted Electronics Projects by Country and Promotion Date

Period	NICS			Europe			USA			Japan			Thai			Total Electronics		
	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	No.of Firms	Total Employ.	Total Invest.	Total Firms	Total Employ.	Total Invest.
1960-1970	1	134	12	0	0	0	1	55	17	4	3,525	1,608	1	510	3	7	4,224	1,640
(share of period)	14.3%	3.2%	0.7%	0.0%	0.0%	0.0%	14.3%	1.3%	1.0%	57.1%	83.5%	98.0%	14.3%	12.1%	0.2%	100.0%	100.0%	100.0%
1971-1974	0	0	0	0	0	0	3	5,942	1,860	2	508	317	3	1,041	111	8	7,491	2,288
(share of period)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	37.5%	79.3%	81.3%	25.0%	6.8%	13.9%	37.5%	13.9%	4.9%	100.0%	100.0%	100.0%
1975-1981	1	42	5	1	30	10	0	0	0	2	716	61	2	857	99	6	1,645	175
(share of period)	16.7%	2.6%	2.9%	16.7%	1.8%	5.7%	0.0%	0.0%	0.0%	33.3%	43.5%	34.9%	33.3%	52.1%	56.6%	100.0%	100.0%	100.0%
1982-1986	2	233	30	5	2,999	433	7	8,288	2,749	9	10,384	8,189	6	1,879	500	29	23,783	11,901
(share of period)	6.9%	1.0%	0.3%	17.2%	12.6%	3.6%	24.1%	34.8%	23.1%	31.0%	43.7%	68.8%	20.7%	7.9%	4.2%	100.0%	100.0%	100.0%
1987	16	10,625	1,817	3	3,106	726	5	2,265	486	25	8,989	8,219	4	272	106	53	25,257	11,356
(share of period)	30.2%	42.1%	16.0%	5.7%	12.3%	6.4%	9.4%	9.0%	4.3%	47.2%	35.6%	72.4%	7.5%	1.1%	0.9%	100.0%	100.0%	100.0%
1988 (Jan-Jun)	17	6,136	7,053	1	1,030	98	8	6,980	1,755	22	10,073	6,376	3	699	281	51	24,918	15,564
(share of period)	33.3%	24.6%	45.3%	2.0%	4.1%	0.6%	15.7%	28.0%	11.3%	43.1%	40.4%	41.0%	5.9%	2.8%	1.8%	100.0%	100.0%	100.0%
Total	36	16,094	8,917	10	7,165	1,267	24	23,530	6,867	64	34,195	24,771	19	5,258	1,100	154	87,318	42,924
(share of total)	23.4%	18.4%	20.8%	6.5%	8.2%	3.0%	15.6%	26.9%	16.0%	41.6%	39.2%	57.7%	12.3%	6.0%	2.6%	100.0%	100.0%	100.0%

Notes: Investment in million baht

Source: Board of Investment

1.5 The Conceptual Framework and Approach

This study of technological capability in the EIBI in Thailand essentially deals with the process by which firms acquire and use technological capabilities more effectively to produce output. The conceptual framework underlying the study will be presented in four stages: first, the types of productive capabilities that are to be examined will be carefully defined at the level of the firm; second, the interrelationships between a firm and its environment will be made explicit; third, the types of technological gaps to be examined will be defined; and fourth, a set of hypotheses to be examined will be presented.

The concept of the firm as being the center of the whole process as well as the main receptacle of productive technological capabilities in an economy is seen as being crucial. Furthermore, at all stages, the potential benefits of bringing both an economic and engineering perspective to bear on the issues cannot be exaggerated.

1.5.1 The Types of Productive Technological Capabilities

A schematic framework of the types of firm level productive technological capabilities is presented in Figure 1.7. The classification scheme divides technological capability into four major categories, roughly following the stages that the typical firm would be expected to follow in carrying out an industrial activity.

(a) Acquisitive capability. This capability involves the ability of the firm to search for process or product technology, to assess the suitability of various possible choices, to conduct a feasibility analysis, to negotiate with the foreign supplier and procure the technology, to install the technology or production process in the factory, and to carry out the necessary test runs prior to start-up. A crucial decision that may affect the extent to which the ability to acquire technology is developed will be the mode of technology transfer that is chosen. For example, a turnkey project with no involvement of local engineers versus a licensing arrangement where local engineers are integrally involved in the whole acquisition process.

(b) Operative capability. This capability deals with the efficiency with which the firm is able to use and operate the technology once it has been acquired. This may itself depend crucially on the understanding of the technology process that the firm acquired during the initial acquisition of the technology. The types of activities which characterize operative capability include: process operation and control; quality control of both products and inputs; manpower development programmes to enhance human capital and employee involvement; service, maintenance and calibration procedures relating to machinery and equipment; inventory control of products, inputs, and spare parts; and sub-contracting and input sourcing arrangements.

(c) Adaptive capability. This capability is reflected in the ability of the firm to carry out incremental modifications and improvements to existing plant and processes as well as minor product design changes. This generally requires the development of an in-depth knowledge of the product or process technology and is likely to involve the establishment of a basic R&D and/or product design facility. However, significant adaptations may result from suggestions emanating from worker involvement schemes such as quality control systems or from the analysis of preventive maintenance records, for example.

(d) Innovative capability. This capability is present when the firm can make "radical" or major modifications and improvements to products or processes or invent completely new products or processes. The existence of innovative capability in Thailand is very limited, involving as it does a considerable expenditure on the human and capital resources needed to carry out research and development activities to a sufficiently high level to generate such paradigmatic changes or inventions. Nevertheless, the level of R&D and/or design facilities are used to indicate the potential that exists for such changes and these differ significantly from firm to firm.

It should be emphasized that in each case, the carrying out of the respective activity need not imply the acquisition of the related capability to the same degree from firm to firm. For example, two firms that acquire exactly the same technology may not be characterized by equal levels of acquisitive capability if one opted for the turnkey plant and the other opted for the licensing agreement mentioned above. The assessment of technological capability required close cooperation between engineers and economists, and both existing and past levels of technological capabilities and the potential for future change were evaluated.

A quantitative assessment of technological capability levels, based closely on the categories discussed above, was carried out with the results being presented in detail in chapter 3. The technological capability rating scheme and a detailed breakdown of the four main capabilities into sub-categories are discussed in section 3.2.2. Indeed, given the nature of the components being measured, qualitative but professional assessments frequently played an important role when quantitative data were not appropriate or not forthcoming.

Figure 1.7 also provides a rough mapping of the above types of technological capability onto those used in several other major studies. It can be seen that there is a close correlation between the various classification schemes and that used in the present study. Two additional types of capability that are frequently mentioned are supportive and diffusive capabilities. These are not discussed at this stage because they relate more to the environment within which the firm makes decisions that determine its acquisition of productive technological capabilities rather than to the types of firm level productive technological capabilities themselves.

1.5.2 The Firm, its Organizational Practices, and the Environment

While we really want to observe the levels of technological capability in a firm and the manner in which it acquired the capabilities, we can frequently only approximate this by observing what the firm actually does with regard to the various technological capabilities, i.e. its organizational practices and behavior, and assuming that this reflects the technological capabilities that a firm possesses. The extent to which a firm is able to experience slack, in the sense that it does not fully utilize the technological capability that it possesses, is likely to reflect the level of pressure imposed on the firm by its environment and/or the ability of management to take advantage of the technological capability that it could command.

This implies that while we can observe the firm's organizational practices and make inferences about levels of technological capability, much of our understanding about the process by which technological capability is acquired and used will come from carefully examining the behavior of the firm when making technological changes of one kind or another. Such changes will frequently be made in response to environmental pressures or stimuli. The impact of these external pressures will be influenced by the firm's performance both in that highly successful firms will be less squeezed by the pressures and in that responses which strengthen performance will tend to be maintained and reinforced while those which erode performance will generate pressures to change operating practices.

In a conceptual sense this analysis, which draws partly from Fransman (1986), emphasizes the importance of the links between the performance of the firm, the environment within which the firm operates, and the organizational practices of the firm.

A more detailed attempt to present these interactions in the context of the types of productive technological capabilities discussed above is presented in Figure 1.8. In the figure, the environment is broadly seen as influencing the firm's efforts to accumulate technological capability in both direct and indirect ways, although the true complexity of all the various linkages has necessarily been suppressed for presentational purposes. The direct impact is through the pressures, price signals, and distortions emanating from government's (implicit or explicit) policies or weaknesses in the implementation of such policies, the existence of market failures (especially in the markets for information and for technology), and other non-policy factors such as external price shocks. The evaluation of the relative importance of these factors will directly have important policy implications, either with regard to reforming existing policies or implementation practices or introducing new ones to address market imperfections.

The indirect impact is portrayed through the influence of policies and other environmental factors on the levels of three types of supportive capabilities in the economy. The presence of external repositories of supportive capabilities in the economy may well be crucial in supporting firms' efforts to accumulate technological capabilities and the assessment of the technological capabilities (or lack thereof) of such agents as listed on the figure is an important part of this research exercise. An evaluation of the supportive infrastructure is presented in section 2.3 of this report.

External repositories outside the country may also play an important role although their existence and capabilities will not be greatly influenced by the Thai policy environment. The last type involves the supportive facilities developed within the firm itself, and it would appear that government policies and market failures may play a critical role in determining the levels and effectiveness of such facilities.

It is important to note that it is not only the levels of the various supportive capabilities that are important but also the strength of the linkages between the agents embodying these capabilities and the directly productive activities of the firms in the industrial sector. In some sense, the effectiveness of these linkages could be said to reflect the level of diffusive capability in the economy and may be critically affected by policy and market failures. A related point is that while the direction of the flows primarily leads from supportive to productive capabilities, there may be important feedback effects form the firms that lead to the enhancement of supportive capabilities.

Although the pressures created by the environment and the back-up available from the various types of supportive capability are important determinants of technological capability in the firm, it should be emphasized that the internal practices of the firm as it responds to external stimuli and the ability of the management of the firm to correctly assess the implications of external developments and choose appropriate strategies will be equally, if not more, important. As mentioned above, the actual performance of the firm will be both a result of the levels of managerial and productive technological capabilities as well as a factor influencing changes and improvements in them.

1.5.3 The Concept of Gaps in the Present and the Future

As part of the conceptual framework, it is important to elaborate on three types of technological gaps that will be used to consider the deficiencies in the existing technological situation and identifying policy reforms to address these deficiencies.

First, there is the gap between the technological capability levels of existing firms and those of the "best practice" firm or firms in Thailand. Several studies of Thailand and other developing countries have indicated that there is significant scope for improving the productivity of the industrial sector by simply eliminating these gaps between inefficient and efficient firms in the same industry.

Second, there is the gap between current "best-practice" in Thailand and current "best-practice" in the world. This gap reflects the ability of efficient Thai firms to acquire and apply the latest technology that characterizes the industry in question. Last, there is the gap between the technological capability that is required to implement current world "best practice" technology and that required to implement world "best practice" technology at some time in the future.

The definitions and existence of the above three gaps has been well recognized by economists and engineers alike. For obvious reasons of tractability, most attempts to analyze them have focussed on the first two. The last gap, although difficult to measure, has considerable importance for the present study given the goal of identifying strategic opportunities and the policy changes that need to be made to exploit these opportunities.

The major difference between the engineering and economic approaches has been in the methodology used to measure the gaps and to identify policy prescriptions to eliminate them, with the former concentrating on quantitative engineering measures of efficiency in a rather mechanical way and the latter concentrating on the estimation of production frontiers and efficiency levels (again in a rather mechanical way) and the economic analysis of firm behavior in making decisions to choose and apply technologies. In this study an attempt is made to integrate and build a bridge between what appear to be two very complementary approaches to examining the problem.

In the present study, the first two gaps are reflected in chapters 3 and 4 where the analysis attempts to put the capability levels of the sampled firms both into the Thai and the world perspective. Chapter 5, which deals more with the capabilities required in the future, also involves the first two gaps but, in addition, considers the likely gaps between existing and future technologies as well.

1.5.4. A Set of Working Hypotheses

Finally, a number of hypotheses that were identified during the conceptual planning stage of the project are listed here to provide an indication of the types of results that were anticipated. These hypotheses are implicitly reflected in much of the analysis which follows.

1. There exist significant possibilities to improve productive efficiency through the development of "operative" capability at the level of the firm. This results from a relative absence of attention to the engineering aspect of RD&E.

2. The acquisition by the firm of technological capabilities is crucially influenced by a combination of (a) the external environment and competitive pressures; (b) the effectiveness of linkages between external supporting agents and the firm; and (c) the internal ability of the firm and its personnel at all levels to assimilate and digest information.

3. A major market failure exists in the market for information and, accordingly, an important role for government is in the area of enhancing the flows of information between agents in the economy and between the economy and the rest of the world.

4. The government has been somewhat ineffective at providing services to encourage the development of the human resources necessary to promote rapid growth - both in terms of manpower resources and entrepreneurial skills. Accordingly, there is

significant scope to enhance the levels of technological capability in Thai firms by formulating a closer conceptual and operational link between the educational system and the needs of the industrial sector.

5. In many cases, the negative impacts of implicit government policies on firm level efforts to acquire technological capability may well exceed the potential positive impacts of explicit policies to promote such acquisition.

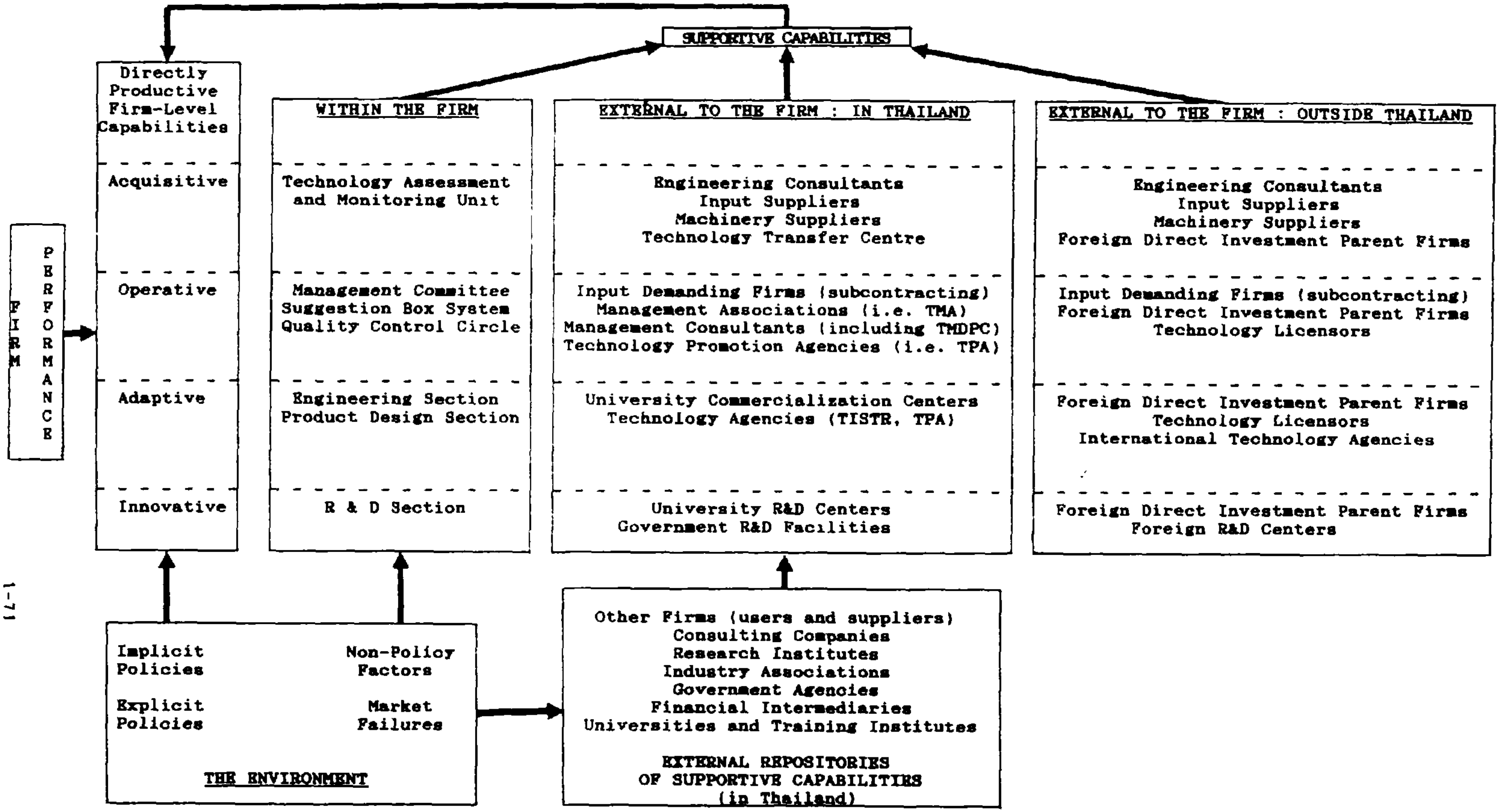
6. The impact of foreign firms on the electronics industry is clearly crucial. Such involvement is likely to have both negative and positive aspects depending on the sector and the approach of the foreign firm towards technology transfer.

7. In the end, it is the *entrepreneurial* skills and flexibility of the firm's management which influence the level and rate of growth of technological capability at the firm level.

Figure 1.7 : Technological Capability Classification System with a Correspondence to other Systems

		Correspondence with Three Other Classification Schemes		
Proposed Firm Level Productive Capability Classification Scheme (with indicative activities)	Of RD&E Mainly Involving	"Managing Technological Development (MTD)" Dahlman et.al.('87)	"Stages of Development" Kim (1980)	"Exports of Technology" Dahlman and Cortes (1984)
(1) Acquisitive Capability Search, Assessment, Negotiation, Procurement, Installation, Embodiment, Start-Up, Test Run, Choice of Technology, Modes of Technology Transfer.	E + Economics	Investment (although emphasizes expansion activities)	Not Explicitly Considered	Acquisition and Translation
(2) Operative Capability Process Operation and Control, Training, Worker Involvement, Maintenance, Inventory Control, Subcontracting, Marketing.	E + Economics	Production	Implementation	Efficient Operation
(3) Adaptive Capability Acquiring In-depth Knowledge of Technology, Technology Digestion, Incremental or Minor Modifications to Products or Processes.	D & E + Economics	Innovation	Assimilation and Improvement	Adjust and Improve
(4) Innovative Capability Carrying out Research and Development Activities, Radical Modifications to Products or Processes, Paradigmatic Change, New Inventions.	R D & E + Economics	Innovation	Improvement	Create New Technological Knowledge
Note: This classification scheme focuses on the firm as a unit and provided a guide for the interviews which identified and quantified (see section 3.2.2) the levels of each type of capability possessed by the firm as well as the internal and external factors that influenced these levels.	Note: the E may not carry the same meaning in all cells.	Note: MTD looked only at highly developed LDCs and their classification was clearly influenced by that choice.	Note: Kim examined only indigenous Korean firms that had been established for some time.	Note: Very similar to the present study's classification scheme.

Figure 1.8 : Schematic Presentation of the FIRM, the ENVIRONMENT, and SUPPORTIVE CAPABILITIES



Notes:
a) The various supportive capabilities mentioned for each type of productive capability are intended to be indicative and not exhaustive or exclusive.
b) The environment impacts both on the establishment of the external repositories and on the existence and strength of the linkages between them and the firm.
c) While the primary linkages would lead from the supportive capabilities to the accumulation of productive capabilities at the firm-level, there may well be important feedback effects as well.
d) Diffusive capability covers the issue of the strength of the various linkages in the above conceptual framework between supportive and productive capabilities and, therefore, is not treated as a separate category.

CHAPTER 2

THE POLICY ENVIRONMENT AND SUPPORTIVE INFRASTRUCTURE

This chapter reviews the policy environment within which firms in the EIBI operate, distinguishing between the policies that affect technological development in an indirect way ("implicit policies") and those which impact directly on technology related decisions("explicit policies"). A comprehensive picture of the supporting infrastructure in the areas of education, research and development, and science-related services is then presented, prior to concluding with a general evaluation of the strengths and weaknesses in the EIBI and the policy and infrastructure environment.

2.1 Industrial related policies

2.1.1 The Electronics Industry in the Development Plans

Prior to the Fifth National Economic and Social Development Plan period (1982-1986), the electronics industry was not singled out for special attention. In the fifth plan, however, recognizing that high protection levels in the past had fostered inefficiency in the industrial sector, the electrical and electronic industry was identified as one of the targets for industrial restructuring. The restructuring involved some rationalization of the tariff structure reducing both the tariff rates on finished products and those on components. However, import duties on many of the raw materials used to produce components remained high, thus discouraging the domestic production of electronic components for the consumer goods industries.

In the Sixth National Economic and Social Development Plan (covering the period 1987-1991) the electronics industry is again explicitly mentioned, this time under two of the general programmes.

First, in the Programme for the Development of the Production System, Marketing and Employment under the section dealing with the diversification of industrial production, the plan calls for the general promotion of the engineering industries by, among other things, giving: "priority to electronics industries that need to be developed simultaneously with metallurgical industries. Particular emphasis will be placed on telecommunications equipment, where product assembly and component manufacturing will increase product value, save foreign exchange and create other, related electronic industries." However, no concrete indications were provided as to what policies would be used to implement this policy, or even who would be responsible for it.

Second, in the Programme for the Development of Science and Technology under the section on manpower and engineering the goal is given to: "encourage institutions now operating in both the government and private sectors to expand production of manpower in the following fields: mechanical engineering, material science, electrical engineering and electronics (including computer science), industrial engineering and chemical engineering." Under the section on improving efficiency in national research and development it is stated that: "special support should be given to genetic engineering and biotechnology, metallurgy and material science, and electronics and computer science, where technological progress has been rapid, because they are beneficial to national development in several areas at the same time ...." and the target mentioned to "establish an organization within the Office of the Permanent Secretary, Ministry of Science, Technology, and Energy for promoting and coordinating research and development in the 3 nationally important fields of genetic engineering and biotechnology, metallurgy and material science, and electronics and computer science."

The plan also discusses several other initiatives, most importantly with respect to technology transfer (see section 2.2.2), that may have significant effects on the electronics industry. However, it is much to early to be able to really evaluate the impacts of the sixth plan since most of the recommendations are rather imprecise and have not yet been implemented to any significant degree.

2.1.2 The Structure of Protection

The Thai government essentially took an import substituting approach to industrial development in the 1960s and 1970s. This resulted in the provision of significant levels of protection to consumer product industries in general. Electronic consumer products in particular faced import duties of 80-100% which yielded very high effective rates of protection. It was in this environment that the large Japanese joint ventures and Tanin were established in the 1960s and the large number of small Thai consumer electronics firms were set up in the 1970s. However, at the top end of the market, it is likely that the competition between the six large consumer electronics producers prevented them from fully taking advantage of the high levels of effective protection.

As mentioned above, the fifth plan induced some restructuring of the tariff rates on electronic products, reducing import duties on radios and televisions to 40% and on components for radios and televisions to 10%. Domestic business taxes were also reduced from 20% to 7%. The net effect of these measures was to reduce the costs of domestic products, to reduce the volume of smuggled goods, and to reduce the avoidance of business tax. However, no significant changes were made to the rates on the raw materials used in components which frequently faced a much higher tariff than the component itself, thus discriminating against the domestic production of consumer product components. This partly explains the very high imported input ratios in most consumer electronics products that was mentioned earlier. Furthermore, many small producers were unable to obtain the reductions in import duties on components which required filing an application and submitting detailed lists of required components. Large producers and assemblers with fixed product composition were therefore favored.

In April, 1985, a round of revenue-raising tariff increases saw almost all the rates increased, with those on televisions rising to 60%, those on radios to 50%, and those on components of radios and televisions back up to 20%.

From 1986 to 1988, a comprehensive policy review of the tariff structure in the electrical and electronic industry was carried out by Boonyubol et al. (1988b) on behalf of the Board of Investment and the Electrical, Electronics and Allied Industries Club of the Association (now Federation) of Thai Industries. The recommendations of the report, preliminary versions of which were presented to the Tariff Committee in the Ministry of Finance, were largely followed in a tariff notification of November 26, 1987 which are summarized in Table 2.1. The changes involved the reduction of import duties on televisions to 40% and radios to 30%, and adjusted the rates on components depending on whether they could be produced in Thailand (then 30%) or not (then 10%). However, the overall categories covering parts and components for televisions and radios faced a reduction in tariff rates back to 10% in order to reduce smuggling. Therefore, with the exception of certain components, such as cathode ray tubes (BTN 852123), deflection yokes (BTN 852129), and printed circuit boards for radios (BTN 851919), for which tariffs are or shortly will be 30%, it would still appear that the components industry is still at a considerable disadvantage.

Table 2.2 presents the details of the present tariff structure on electronics products corresponding to the previous import and export tables as well as the tariff rates on some major inputs into the electronics industry. In addition to the problems discussed above, it is clear from the Table that other products in the electronics industry also face relatively high rates of protection, especially in the telecommunications and industrial electronics (especially measuring and instrumentation equipment) sectors. In many cases, these types of equipment are crucial in upgrading the production capability of firms both within and outside the electronics industry, and such high rates in these sectors which have very low domestic production levels is particularly worrying since they tend to discourage the importation and use of such equipment.

It should be added that, in addition to the incentive effects of the tariff structure outlined above, there have been considerable complaints about the efficiency and fairness with which customs officials carry out their task. This point is especially relevant for electronics activities since the number of different types of parts and components in a final product may be very large and not exactly uniform from batch to batch. Delays in clearance and arbitrary classification of imported inputs have been frequently reported.

2.1.3 Board of Investment Incentives

The Board of Investment is the government agency responsible for promoting private sector investment in Thailand and provides a number of tax incentives, guarantees, and investment services in order to accomplish this. Since its formation in the early 1960s, the BOI has promoted firms in a wide range of activities including all of the categories of the electronics industry. In recent years, the BOI has become increasingly concerned with promoting regional development and projects that produce for export, and has accordingly offered more attractive incentive packages for projects that fulfill these goals.

At the present time, the BOI offers incentives to projects that undertake the production and assembly of electronic products and invest a minimum of two million baht. In general, consumer electronics products must be wholly or largely exported while other products may be produced either for the domestic market or for exports. However, firms that produce only or largely for the domestic market may not be majority foreign-owned. Export firms, on the other hand, may be majority or 100 percent foreign-owned with some degree of flexibility concerning the percentage of output that can be supplied to the domestic market by export oriented firms.

In terms of overall involvement, the BOI has played an extremely important role in the electronics industry (see Table 2.3). Whether or not the BOI incentives are a crucial factor in stimulating firms to invest, however, is more difficult to evaluate. In any case, more than 60 percent of electronics producers received promotional status from the BOI at the time they commenced production or expanded their facilities. Indeed, with the exception of the two investments by Philips, all the major players in the electronics industry and the vast majority of the firms with foreign involvement are BOI promoted firms. With regard to employment, BOI promoted firms are on average seven times larger than non-BOI promoted firms and account for more than 90 percent of electronics industry employment. This figure is certainly even higher for electronics engineers and technicians. The majority (57 percent) of the non-BOI promoted firms are concentrated in the small-scale consumer electronics sector with a number in the even smaller-scale industrial electronics (18 percent) and components (13 percent) sectors. BOI promoted firms are particularly dominant in the large-scale, foreign-owned components sector where they account for almost 90 percent of the firms and 100 percent of the employment.

In addition to the inclusion of the electronics industry in the list of activities eligible for promotion, the BOI has also undertaken some specific initiatives related to the development of electronics in Thailand. In 1985, the Sub-committee for Development of the Electronics Industry for Export was formed with the responsibility for research and planning for the electronics industry and for coordinating with other agencies in the same area. The sub-committee supported the recommendations of ADL (1986) regarding the promotion of contract manufacturing in a three phased manner (see section 1.3.2) and proposed that they be officially adopted as an action plan. Meanwhile, the sub-committee played an important role in promoting and organizing the Thai CRT joint venture with Mitsubishi to produce cathode ray tubes for color televisions (scheduled to begin production in 1989) and in the restructuring of the tariff structure that was discussed in section 2.1.2 above. Several overseas missions dedicated to the electronics industry and involving a number of private sector participants have also been carried out by the BOI in the last several years.

2.1.4 Export Promotion Policies

Around the early 1970s, the Thai government, faced with increasing balance of payments problems, began to carry out policies designed to promote the growth of exports. The Ministry of Finance implemented policies in late 1971 and early 1972 to rebate import duties and other taxes on imported inputs and machinery and equipment that were used in the production of exports. In addition, a new regulation of the Board of Investment in 1972 enabled the provision of special incentives to exporters. The Board of Investment incentives are essentially granted within the same broad guidelines as those provided by the Ministry of Finance although the exemptions are provided in a much simpler and more immediate manner, thus placing a premium on BOI promotion status even for exporters who would be eligible for most of the tax rebates through other channels. These policies have been carried out concurrently with the import-substituting policies and have been marginally improved, although not significantly altered, since the early 1970s.

The impact of these changes was rather swiftly felt in the electronics industry with the location in Thailand of the three large American integrated circuit companies which dominated electronics exports for almost a decade. Since that time, the importance of export firms in the BOI's activities has risen steadily (see Table 2.4) as the BOI has increasingly favored export projects and the opportunities for marketing most of the items experiencing high growth (i.e. electronic components and parts) in Thailand are negligible due to the small size of the domestic market or the protection policies discussed earlier. In the past year and a half, the percentage of export oriented projects in total electronics projects has approached 100 percent, and an increasing number are planning to produce products which involve more processing and use of domestic inputs than the integrated circuit producers of the previous decade.

One rather worrying aspect of the concentration on export promotion has been the neglect by the BOI of those firms producing inputs that may be used in the exporting firms, the indirect exporters. In several instances, it was reported that firms which had received promotional status with the condition to export 100 percent of output experienced difficulties when applying to sell a percentage of their output to a firm producing for the export market. Problems were reported both with the BOI and the Ministry of Finance and delays of several years in approving requests were not uncommon.

2.1.5 Other Policy Measures

In addition to the main trade and industry policies discussed above, there are a number of other areas in which implicit government policies could have affected the development of the electronics industry - such as exchange rate policy, factory licensing regulations, immigration restrictions, small industry promotion, regional industrialization incentives, and so on. However, perhaps the most important concerns the multiple taxation feature of the existing business tax system which provides a disincentive to the development of sub-contracting and significantly hinders the development of linkages and technology flows between firms in the industry. In an attempt to address this problem, the Revenue Department introduced a scheme that permits manufacturers to purchase domestic intermediate inputs to be used in the production of exports or goods for the domestic market with a reduced rate of business tax. Eligible companies which register with the Revenue Department are subject to a rate of business tax on the purchases of such inputs of only 0.1% although the response has been rather low so far. Furthermore, plans are underway for the replacement of the business tax by a value-added tax although there has apparently been considerable opposition to this thus far from the private sector.

TABLE 2.1

Changes in Tariffs on Electronics Products in NMF 9/30 - Page 1

BTN Code	Description	Old Rate	New Rate
84.53	Statistical machines, magnetic disk type	40%	10%
84.55	Keyboards	40%	10%
85.01.27	Other, coils	35%	10%
85.01.30	Transformers (valid until 30/9/88) Transformers (valid from 1/10/88)	35% 10%	10% 30%
85.01.31	Transformers (valid until 30/9/88) Transformers (valid from 1/10/88)	35% 10%	10% 30%
85.01.32	Transformers (valid until 30/9/88) Transformers (valid from 1/10/88)	35% 10%	10% 30%
85.01.33	Transformers (valid until 30/9/88) Transformers (valid from 1/10/88)	35% 10%	10% 30%
85.06	Parts & accessories of electro-mechanical domestic appliances, with self contained electric motor	10%	20%
85.14	Microphones, loudspeakers, etc.	50%	40%
85.14.02	Loudspeakers to be used with automatic electronic data-processing machines performing operations according to instruction sets of work system (programs) that can be changed	50%	30%
85.14.05	Parts of microphones, loudspeakers, etc.	20%	10%
85.15.21	Television receiving sets, colour	60%	40%
85.15.22	Television receiving sets, black & white	60%	40%
85.15.24	Parts & accessories of television receivers	20%	10%
85.15.26	Radio reception apparatus	50%	30%
85.15.27	Radio reception apparatus	50%	30%
85.15.28	Parts & accessories of radio receivers	20%	10%

TABLE 2.1
Changes in Tariffs on Electronics Products in NMF 9/30 - Page 2

BTN Code	Description	Old Rate	New Rate
85.18.01	Electrical capacitors, fixed or variable	30%	10%
85.18.02	Parts	30%	10%
85.19.01	Switches	35%	10%
85.19.04	Fuses	35%	10%
85.19.05	Plugs & sockets	35%	10%
85.19.07	Resistors, fixed or viariable	35%	10%
85.19.19	Other, circuit boards	35%	10%
85.21.21	Electronic tubes, diodes	35%	10%
85.21.22	Transistors	35%	10%
85.21.23	Cathode ray tubes for producing & assembling of 85.15 b(1), (2) or (3)		
	(valid until 30/9/88)	35%	10%
	(valid from 1/10/88)	10%	30%
85.21.24	Photovoltaic cells	35%	10%
85.21.29	Other, deflection yoke for producing & assembling of 85.15 b(1), (2) or (3)		
	(valid until 30/9/88)	35%	10%
	(valid from 1/10/88)	10%	30%
85.21.29	Other, integrated circuits	35%	10%
85.23	Insulated elect. wire, cable, bars, etc.	40%	10%
85.25	Insulators of any materials to be used with automatic electronic data-processing machines performing operations according to instruction sets of work systems (programs) that can be changed	35%	10%
92.11.10 to .23	Sound recorders and players	50%	30%
92.11.24	Video recorders	50%	30%

Source: Ministry of Finance Notification (NMF) No. 9/30, November 26, 1987

TABLE 2.2
Nominal Tariff Structure on Electronic Products (January 1988)

Product Group	Tariff Rates	Product Group	Tariff Rates
1. Consumer Products		5. Electronic Components	
Televisions	40%	Passive	
Video Recorders	30%	- Resistors & Relays	10%-35%
Radios	10%-30%	- Capacitors	10%-40%
Stereos	50%	- Transformers	10%-35%
Tape Recorders	15%-50%	- Other Photocells	5%-10%
Watch Movements	15%	Active	
Others	30%	- Electronic Tubes	5%-35%
		- Transistors	5%-10%
2. Communications Equipment		- Integrated Circuits	35%
Telephones	40%	- Valves (crystal)	5%-35%
Telegram Equipment	5%-40%	- Rectifiers	5%-35%
Radio Broadcasting Eq.	5%	Other Parts	
Television Broad. Eq.	5%	- Parts for Broad. Eq.	5%-40%
Others	5%-40%	- Television Parts	10%
		- Radio Parts	10%
3. Computer Hardware		- Cathode-Ray Tubes (CRT)	5%-10%
For Office Use	40%	- Microphones	40%
Computers & Parts	20%	- Loudspeakers	40%
		- Microphone, Loudsp. Parts	10%
4. Industrial Electronics		- Cabinets	60%
Electronics	35%	- TV Camera Tubes	5%-35%
Industry	35%	- Instrument Parts	35%-40%
Fisheries	5%	- Electrical Goods Parts	40%
Medical	15%	- Medical Eq. Parts	15%
Traffic Control	10%	- Computer Tape & Media	30%
Load Protectors	35%	- Ball Bearings	20%
Others	40%		

Source: Department of Customs

TABLE 2.3

Characteristics of Electronics Producing Firms by Promotion Status and Sector

	Consumer Electronics 1/			Communications Equipment			Computer Hardware			Industrial Electronics Equipment			Electronic Components			Total Electronics		
Period	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.	No.of Firms	Total Employ.	Average Employ.
Promoted Firms	15	8,678	579	5	722	144	3	1,052	351	6	712	119	36	27,466	763	65	38,630	594
(share of total)	39.5%	85.9%		71.4%	45.1%		50.0%	72.0%		46.2%	80.8%		87.8%	99.6%		61.9%	92.8%	
Non-Promoted Firms	23	1,422	71	2	880	440	3	409	136	7	169	24	5	118	24	40	2,998	81
(share of period)	60.5%	14.1%		28.6%	54.9%		50.0%	28.0%		53.8%	19.2%		12.2%	0.4%		38.1%	7.2%	
Total Electronics	38	10,100	289	7	1,602	229	6	1,461	244	13	881	68	41	27,584	673	105	41,628	408
(share of period)	100.0%	100.0%		100.0%	100.0%		100.0%	100.0%		100.0%	100.0%		100.0%	100.0%		100.0%	100.0%	

Notes: 1/ Employment figures not available for 3 Thai-owned consumer electronics firms. Averages have been calculated accordingly.

Source: Compiled from a variety of sources and SP5 survey

TABLE 2.4

BOI Promoted Electronics Projects by Export Orientation 1/

Period	Export-Oriented			Non-Export Oriented			Total Electronics		
	No.of Firms	Total Employ.	Total Invest.2/	No.of Firms	Total Employ.	Total Invest.2/	No.of Firms	Total Employ.	Total Invest.2/
1960-1970	0	0	0	7	4,224	1,640	7	4,224	1,640
(share of period)	0.0%	0.0%	0.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
1971-1974	5	6,879	1,957	3	612	331	8	7,491	2,288
(share of period)	62.5%	91.8%	85.5%	37.5%	8.2%	14.5%	100.0%	100.0%	100.0%
1975-1981	5	1,514	173	1	131	2	6	1,645	175
(share of period)	83.3%	92.0%	98.9%	16.7%	8.0%	1.1%	100.0%	100.0%	100.0%
1982-1986	26	23,662	11,822	3	121	79	29	23,783	11,901
(share of period)	89.7%	99.5%	99.3%	10.3%	0.5%	0.7%	100.0%	100.0%	100.0%
1987	50	23,887	8,566	3	1,370	2,789	53	25,257	11,356
(share of period)	94.3%	94.6%	75.4%	5.7%	5.4%	24.6%	100.0%	100.0%	100.0%
1988 (Jan-Jun)	50	24,825	15,457	1	93	107	51	24,918	15,564
(share of period)	98.0%	99.6%	99.3%	2.0%	0.4%	0.7%	100.0%	100.0%	100.0%
Total	136	80,767	37,975	18	6,551	4,948	154	87,318	42,924
(share of total)	88.3%	92.5%	88.5%	11.7%	7.5%	11.5%	100.0%	100.0%	100.0%

Notes: 1/ An export-oriented project is on that exports 80% or more of output
2/ Investment in million baht

Source: Board of Investment

2.2 Technology Policies

2.2.1 Technology Planning

It is in the sixth national economic and social development plan (1987-1991) that the science and technology policies towards electronics and computer technologies were first integrated into the national development plan. Indeed, as mentioned earlier, the plan's programme for the development of science and technology which calls for:

- special national research expenditure to be allocated to genetic engineering and biotechnology , metallurgy and material science, and electronics and computer science,
- an establishment of organization for promoting and coordinating research and development in the 3 national priority areas.

However, more concrete and less conflicting science and technology policies are yet to be formulated. In recent years, besides this study, some related policy researches were carried out which will help to accommodate the process. Many of these were already discussed in section 1.3. It should be added that there is an ongoing study on the status of the electronics and computer technologies in six industry areas to identify priorities for MOSTE involvement in the industry. Two additional reports, STDB (1987a) and (1987b) comprised a useful collection of documents distributed and discussions made during seminars organized by the STDB. Some technological evaluations were made as of the possibility of the requirement for the development of the electronic ceramics and computer software industries.

Presently, policy makers are more aware of the far reaching impacts of electronics and computer technologies. The function of keeping a close look on the development of these technologies and industries and hence planning a medium and long term S&T policies accordingly was assigned to many related organizations. Some important ones are:

- The Sub-committee for the Development of Electronics Industry for Export, BOI
- Planning and Evaluation Section, STDB
- National Electronics and Computer Technology Center (NECTEC), MOSTE.

Of all these offices, the BOI's Sub-Committee is the first to be set up, in early 1985, while the other two offices were later established in late 1985 and late 1986 respectively. The Sub-Committee for the Development of Electronics Industry for Export probably plays more important role in shaping the country's policy towards electronics industry. It primarily function as an advisory committee to the BOI on policy matters related with electronics industry. Its coverage is not limited, as might be implied by its name, only to electronics industry for export but also to domestic market as well. It would certainly have to take a period of time before other two organizations could start to play any effective role in the formulation of the country 's electronics industry-related policy.

2.2.2 Technology Transfer and Diffusion Policy

The policy on technology transfer which is more concrete and specific for electronics and computer based electronics industries is yet to be formulated. The Technology Transfer Center, Ministry of Science, Technology, and Energy, is a major government office in charge of general policy on technology transfer. However, due to inadequate manpower and budget allocation not many of the Center's objectives can be pursued. The center's activities have been, basically, occupied by information dissemination and workshops on negotiation for fair technology transfer agreement. The Center has yet to expand its activities to cover the more policy-oriented functions, namely:

- planning and listing priority technologies needed,
- analyzing, evaluating and selecting technologies for transfer,
- follow-up and evaluating the technologies imported

The Technology Transfer Center has prepared a drafted policy outline and plan for the country's transfer of imported technology. It is being discussed among relevant organizations such as the Department of Technology and Environment Planning, the NESDB, the BOI, and the Bank of Thailand for further improvement.

The Sub-Committee for the Development of Electronics Industry for Export in the BOI is another government office which keeps a close look on the issue of technology transfer, particularly on electronics and computer technologies. In March, 1986 the Committee succeeded to have the following clause: "Joint venture agreement and foreign investor's technology transfer agreement have to be approved by the Board of Investment" included as a necessary condition for being promoted by BOI to produce color picture tubes.

Furthermore, the Committee also recommended to the Board that a requirement for a switching and exchange equipment producer to train Thai technicians and engineers to replace foreign experts in an appropriate period of time be included as condition for being promoted. The Board of Investment agreed with the point and due to this requirement the NEC Corporation had to include technical training programme and technology transfer plan which accounted for more than 50 percentage of the corporation's proposal documents presented to the Board.

2.2.3 R&D Policy

Three important R&D policy guidelines stated in the Sixth National Economic and Social Development Plan called for (NESDB, 1987):

- attempt to set the total national research expenditure as close as possible to 0.5 percent of GNP,
- special support for research work in genetic engineering and biotechnology, metallurgy and material science, and electronics and computer science, and
- establishment of an organization for promoting and coordinating research and development in the mentioned 3 priority areas.

With the establishment of the Science and Technology Development Board (STDB) in July 1985, and the National Electronics and Computer Technology Center a year later in September 1986, more specific R&D policies for electronics and computer based technology are gradually taking shape. In its position paper, the STDB advocated that the RD&E activities will help "create the foundation for expanded indigenous involvement in industrial growth." (STDB Position Paper). The paper further stressed, the role of "applied electronic technology" as important to help the natural resource based industries (ie. biotechnology and material technology based industries) achieve competitive status. Finally, as for areas on which RD&E activities should be focused, the paper suggested that they include areas of computer applications and software development.

More specific prioritization of RD&E topics was further developed by the NECTEC. Ten high priority projects have been selected for financial support by the center. They are:

- Project on Artificial Intelligence
- Project on Computer Network
- Project on VLSI Design and Fabrication
- Project on Biomedical Electronics and Instrumentation
- Project on Technology Transfer and Human Resource Development
- Project on Industrial Electronics and Instrumentation
- Project on Development of Material and Device Technology
- Project on Computer System Technology
- Project on Computer Software Development, and
- Project on Telecommunication Equipment Development.

In fiscal year 1988, NECTEC was allocated a total sum of 24 million baht from the Government budget to support these projects.

Furthermore, it also commissioned a joint research team from Chulalongkorn University and King Mongkut Institute of Technology Lad Krabang to survey the status of electronics and computer based industries of the country. The research team will have to come out with medium and long term plans to serve as the country's RD&E activities guideline.

The Center also set the following goals:

- to develop high capability research and development institute for electronics and computer based technologies,
- to develop an efficient institute for services and disseminations of electronics and computer technologies
- to develop highly efficient teams to help in the technology transfer process.

2.2.4 Manpower Policy

While in the 6th National Economic and Social Development Plan it is clearly stated that "human resource development in the field of science and technology is of the utmost importance" (NESDB, 1987) and it was further specifically stressed that "manpower with a high level of scientific and technological competence" is necessary for new industrial projects in petrochemicals, fertilizers, electronics, nevertheless, the government, so far, has hardly done anything to match these policy statements. Budgets allocated for high level education in engineering are barely enough to replace obsolete equipments. Staff in higher education can hardly be updated to cope with rapid technological changes due basically to the government 2% growth ceiling of the government officer.

Concern was also raised in the sixth plan of the very small number of scientific and technological manpower both in absolute term and in relative with other disciplines (NESDB, 1987). However, the situation can not be expected to improve much. In an interview with the Permanent Secretary of the Ministry of University Affairs, it was said that the present ratio of producing about 17 percentages of S&T graduates can only be expected to increase to about 22 percentage at the end of the sixth plan in 1991. The figure is far below the approximately 40-50 percentages in countries like, Singapore, Korea and Taiwan.

In the recent years, there are at least three studies on the situations of human resources, with slightly differences in scope and emphasis. The first study conducted during 1984/85, covered survey and manpower planning for scientists and technologists as a whole (MOSTE, 1984). A more specific study on demand and supply of manpower in three areas, namely biotechnology, material technology and electronics and computer technologies was carried out during 1987/88. The most specific study, concentrated mainly on electronics manpower, was conducted earlier in 1985 to forecast possible increase in employment of electronics and computer related engineers and technicians, due to the country's social and economic development plan (Petchsuwan et al., 1985). All these reports came out with the same conclusion that, unless some major policy changes in science and technology education are made within a few years time the country will certainly face with a serious shortage of scientific and technological manpower. Unfortunately, up to now no concrete action from the government has been seen.

Besides problems of the quantity of engineering manpower, the same, if not more, serious concern is its quality. In the sixth plan, the point was briefly addressed but measure to remedy this shortfall was not proposed. Given the facts that, technological changes in the electronics and computer based industries have been extremely rapid in this decades, it would be obvious that the problem of quality of electronics engineer has to be of highest concern. Manpower policy directed to this sector has to fully address the matter and map out efficient education system that is flexible enough to keep being up-to-date amidst the technological changes.

2.3 Supportive S&T Infrastructure

The country's S&T infrastructure is supposed to help facilitate producing firms' productivity improvement that ranges from enhancing quality control activities, incremental adaptation of products or processes up to research and product innovation. The services that the S&T infrastructure has to provide, therefore, will cover a broad spectrum of activities. They include:

- training competent manpower to supply producing firms.
- providing efficient technical information services

- doing basic R&D work that would support the firms' activities.
- providing basic technical services, for instance, calibration, product testing etc.

The following will attempt to summarize the major S&T infrastructure for the electronics and computer based industry.

2.3.1 Education and Training

1) Formal Education

We will discuss status and situation of this supportive function in two levels:- degree and below degree levels.

a) Degree Level Programmes in electronics and computers are available in almost every state universities. Recently, a few private universities began to offer either of these programmes as well. Table 2.5 summarize the status of higher education in this subject areas.

Table 2.5

Educational Programmes in Electronics and Computer being offered in Universities. (as of 1988)

Field / University	Electronics Bachelor	Electronics Master	Electronics Doctor	Computer Bachelor	Computer Master	Computer Doctor
A) State Universities						
1. Chulalongkorn	x	x	x	x	x	x
2. Chiangmai	x					
3. Kasetsart	x	x		x		
4. Khonkhaen	x	x				
5. Songkla	x	x				
6. KMITL	x	x	x	x	x	x
7. KMITT	x	x				
8. KMITNB	x	x				
9. NIDA					x	
B) State Open Universities						
10. Ramkamheang				x		
C) Technical Institute						
11. Inst. of Tech.& Voc. Education	x					

Source : survey

Notes :* Included in Electrical Eng. programmers.

Table 2.5 (cont.)

Field / University	Electronics Bachelor	Electronics Master	Electronics Doctor	Computer Bachelor	Computer Master	Computer Doctor
D) Private Universities						
12. South East Asia Univ.	x					
13. Sripatum Univ.	x					
14. Univ. of Thai Chamber of comm.				x		
15. ABAC				x	x	
16. Payab				x		

Source : survey

Notes :* Included in Electrical Eng. programmers.

Table 2.6 shows past record of number of graduates in electronics and computers turned out by the higher education system. The number of graduates in bachelor degree has increased at a yearly rate of about 17 percentage. Which is relatively high. However, since initially the number of bachelor graduates are unreasonably low, therefore even this high growth rate can not produce enough electronics and computer related manpower to supply fast growing demand.

Table 2.6

Number of Graduates in Electronics and Computer

Level / Academic year	1981 (81/82)	1982 (82/83)	1983 (83/84)	1984 (84/85)	1985 (85/86)
Bachelor's degree					
Electronics	431	641	623	668	791
Computer*	60	44	78	172	136
Total	491	685	701	840	927
Master's degree					
Electronics	25	31	43	33	25
Computer*	35	68	35	44	27
Total	60	99	78	77	52
Grand Total					
Electronics	456	672	666	701	816
Computer*	95	112	113	216	163
Total	551	784	779	917	979

Source : TDRI (1988) p. 40, 41, 43

Notes : * This comprises both computer engineering and computer Science graduates.

A comparison between projected supply and demand of electronics and computer related manpower over time is shown in table 2.7. It is obvious from the table that serious shortage is inevitable if no improvement in production capacity is made. Furthermore, it should be pointed out that the projection was made using base scenario. Hence, bearing the recent surge of investment in electronics and computer-based industries in mind, it is evident that the shortage will be far more serious.

Table 2.7

Projection of Supply and Demand of Electronics and Computer Manpower (Degree Level)

(Base Scenario)

	1988		1989		1990		1991		1996		2001	
	Supply	demand	supply	demand	supply	demand	supply	demand	supply	demand	supply	demand
Bachelor Degree												
Electronics	720	943	753	1,053	786	1,032	820	1,104	987	1,412	1,154	1,929
Computer	131	263	140	253	150	258	160	283	208	320	256	1,460
Master Degree												
Electronics	44	69	48	75	51	74	55	81	72	105	89	143
Computer	46	88	47	83	49	84	51	93	61	103	70	145
Grand Total												
Electronics	764	1,012	801	1,128	837	1,106	875	1,185	1,059	1,517	1,243	2,072
Computer	177	351	187	336	199	342	211	376	269	423	326	605

Source, TDRI (1988) pp. 53-54, 65-66

Beside quantity, quality of electronics and computer related manpower is also of much concern. Despite rapid technological changes in these subject areas, it is very difficult for universities to have their teaching staff kept up with these developments. The followings are some important causes:

- the environment in the universities that allows senior staff to become stagnant and, in some cases, even to become opposed to curriculum changes.
- the serious shortage of competent manpower started to aggravate brain drain of capable University staff into producing firms,
- the 2% growth ceiling set up by the government to limit the number of yearly recruited officers

adversely effect the government universities' flexibility to inject in new blood.

The problem of teaching staff combined with insufficient and obsolete laboratory equipments constitute the main causes that, if no appropriate measures are taken, will rapidly degrade graduates in these subject areas.

b) Below Degree Level In term of quantity production of below degree electronics and computer manpower suffered from differing problem, namely an overproduction. A comparison of projected supply and demand of electronics technicians overtime is shown in table 2.8.

Table 2.8
Projection of Supply and Demand of Electronics and Computer Manpower (Below Degree)

Year	1988	1989	1990	1991	1996	2001
Supply						
Voc, Cert,	934	1,038	1,142	1,247	1,768	2,288
Tech.Cert.	4,447	5,207	5,638	6,068	8,222	10,375
Higher.Voc,Cert.	5,985	6,530	7,074	7,619	10,342	13,066
Total Supply	11,695	12,775	13,855	14,934	20,332	25,730
Total Demand	-					
Base Scenario	4,570	4,868	4,828	5,171	6,368	8,859
High Scenario	4,555	4,836	5,136	5,456	10,510	16,092

Source : TDRI (1988) p. 55, 67, 70

From the table it is evident that, even in the case of high scenario, the number of technicians turned out far exceeds the number of projected demand. For instance, in 1988 the number of supply is 11,695 which is 2.6 times that of projected demand.

However, amidst the problem of excess supply, shortage of technicians in some areas are also evident. This is because the curriculums being used in most vocational schools and colleges are basically those of conventional electrical engineering, whereas growing demand has been in new disciplines such as electronics, industrial control and instrumentation etc. Therefore, an education system which can response flexibly to demand both in term of quantity and specialization is much needed.

Competent technicians function crucially in upgrading quality and improving productivity in producing firms. Engineers can never fully perform their duties without support from qualified technicians. Therefore, efficient and high quality vocational education is an essential condition for sound development of technological capability in the country.

2) <u>Informal Education</u>

Informal education can play a very crucial role in the process of manpower development, particularly in a society with insufficient formal education system and specifically in areas of rapid technological changes. This system is very helpful in

- retraining senior technicians and engineers so that they can keep up with new development
- top-up training to turn out particularly needed man power for immediate use
- providing forums for technicians and engineers from different firms to exchanges experiences and know-how which will greatly help in technology diffusion process.

Presently, an organization which is most active in providing seminar and training courses still is the Technological Promotion Association (TPA), a non-profit private organization founded in 1973. During April 1987 and March 1988, the

Association has managed to organize 317 seminar and training courses with a total of 11,756 technicians, engineers and managers participated. Seminar and training courses which are of direct relevant to electronics and computer technologies are:

- 36 seminar and training courses organized by the TPA's Industrial Instrumentation Committee which cover topics such as programmable sequence controller, distributed process control systems, industrial motor speed control system and microprocessor-based instruments etc., with participation from a total of 1,151 technicians, engineers and managers.
- 38 seminar and training courses organized by the Computer Committee which cover simple topics such as dBase, LOTUS and more sophisticated ones such as expert system, C Language, assembly language programming, microprocessor architecture etc. The participants amounted to 1,058 persons.

The remarkable increase in seminar and training activities in Universities campus is a commendable trend in recent years. The Universities could considerably benefit from the activities in two ways:

- in term of financial benefit to the universities and staff concerned,
- in term of opening up forums for people from producing firms and universities staff to meet, exchange ideas etc. This will certainly develop into a more fruitful linkage between firms and universities.

Seminars and training courses in the universities cover a wide spectrum of topics, for instance:

- industrial applications of microprocessor
- computer aided design and its application
- surface mount technology
- programmable sequence control
- motor speed control etc.

2.3.2 Research and Development

Although there are cases of producing firms directly engaging in development and engineering works themselves, nevertheless, in most cases the RD&E activities have been performed in the public sector.

The research and development activities in the public sector are carried out exclusively in state universities. Up to the year 1987, most of the research funding have been from the government budgets the amount of which ranges from ten thousands baht to some hundred thousands baht for each project. All these funding are allocated on the year by year basis. After the establishment of the STDB and the NECTEC respectively, funding for research projects that cover a time period of up to 6 years and amount to some millions baht were made possible. The total budget for R&D activities increased significantly due to research funding allocated through those two newly founded organizations. Table 2.9 shows estimation of R&D funding in electronics and computer related projects.

Table 2.9

Estimation of R&D Funding in Electronics and Computer Related Projects.

(million Baht)

Sources / Fiscal Year	NECTEC	STAB	Other Government Budget	Total
1984	-	-	5.3	5.3
1985	-	-	6.2	6.2
1986	-	-	9.3	9.3
1987	-	-	8.9	8.9
1988	23.0*	10.0*	10.0*	43.0

Source : NRCT, NECTEC, STDB

Note : * approximation

A list of research and development projects supported by the NECTEC is summarized and shown in table 2.10.

Table 2.10

Research and Development Projects Supported by National Electronics and Computer Technology Center

Research Topic	Institution	Period	Budget (Million Baht)
Project: Artificial Intelligence			
1. Development of Electronics Dictionary for Machine Translation	KMITT	1987-1992	2.5
2. Text Generation System for Machine Translation	KMITL	1987-1992	2.5
3. Development of an Input-Out-ut System and a Translation Support System	KU	1987-1992	2.5
4. Development of Integrated System for Machine Translation	KMITT	1987-1992	2.5
5. Automatic Recognition of Thai-English Characters	KMITL	1988-1990	1.0
6. The Analysis of Thai for Machine Translation	CU	1987-1992	2.5

Source : NECTEC

Table 2.10 (cont.)

Research Topic	Institution	Period	Budget (Million Baht)
Project :Computer Network			
1. Computer Network	Joint Research	1988	0.5
2. Computer Network I	NECTEC	1988-1991	16.0
3. Code and Software Studies for Computerized Patent Data Base	DOSS, MOSTE	1988	0.4
Project:VLSI Design and Fabrication			
1. Design and Fabrication & Prototype IC	KMITL	1988-1990	3.0
2. CAD Software for VLSI Design "NECTEC I"	KMITL	1988-1990	2.6
3. CAD Software for VLSI Design "NECTEC II"	KMITT	1988-1990	2.4
4. VLSI Commercialized Sample Design	CU.	1988-1990	1.2
5. VLSI Commercialized Sample Design	KMITT	1988-1990	1.2
6. VLSI Commercialized Sample Design	KMITL	1988-1990	1.2

Source : NECTEC

Table 2.10 (cont.)

Research Topic	Institution	Period	Budget (Million Baht)
Project:Biomedical Electronics and Instrumentation			
1. Construction and Development of ICU Monitoring System for 4 Patients	KMITL	1988-1989	0.8
2. Computerized X-ray Tomography	KMITL	1988-1990	7.0
Project:Technology Transfer and Human Resource Development	-	Yearly budget	0.8
Project:Industrial Electronics and Instrumentation			
1. Universal Data Logger	SU.	1988	0.3
2. Programmable Controller	CU.	1988	0.35
3. Research and Development of Sensors and Transmitters	KU.	1988-1989	0.6
4. Industrial Automatic Pattern Tracing and Cutting Machine	KMITL	1988	0.4
5. AC. Motor Controller	CMU	1988	0.35
6. Industrial Robot	KMITT	1988-1990	1.15
7. A Sugar Content Meter for Sugar-Cane	KKU	1988-1989	0.24
8. Feed Mix Control System	KMITL	1988	0.2

Source : NECTEC

Table 2.10 (cont.)

Research Topic	Institution	Period	Budget (Million Baht)
Project: Development of Materials and Devices Technology			
1. Fabrication of Prototype Semiconductor Pressure Transducer for Biomedical Application	KMITL	1988	0.5
2. Opto electronics	CU.	1988-1990	3.6
3. Design and Fabrication of the Prototype of Silicon Rectifier for Mass Production	KMITL	1988	0.45
4. Research and Development of High To Superconductor Microbridge Josephson Junction	KMITT	1988-1990	0.94
5. Design, Fabrication and Development of DMOS Power MOSFET	KMITL	1988	0.4

Source : NECTEC

Table 2.10 (cont.)

Research Topic	Institution	Period	Budget (Million Baht)
Project: Computer Software Development			
1. An Integrated Package for Restaurant	SU	1988	0.09
2. A Development of Software for the Transaction of Government Budget	CU	1988-1990	0.82
3. Pilot Software for a Relational Database Management System	SU	1988	0.2
4. Clinical Package	SU	1988	0.09
5. Development of Software for Export-Oriented Canned Food Industry	SU	1988-1990	1.0
Project:Computer System Technology			
1. Development of a Learning and Development KIT for Hardware Microcomputer System	CMU	1988-1989	0.6
2. Computer System Technology	KU	1988-1989	2.8
3. Still Image Data Base System on Personal Computer	CU	1988-1989	0.54

Source : NECTEC

Table 2.10 (cont.)

Research Topic	Institution	Period	Budget (Million Baht)
Project:Telecommunication Equipment Development			
1. Microprocessor Controlled UHF Frequency Synthesizes	KMITT	1988-1990	1.26
2. Optical Fiber Data Communication System	KMITT	1988-1990	1.2
3. Development of Pilot Scale Industrial Process for Through Hole Plating	KMITT	1988-1991	1.2
4. A Design and Construction of Radio Frequency Shielded Encloser	CU	1988	0.5
5. Telephone Emergency-Record Answer (Tera-II) Unit	KMITL	1988	0.6

Source : NECTEC

The electrical engineering symposium has been jointly organized by the country's departments of electrical engineering since 1978, to present results of research works. The works were basically, carried out jointly by Universities' staff members and their graduate students or fourth year students. The numbers of papers being presented in the symposia since 1978 are summarized as shown in Table 2.11.

Table 2.11

Number of Papers being Presented in the Electrical Engineering Symposia

Year / Field	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87
Electronic Circuits	10			34	16	14				
		21						23	38	28
Electron Devices	10		-	9	7	10	-			
Power System			-	10		11	-			
	10	9			16			7	15	15
Circuit Theory										
Communication	7	8	-	9	11	15	-	13	19	15
Computer and Micro Processor Control Systems	13	7	-	21	18	15	-	23	28	17
Other	-	-	-	9	5	-	-	-	-	-
Total	50	45	-	101	73	70	-	71	106	92

2.3.3 S&T Services

In our discussion, we will divide S&T Services into two broad category, namely technical service and information service.

1) Technical Services Major organizations providing technical services for producing firms and their respective services are listed as shown in table 2.12.

Table 2.12

Major Organizations Providing Technical Services and their Respective Services.

Services / Organization	Calibration	Testing	Consultancy
Dept. of Science Service MOSTE	*	*	-
Testing and Standard Center TISTR	*	-	-
Thai Airways International	*	-	-
Technological Promotion Association	*	-	*
Chula-Unisearch	-	-	*
R&D Center KMITL	-	*	*
University Laboratories	*	*	-

Calibration is the only service which is relatively widely available. However, there exists some important discrepancies which need prompt action. They are:

- except for two private organizations, ie. TPA and the Calibration Laboratory at Thai Airways International Co., Ltd., other laboratories' services are generally not prompt enough to be attractive to the producing firms.

- as is generally true in most government offices, manpower available in the government laboratories are, in average, incompetent,
- though many laboratories maintain high-quality standards that are traceable to international ones, (for example, the Testing and Standard Center, TISTR maintains electrical standards that are traceable to Electrotechnical Laboratory (ETL) in Japan or the Calibration Center of the Thai Airways International Co., Ltd., maintain time and frequency standards that are traceable to National Bureau of Standard (NBS) the USA) there is no national coordinating body to maintain the national standards.

Besides calibration, most government laboratories also provide services to test whether products are in compliance with the country's industrial standard. Except for the Department of Science Service which provides testing services for VHF & UHF transceivers, other laboratories perform, testing of basic electrical quantities. Some products being tested in the universities are uninterruptible power supply, ground leak interrupter.

Electronics and computer technologies related consultancy in Thailand is yet in an infant stage. Usually, universities' staff are providers of the services which are for the most cases on individual basis rather than business like. Services provided range from advices on purchasing of equipments, suggestions for machinery adaptation in order to improve productivity, recommendations for methods to assure quality etc.

Presently, there exist a few organizations which provide this sort of services. They include:

- the TPA's calibration center which gives advice related with purchase, maintenance and calibration of electrical, electronic and industrial instruments,

- Chula Unisearch, Chulalongkorn University undertakes, on commission, to study the feasibilities of many investment projects,
- some computer-aided-design services are also available in the Computer Center, Faculty of Engineering Chulalongkorn University,

2.4 A Summary Evaluation of the Present Situation

This section summarizes the major strengths and weaknesses of to the policy and infrastructure environment related to the EIBI in Thailand. Following a general comment on structure, the section will consider the main issues relating to policy formulation, policy implementation, and the technological infrastructure.

2.4.1 General Structure

The EIBI in Thailand consists of a number of different electronics enclave industries, all of which continue to rely heavily on imported inputs and generating quite low levels of value-added (see Figure 2.1). There continue to exist a number of large consumer electronics companies which receive relatively high levels of protection and operate at low levels of efficiency. The industry as a whole, and especially the electronic component sector, is becoming increasingly dominated by foreign companies, most of which export virtually all of their output and have very little contact with the local industry. Several software companies have begun to operate but the development of the industry is very much in the beginning stages. The net result is that the linkages between the various electronic industry groups are considerably underdeveloped as well as those between the electronics industry as a whole and the rest of the manufacturing sector.

2.4.2 Policy Formulation and Planning

At the implicit policy level, it is very clear that technological considerations have only played a very peripheral role. Other policy goals such as export promotion and industrial decentralization tend to dominate the policy formulation process although the importance of technological issues are increasingly recognized. In fact, there is no explicit industrial development plan for the EIBI in Thailand, in direct contrast to the clear policy statements of Taiwan and Korea. At the explicit policy level, the planning process is characterized by a considerable lack of coordination between all parties concerned. Even within the NESDB, there appears to be a considerable absence of coordination between the various divisions responsible for technology-related issues. Although more initiatives that mention science and technology are currently being talked about, there appear to be few efforts to provide perspective to the technology planning exercise, either with regard to where Thailand presently stands, what the concrete needs are, what institutional reforms or development are required, or how to go about addressing the problem areas.

2.4.3 Policy Implementation

Another symptom of the lack of coordination at the planning level is a similar lack of cooperation with regard to implementation. MOSTE itself consists of many diverse departments and institutes which tend to be far flung both in terms of psychic and geographic distance. For example, the operations of NECTEC and STDB seem to be carried out more or less independently and the linkages between MOSTE and other agencies such as the education ministries and the investment-related organizations are very weak. An additional problem concerns the quality of the manpower which are assigned the responsibilities of policy implementation.

Such problems mean that even when a reasonable working plan exists, such as in the case of technology transfer policies which may help better to take advantage of foreign technology in Thailand, the ability to coordinate and carry out the plan may well be non-existent.

2.4.4 Supporting Infrastructure

It is at the level of supporting infrastructure that the most serious constraints on the development of the EIBI are experienced.

The shortages of electronics, computer, and other related engineers as well as appropriately trained technicians are posing serious problems both for producing firms as well as R&D efforts in electronics-related industries. The universities and technical training institutes tend to be rather inflexible, not responding well to the needs of the rapidly changing technological scene of the EIBI. Curricula are adjusted very slowly and the numbers of engineering graduates have not been keeping up with demand. The situation has recently been exacerbated by the increasing brain drain from universities into much higher paid private sector jobs. Informal education opportunities, although increasing in number, still leave a lot to be desired.

With the increasing attention being paid to R&D, the level of commitment to electronics research work by the public sector has improved a lot in recent years. However, private sector R&D is still almost non-existent and the linkages between private firms and research centers or universities remain very weak. The lack of highly-trained technical manpower is particularly severely felt in this regard.

The quality and quantity of electronics calibration, testing, and consultancy services also require considerable development, especially in the testing and consultancy areas. The absence of a national body to coordinate and maintain a set of national standards is a serious weakness.

Lastly, the weaknesses in the supportive metal-working, high precision metal and plastic parts, and chemicals industries place serious constraints on the extent to which the electronics industry can enhance its value-added and develop potentially fruitful subcontracting linkages. The industries which do exist tend to be characterized by low quality and accuracy, high cost, considerable unreliability, and low production capacities.

CHAPTER 3

PROFILE OF PRESENT TECHNOLOGICAL CAPABILITIES OF THE EIBI IN THAILAND

3.1 Products, Processes and Technologies

3.1.1 Overall Description of the Electronics and Information Technology-Based Industries in Thailand

In section 1.3.1, the activities in the electronics industry are classified according to types of products into six broad groups, namely, consumer electronics, communications equipment, computer hardware, industrial electronics equipment, electronic components, and computer software.

However, from the point of view of the production processes, the production levels in the electronics industry can be divided into 6 levels or stages as follows:

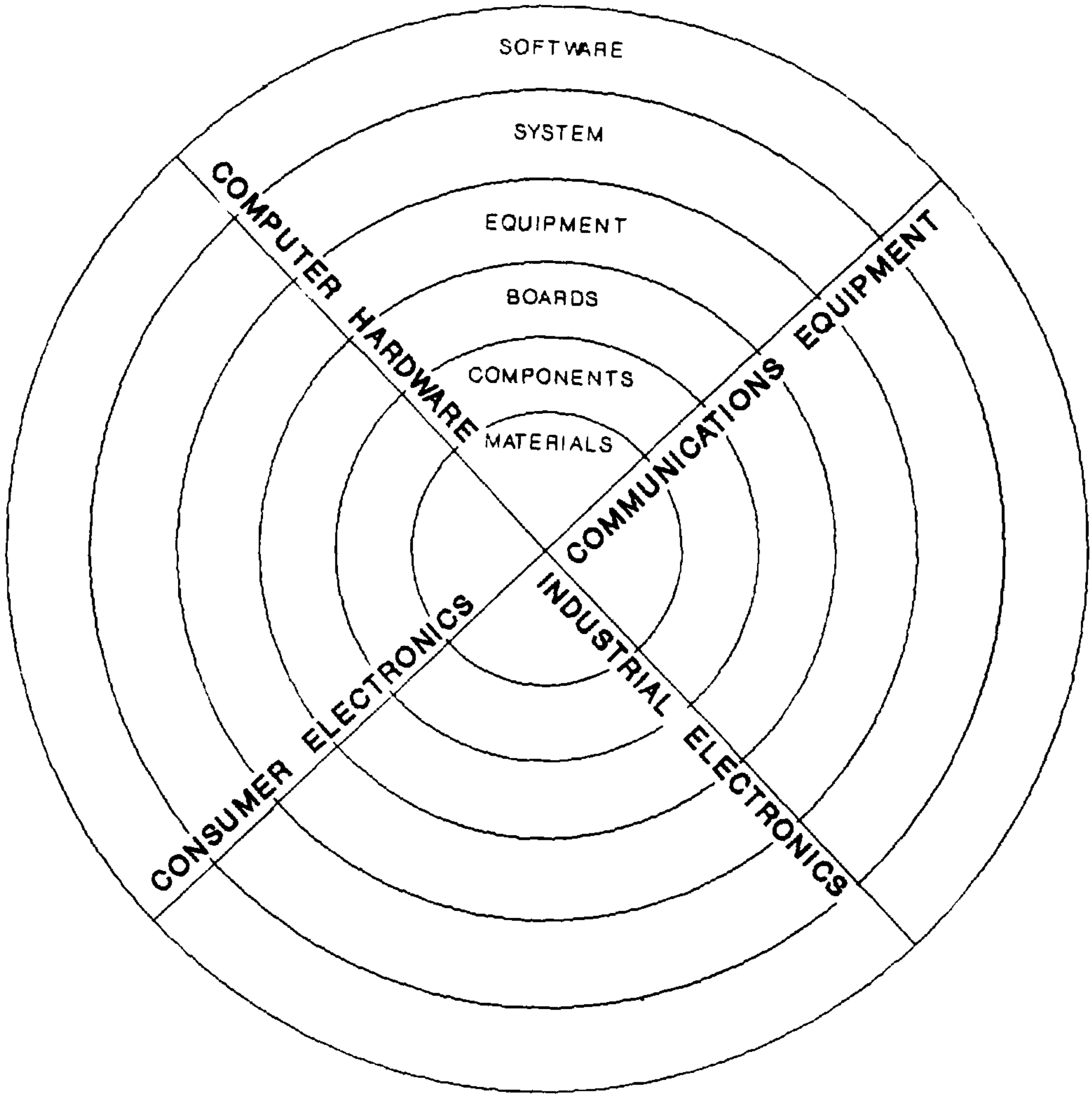
(1) materials
(2) components
(3) circuit boards
(4) equipment
(5) systems
(6) software

As all electronic products have to go through these production stages, the relation with various categories of electronic products is shown in Figure 3.1. All electronic components and devices are based on certain kinds of materials. With the same materials, electronic components and devices are produced to perform different functions. From designs of circuits and board layouts, components and devices are assembled into boards. Each type of board is designed to perform certain functions, and an equipment consists of boards of different functions. Various types of equipment are connected together into a system. As most systems at present are digital, software for the operation of the system and equipment must be programmed in.

Manufacturing processes of electronic products in Thailand mostly involve components, circuit boards and equipment. The processes consist mainly of assembly work ranging from the assembly of integrated circuits and other components to the assembly of equipment. In the assembly of integrated circuits, finished wafers are brought in from abroad for cutting, packaging and testing. Similarly, the assembly of equipment depends almost totally on imported electronic components, while local components have only a fractional share of the cost and mostly consist of non-electronic items. Large scale activities in material processing and manufacture of systems have not been developed.

Technologies in the electronics industry may be divided into product design technology and production technology. The relation of these technologies with the various production levels are shown in Table 3.1. Examples of products are also given at each product level.

Figure 3.1.
Linkages of Production Levels in The Electronics Industry



For product design technology, there is a hierarchy of design levels. Circuit design technology is common for components, boards and equipment. Electronics engineering expertise is required at all design levels and computer science plays a prominent role in software design as well as in some systems. Mechanical engineering and industrial engineering are necessary in the production of equipment. Lastly, at the materials level and the production of some components, the technology is mostly in the chemical field.

A description of the products, processes and technologies in each category will be presented in the following sections.

Table 3.1.
Technology Areas for
Electronics and Information Technology Based Industries

Product level	All Product Areas		Technology Area: Product Design	Technology Area: Production
Software	1) Application Software	Banking, Administration, Engineering, Manufacturing, Office, AI,CAD/CAM/CAE, Expert systems, Image Processing,etc.	Comp. Sci.	-
	2) System Software	Operation Systems, Compilers, etc.	Electronics	-
Systems	Computer Systems, Switching Systems, Process Controllers, Computerized Tomography, Remote-Sensing, etc		Electronics Comp. Sci.	-
Equipment	CPU, Disk Drives, Printers, Monitors, Transmitters Receivers, Instruments		Electronics Mechanical Ind. Eng.	Electronics Mechanical Ind. Eng.
Boards	Single-Board Microcomputer, Electronics Board, Keyboards		Fully Electronics	Electronics Ind.Eng.
Components	1) Active Components	Diodes, Transisters, Sensors, etc.	Mostly Electronics	Chemical Mechanical
	2) General Components	Resistors, Capacitors, Inductors, Relays, PCBs, Stepping Motors	- -	Electrical Electronics
Materials	Silicon, GaAs, Ceramic		- -	Mostly Chemical

3.1.2 Consumer Electronics Industry in Thailand

The processes used in the consumer electronics industry in Thailand are mainly limited to assembly. Imported components account for between 50 to 80 percent of total component value. They mainly include electronic components like transistors, integrated circuits, resistors, capacitors and some specialized components or sub-assemblies like cathode-ray tubes for television and tape-mechanisms for audio cassette tape recorders.

Locally manufactured components include plastic parts, metal parts, printed circuit boards, coils and transformers, speakers, etc.

The assembly process is generally divided into 2 main lines (see Figure 3.2): first, the assembly of the front panel and chassis where control knobs, speakers and other components are attached; and second, the assembly of the printed circuit board where electronic components are inserted on the board and then soldered. The printed circuit board is then mounted on the chassis and the interconnections are wired. The equipment is then adjusted and tested. If passed, it is packaged for sale.

The required technologies are:

1. Mechanical technologies which include sheet metal working, plastic molds and sheet metal dies making, plastic injection., etc.

2. Chemical technologies which are printed circuit board etching, electroplating of plastic and metal surfaces, etc.

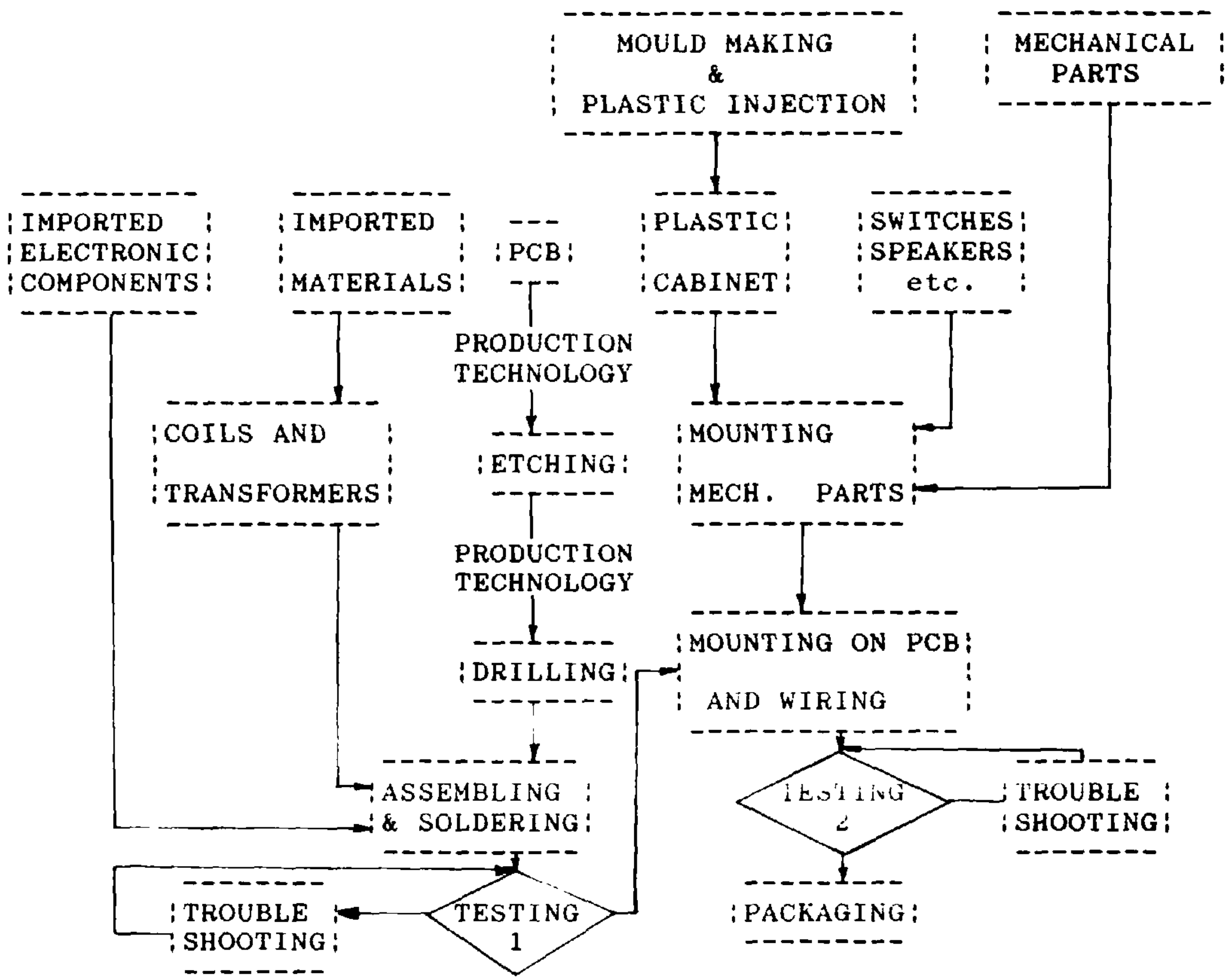
3. Silk screen printing technology for front panel, printed circuit board.

4. Test and measurement technology.

5. Quality control technology for mass production.

Figure 3.2

A Typical Production Process in The Electronic Equipment Industry



In all, Thailand has about 17 manufacturers of radios and 24 of televisions plus one manufacturer of home stereos. There is a large number of small shops that assemble radios, televisions, power amplifiers, equalizers and home stereos.

3.1.3 Communications Equipment Industry in Thailand

The communication equipment industry in Thailand is still in an infant stage. There are essentially two small Thai companies who manufacture radio transceivers including base stations for domestic market such as for fishing boats, police, military and governmental offices. They together possess about 20% of the local market share with the remainder being imported.

The market for telephone sets has increased dramatically in the past several years after the Telephone Organization of Thailand (TOT) allowed subscribers to obtain their telephone sets directly from suppliers, and not solely from TOT as before. The expansion of the telephone system has also contributed to this growth.

Apart from radio transceivers and telephone sets, no other major communications products are produced for the local market. A few small-size Private Automatic Branch Exchanges (PABX) are produced by one or two small Thai firms, but the production is still at a very low level.

In 1987 one company was promoted by the Board of Investment to manufacture public telephone switching equipment for the domestic market with a capacity of about 100,000 lines per year, but the operation has not been started yet. Four other applications for the production of public telephone switching equipment of about 100,000 lines per year each were not granted BOI privileges.

After the investment conditions in Thailand become favorable in early 1987, a large number of manufacturers of communications equipments started their assembly in Thailand for export, mostly producing various types of telephone sets including cordless telephones. The overall production capacity up to the middle of 1988 was about 10 million units per year.

As in the case of consumer electronics, the manufacturing processes involve exclusively assembly work with imported components. Only marginal levels of local components and materials are included, with most of them being non-electronic or for packaging purposes.

3.1.4 Computer Hardware Industry in Thailand

Due to the unfavorable taxation structure for locally assembled microcomputers, the local companies mainly import semi knocked-down (SKD) parts for assembly from Taiwan and Japan. The pioneer in this industry started with their own R&D in Thailand around 1982 and designed and assembled their own 8-bit CP/M-based microcomputers. Later on the system was upgraded into a 16-bit MS/DOS-based machine which is still being produced.

Other computer hardware activities in Thailand include the production of peripheral equipment such as keyboards, monitors, and disk drives for export. They are mainly foreign-owned and BOI-promoted multinational companies. The products, processes, and technologies related to the computer hardware industry in Thailand are shown in Table 3.2.

A flowchart of the manufacturing process of microcomputers is shown in Figure 3.3. The process is similar to that of consumer electronics where electronic computers are first assembled on printed circuit boards. Then the finished boards are assembled into a cabinet. Testing is carried out both at the stage of printed circuit board assembly and of cabinet assembly.

Table 3.2
The Computer Hardware Industry in Thailand

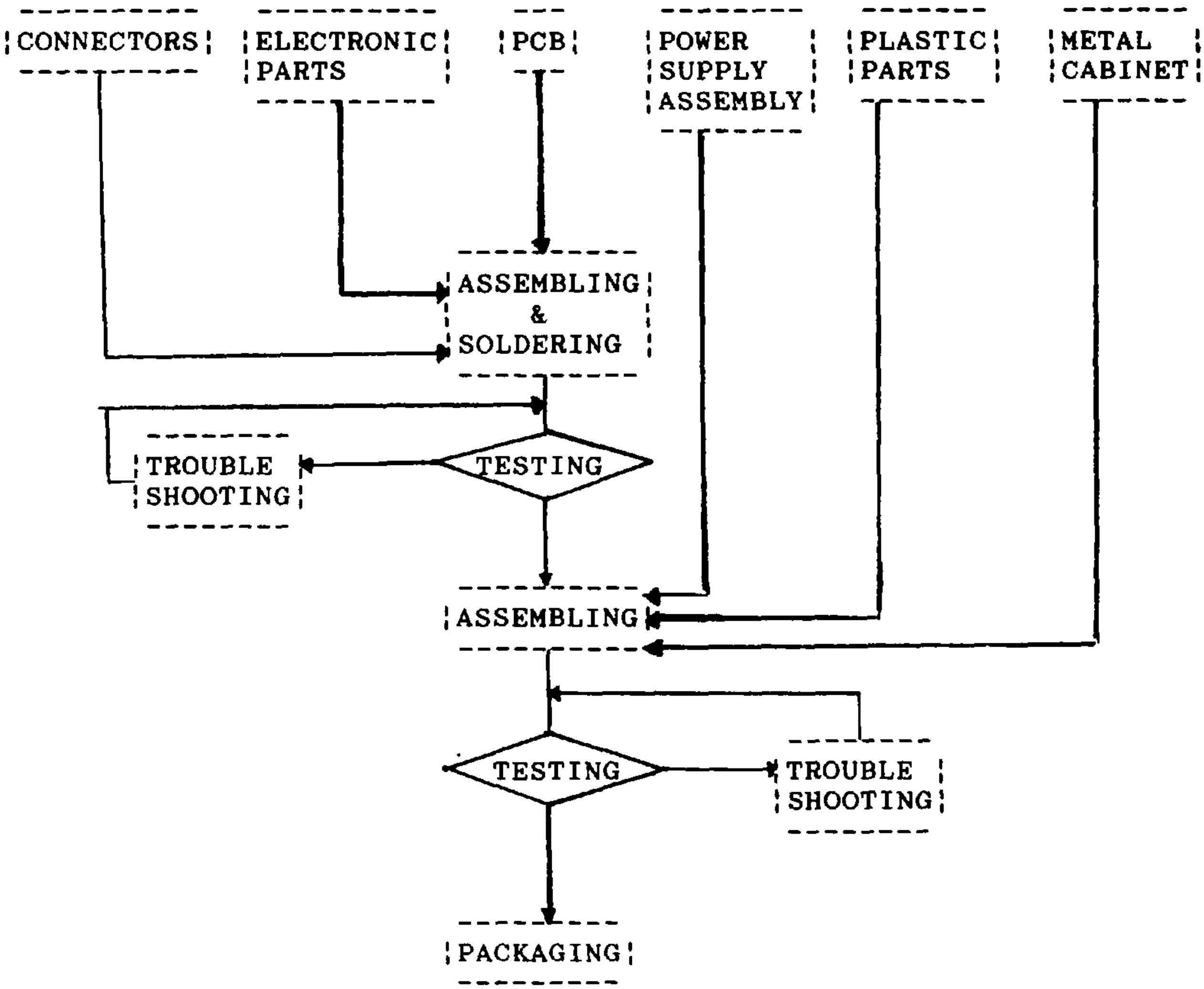
Product	Process	Technology
Microcomputer Systems	Component Insertion on PCBs Soldering (manual) Mother board + Case Assembly Test Packing	8-bit Machine Microprocessor : Z-80, 8085 Operating System : CP/M 16-bit Machine Microprocessor : 8086, 80186, 80286 Operating System : MS-DOS (IBM Compatible)
Sub-system		
Keyboard		Bouncing Type
Monitor		CRT, Monochrome, 14"
Disk Drive		Diskette Drive 5.25", 3.5"
Printer		Mechanical impact type
Plug-in-Card		Thai Character Display Card (Modified graphic card + IC + Firmware)
Power Supplies		Switching power suppilies, Voltage stabilizer, Uninterupted power supplies

Notes : 1) Bit is a computer terminology. It may be regarded as a performance indicator of computers. A high bit number implies a fast processing speed and large size of addressable memory. Hence ,a 16-bit machine is more powerful than an 8-bit one.

2) Operating system refers to a computer software that generally acts as the part between the application software and the hardware mechanism . CP/M and MS-DOS are the operating system products of Digital Research Inc. and Microsoft Inc. U.S.A. respectively.

Figure 3.3

The Manufacturing Process of Microcomputers§



3.1.5 Industrial Electronics Equipment Industry in Thailand

The industrial electronics industry is the smallest among the categories of electronics industries in Thailand, even though it covers a wide range of products from analytical and process control instruments, to medical equipment military equipment and general industrial electronic equipment.

There are very few products manufactured in Thailand in this category. Power supplies and particularly uninterruptible power supplies for computer systems account for the largest share of the production and are produced by several promising small Thai firms.

The process and technology for producing these products are similar to those for consumer electronics equipment. The major difficulty for the producing firms is not a technical matter but the procedures of taxation on imported parts. Even if the small Thai firms can negotiate for low prices for components from overseas sources, the prices are still not accepted by the customs officials for tax calculation.

3.1.6 Electronic Components Industry in Thailand

There are about 40 manufacturers of electronics components in Thailand producing a wide range of products such as interface cords, condensers, miniature ball bearings, printed circuit boards, integrated circuits, and so on. Eleven firms were selected for interview. Table 3.3 summarizes the shares in production of these firms in compared with total production.

Table 3.3

Production Capacities of Electronic Components§

Product	Major Existing Firms		Firms Surveyed	
	Number	Production	Number	Production Value ('000 B)
Condensers	1	300 M.pieces	1	300 M.pieces
Hard Disks	1	2.6 M.pieces	1	2.6 M.pieces
Integrated Circuits	5	1,766 M.pieces	3	1,600 M.pieces
Interface cords	4	N.A.	1	Key board cord 7.2 M.pieces
Printed Circuit Boards	6	N.A.	4	133,333 ft^2
Miniature Ball Bearings	2	1,900 M.Baht	2	1,900 M.Baht

Sources : BOI and Survey

In most cases, the production of electronic components, particularly semiconductor devices, starts from the extraction and purification of raw materials. The purified material will then go through stages of material processing after which they will be assembled, packed and tested before shipping to the market. In our discussion, we will broadly classify the manufacturing processes of electronic components into four stages, namely raw material purification, device design, manufacturing, and testing. These stages are briefly outlined below.

(1) Raw material preparation. This stage involves processes to extract and purify raw materials and to prepare them into appropriate forms for component production. In integrated

circuit manufacturing, this process ranges from silicon extraction to purification and crystal growing.

(2) Device design. This stage covers the electronic and mechanical designs of tools to fabricate electronic components from the prepared raw materials. Design of masks used in impurity doping for manufacturing ICs could be considered as one process in IC design.

(3) Manufacturing. This whole stage transforms prepared raw materials, with the help of design work, into end products. The stage can be further subdivided into processing, and assembly/packaging. Impurity doping in IC manufacturing or printing and etching in PCB production fall under manufacturing while lead bonding and package sealing in IC manufacturing fall under assembly.

(4) Testing. The last stage tests whether the end products fully satisfy the specified requirements.

Given this classification, we can summarize the major processes utilized in the electronic components industry in Thailand as in Table 3.4. Indicative flow-charts of the production processes of integrated circuits, printed circuit boards and lithography are shown in Figures 3.4, 3.5 and 3.6 respectively.

Table 3.4

Processes in the Electronic Components Industry

Product	Raw Material Purification	Device Design	Manufacturing: Material Processing	Manufacturing: Assembly/Packaging	Testing
Condensers				O	O
Hard Disks				O	O
ICs				O	O
Interface Cords			*	O	O
PCBs		*	O	O	O
Miniature - Ball Bearing				O	O
Others					

Notes: * - partly done, O - mostly done.
Source : Survey

From Table 3.4, it is quite clear that most of the processes utilized in the industry are much closer to the product end than the raw material end. Most firms simply assemble imported pre-fabricated parts into electronic components or devices. For example, the production of electronic condensers involves assembling tab-terminal, sealing rubber, aluminum fail, and separating paper. It is only in printed circuit board (PCB) manufacturing that most of the processing steps are carried out in the country, and some firms are even capable of doing some PCB manufacturing design work.

This general trend is somewhat worrying since the raw material end processes usually creates relatively more value added although it is more capital and technological intensive.

The technologies used in the industry are basically determined by processes being available in the country. Judging from the discussion on existing manufacturing processes in the previous paragraphs, it is not difficult to see that production technologies are the main portion of technologies in the industry.

A summary of the state of technology in the firms is as follows:

(1) The main technologies in the industry are production technologies which include production planning, production control, production management, inventory control(just-in-time), quality control, equipment maintenance.

(2) The main processing technologies are in the PCB industry. These are photolithographic technology, printing and etching (basically chemical technology), and high precision technology.

(3) Some design technologies are also available in the PCB industry. These range from electronics circuit design to artwork design using CAD.

3.1.7 Computer Software Industry in Thailand

The Computer software industry may be classified into three groups:

(1) the microcomputer software industry

(2) the super-mini computer software industry

(3) the mainframe software industry

Figure 3.4

A Typical Production Process in The Electronic Components Industry

IC Production Process

1st Step Die-Fabrication

SCRIBING	The wafer is cut into individual dies using saw and tempress. It is washed with de-ionized water and then dried in an oven.
INSPECTION	The dies are then placed on glass and examined by microscope. The bad dies are inked with an inker.

2nd Step Assembly

DIE ATTACH	Frames for dies are cleaned and attached to the base. The warm dies are attached to the frame.
LEAD BOND	Gold and aluminium leads between die and frame are bonded.
INSPECTION	The quality of the bonds is inspected by microscope. Units not properly bonded are re-bonded.

3rd Step End of Line

FINAL SEAL	The unit is plastic-mold in the mold press. It is checked for leakage by tracer flow.
M-PYROL CLEANING	The unit is cleaned with M-Pyrol degreaser to take off small plastic chips. It is then dried.
BENCH PRESS	The leads of the unit are separated using a hydraulic bench press. It is then tested by temperature cycling.
MARK	The IC is marked with name, lot number etc.
TIN DIP	The lead is tin plated.
DERAIL	The IC's are separated from the rail.

4th Step Testing

TESTING	Parameters of the IC are automatically tested as final quality control.
END	

Figure 3.5

A Typical Production Process of PC Boards

Basic Flow-Chart with Pictorial Sequence of The

Print-Plate-Etch Process for Double-Sided PC Boards

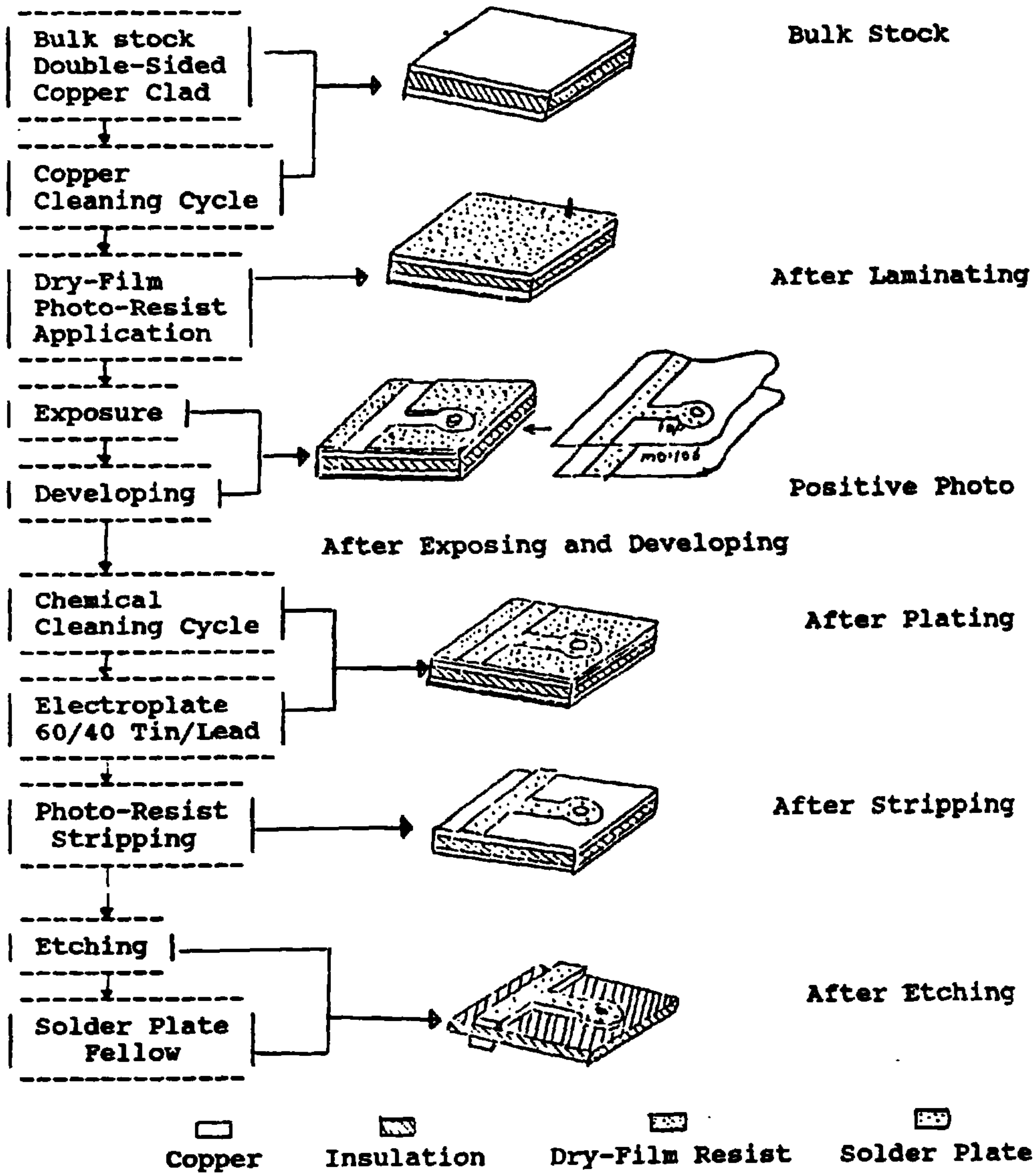


Figure 3.6

A Typical Photo-Lithographic Process

Photo-etching production process

Pattern Drafting	Pattern is drawn at the designated degree of magnification. Accuracy or less than + 10 microns is common
Precision Reduction Camera	Original pattern is reduced by a precision reduction camera
Multiple printer	Multiple printer is used to mass produce the patterns used in photo-etching
Coating Printing	A photosensitive resin is coated onto a metal surface
Developing	After exposure of the metal plate it passes on to the developing process
Etching	The surface of the exposed metallic material is etched
Inspection	The finished product is inspected

In terms of technology, the microcomputer industry involves both the systems level and the application level. Thai Dbase, Thai spread-sheets and Thai word processors are generally sold as part of the microcomputers which are mainly 16-bit IBM XT/AT and IBM-compatible systems. The Thai technology involves both hardware and software modifications of the microcomputer. Imported plug-in graphics cards are modified using programmable logic array (PLA) and locally-made firmware. An algorithm to convert a sequentially key-in letters into four physical levels of display to make a meaningful line in the Thai language is regarded as very innovative. Thai word processors are also written locally by various vendors and university researchers.

Other software packages that are common in microcomputer applications include accounts payable, accounts receivable, general ledger, payroll, and inventory. LAN has been here for quite some time but it has not made any real contribution as it should have done. Recently, 32-bit machines were introduced into the local market, namely the COMPAQ-386 and IBM PS/2. It is expected that it will not be widely used until more support/application software and also less-expensive machines are available.

Software for super-mini computers are used in hospitals, finance companies, insurance businesses, manufacturing firms, and governmental organizations. The software are generally developed in-house by the hardware supplier itself. However, some hardware suppliers do not develop the software by themselves but use the services of various local software houses. Some companies also have begun to export their proven locally-made software packages, such as hospital and hotel information systems. The recent announcement of the IBM AS/400 will definitely increase the local market for super-mini computer software. It is worth mentioning that the basic technologies that have made this class of software grow are relational database management systems, screen generators, and report generators.

The software industry in the mainframe range has served the banking sector, airline reservation systems, and large governmental organizations. The software for bank information systems is mainly imported and then modified to suit local requirements. The well-known packages are SAFE II in the IBM 43xx and 30xx series and BASE-24 in Tandem computers. Automatic Teller Machines (ATM) are available for bank customers via the so-called ATM pools which make efficient use of the communication facilities. The development of banking software is generally carried out jointly by the suppliers and the bank's own EDP staffs.

It should be mentioned here also that the super-mini computer and mainframe software are mainly of an on-line-transaction nature. The remote terminals are connected via a public switching telephone network (PSTN). The package switching network will not be available until the end of 1988.

Tables 3.5, 3.6 and 3.7 summarize the computer software industry in Thailand in terms of products, processes and technologies.

Table 3.5

The Microcomputer Software Industry in Thailand

Product	Process	Technology
Thai Dbase II/III	- Requirements analysis	Hardware - 16 bit- IBM PC/XT/AT (mostly compatible systems)
Thai Spread Sheet	- Design	
Thai Word Processor	- Programming	- Thai Character Display Plug-in Card (modified graphics card with programmable logic array (PLA) and firmware)
Account Payable	- Test	
Account Receivable	- Documentation	
General Ledger		Software - Operating System : MS-Dos
Payroll		- Compiler : BASIC, C, Pascal, COBOL
Inventory		- Utilities : DBMS using Dbase II/III Assembles (8086, 80186, 80286) Screen Editor, Line Editor Debugger
Custom-made Packages		Data Communication/Network LAN : IBM-Token Ring Ethernet Novell Netware

Table 3.6

The Super-mini Computer Software Industry in Thailand

Products	Process	Technology
Hospital Information Systems (i.e Smitiwej, Bhumibol, Krungthep, Hua-chiew, Siriraj, Phayathai) Finance Information Systems (i.e. IFCT, Patara Thanakij, SET) Insurance Information System (i.e. Thai Life) Manufacture Information System (i.e. PTT, Toyota, Seagate, Sanyo Universal Electric) Government Information System (i.e. BMA)	Feasibility Organization and planning Requirements Analysis Product Design Detailed Design Programming (Coding) Unit Test Integration and Test Acceptance Test Veritication/Validation Documentation Operation/Maintenance	Hardware - IBM 36, IBM 38, AS/400 - NEC Astra Series - Perkin Elmer 3100 Series - VAX 700 series, 8600 series - HP 3000 series Software - Operating systems (Propietary) - Compiler : COBOL, RPG - Utilities: Relational Data Base Management System (RELIANCE...) Screen Generator Query Languages Report Generator Fourth Generation Language Data Communication/Network - PSTN (Public Switched Telephone Network)

Table 3.7

The Mainframe Computer Software Industry in Thailand

Product	Process	Technology
Bank Information System	Feasibility	Hardware
(Bangkok Bank, SCB, TFB,		- IBM 4300, 3080, 3090 Series
Thai Military Bank, Bank of Asia,	Organization and Planning	- NEC 610, 630 Series
Central Bank etc.)		- TANDEM
	Requirements Analysis	- CDC
Airline Reservation System		- BORROUAH
(Thai International Airline, etc.)	Product Design	- UNIVAC
		- ATM (Automatic Teller Machines)
Housing Registration System	Detailed Design	
(Ministry of Interior)		Software
	Programming (Coding)	- Operating System (Propriety)
Narcotics Control System		- Compiler : COBOL
(Office of Narcotics Control Board)	Unit Test	- Utilities : Relational Data Base
		Management System
Tax Information System	Integration and Test	Hierachical Data Base
(Ministry of Finance)		Management System
	Acceptance Test	Screen Generator
		Report Generator
	Verification/Validation	Query Language
		- Packages : SAFE II
	Documentation	BASE 24
		PROFIT
	Operation/Maintenance	- Others : Online Transaction
		Processing
		Home Bangking Services
		Data Communication/Network
		- PSTN
		- STAR connection

3.2 The Survey of Producing Firms

3.2.1 The Characteristics of Firms Surveyed

In order to obtain detailed insights into the levels of technological capability in Thai firms, a detailed survey of a sample of firms in the electronics industry was carried out. The initial sampling frame was drawn from a comprehensive list of firms in the industry and was designed to be representative in terms of ownership, size, industry group, export orientation, Board of Investment promotion status, and age. Of an initial sampling frame of around 50 firms, the researchers were able to interview, visit the factories, and assess the technological capabilities of 32 firms. While the self-selection process clearly biased the sample towards those firms that would cooperate, it is felt that the final 32 firms represents a reasonable cross-section of the EIBI in terms of virtually all the characteristics mentioned above.

A summary of the characteristics of the surveyed firms is shown in Table 3.8 with their products being presented in Table 3.9. It can be seen that the sample includes 8 consumer electronics firms, 3 communications equipment firms, 4 computer hardware firms, 4 industrial electronics firms, 10 electronic components firms, and 3 software firms. Of the total, 19 had received Board of Investment promotion at one time or another and just over 40 percent (14 firms) were export oriented. In terms of ownership, the sample includes 14 small and medium Thai firms, 3 large Thai firms, 6 joint-venture firms (only one of which is small), and 9 wholly foreign-owned firms. The age of the firms ranges from almost 25 years to less than one year with the average being about 12 years.

Table 3.8

Summary of Characteristic of Surveyed Firms

Firm code	Characteristic				
	Start up date	Size of firm	Foreign share(%)	Export orientation (yes/no)	Promoted status (yes/no)
Area 1 : Consumer Electronics					
Consume 1	1970	M.	49%(Jap)	no	yes
Consume 2	1964	L.	-	no	yes
Consume 3	1973	M.	-	no	yes
Consume 4	1967	L.	49%(Jap)	no	yes
Consume 5	1987	L.	100%(JAP)	yes	yes
Consume 6	1981	M.	-	no	no
Consume 7	1979	M.	-	no	no
Consume 8	1974	M.	70%(Hol-land)	no	no
Area 2 : Communication Equipments					
Commu 1	1971	S.	-	no	no
Commu 2	1968	M.	-	no	yes
Commu 3	1987	L.	100%(U.K)	yes	yes
Area 3 : Computer Hardware					
Hardware 1	1980	L.	100% (Holland)	no	no
Hardware 2	1986	S.	-	no	no
Hardware 3	1981	S.	-	no	no
Hardware 4	1974	L.	100%(U.K)	yes	yes
Area 4 : Industrial Electronics Equipment					
Ind 1	1982	S.	-	no	no
Ind 2	1978	M.	-	no	no
Ind 3	1984	S.	49%(U.K)	yes	yes
Ind 4	1985	S.	-	yes	yes

Table 3.8

Summary of Characteristic of Surveyed Firms

(continued)

Firm code	Characteristic				
	Start up date	Size of firm	Foreign share(%)	Export orientation (yes/no)	Promoted status (yes/no)
Area 5 : Electronic Components					
Compo 1	1982	L.	100%(Jap)	yes	yes
Compo 2	1984	M.	-	yes	yes
Compo 3	1982	S.	-	no	no
Compo 4	1973	L.	100%(US)	yes	yes
Compo 5	1972	M.	49%(Jap)	yes	yes
Compo 6	1983	L.	100%(US)	yes	yes
Compo 7	1985	L.	-	yes	yes
Compo 8	1974	L.	100%(US)	yes	yes
Compo 9	1985	L.	100%(US)	yes	yes
Compo 10	1980	L.	45%(Jap)	yes	yes
Area 6 : Computer Software					
Software 1	1968	L.	-	no	no
Software 2	1960	M.	-	no	no
Software 3	1985	S.	-	no	no

Source : Present Survey 1988
Notes : L. = Large firm : Manpower > 300 or Revenue > 500 M฿
M. = Medium firm : Manpower >100 or Revenue > 50 M฿
S. = Small firm : Manpower < 100 or Revenue < 50 M฿
Thai firm : Thai share holder > 90%
Joint-venture firm : Foreign share holder 10-90 %
Foreign firm : foreign share holder > or = 90 %
Export orientation : 50% of products are exported
Promotional status : received BOI promotion or not

Table 3.9

Summary of Products of the Surveyed Firms.

Firm code	Principal electronic products
Area 1 : Consumer Electronics	
Consume 1	Color Televisions
Consume 2	Color Televisions Radio Cassette Recorders
Consume 3	Car Radios Stereos
Consume 4	Color Televisions Radio Cassette Recorders
Consume 5	Microwave Ovens
Consume 6	Home Stereos
Consume 7	Color Televisions Radio Cassette Recorders
Consume 8	Color Televisions Radio Cassette Recorders
Area 2 : Communication Equipment	
Commu 1	Radio Transceivers
Commu 2	Radio Transceivers
Commu 3	Cordless Telephones Telephone Receivers Key Telephone Systems
Area 3 : Computer Hardware	
Hardware 1	Microcomputer Systems
Hardware 2	Thai Cards
Hardware 3	Microcomputer Systems
Hardware 4	Monitors
Area 4 : Industrial Electronics Equipment	
Ind 1	Education Kits Electronic Parts
Ind 2	Power Line Stabilizers Uninteruptible Power Supplies
Ind 3	Solar Cell Panels
Ind 4	Microwave Components

Table 3.9

Summary of Products of The Surveyed Firms.

(continued)

Firm code	Principal electronic products
Area 5 : Electronic Components	
Compo 1	Miniature Ball Bearings
Compo 2	Printed Circuit Boards(PCB)
Compo 3	Printed Circuit Boards(PCB)
Compo 4	Integrated Circuit Assembly
Compo 5	Printed Circuit Boards(PCB)
	Micro Speakers
	Tuners
	Transformers
	Resistors
	Coils
Compo 6	Disk Drive Assembly
Compo 7	Integrated Circuit Assembly
Compo 8	Integrated Circuit Assembly
Compo 9	Interface Cords
	Keyboard Cords
Compo 10	Electrolytic Condensers
Area 6 : Computer Software	
Software 1	Software
Software 2	Software
Software 3	Software

Source : present survey 1988

3.2.2 The Rating of Technological Capabilities

In order to be able to analyze the technological capability of the firms in the sample, the following rating system was devised, with the first part drawing on the conceptual framework presented in section 1.5 and second on a methodology employed in a comprehensive study of the engineering industry in Thailand carried out under the auspices of the World Bank by Frederick Moore (World Bank, 1980).

First, the four types of technological capability - acquisitive, operative, adaptive, and innovative - were further subdivided into a number of categories corresponding to the various types of activities that are required in order to acquire, operate, adapt, or innovate the respective technologies. The detailed categories for each capability and brief descriptions of the nature of the activities are presented below:

(1) Acquisitive Capability

Search	The ability to find the required technology;
Assessment	The ability to evaluate the merits of a technology and to make comparisons between alternative technologies;
Negotiation	The ability to negotiate reasonable terms for the acquisition of the chosen technology;
Procurement	The ability to successfully purchase the selected technology;
Plant lay-out and design	The ability to design and lay out new production lines;
Installation and start-up	The ability to install and start-up new machines and perform the tests necessary to achieve satisfactory performance;

Operative Capability

Process	The ability to efficiently operate the production process;
Maintenance	The ability to keep the machinery and process in proper operating condition, including the calibration of test and measuring instruments;

Quality control	The ability to ensure the uniformity, performance, and yield of the product;
Inventory Control	The ability to monitor and control the amounts of stocks of raw materials and goods in process to ensure the continuous flow of production at a reasonable cost;
Manpower Development	The quality of and investment in programs to develop and upgrade staff both in-house and elsewhere.

Adaptive Capability

Technology Digestion	The extent to which current technology has been understood and used to full effectiveness in the factory;
Minor Product Modification	The extent to which minor changes in the product design or in the use of raw materials have been made to suit local conditions or to reduce costs of production;
Minor Process Modification	The extent to which minor changes have been made in the production process in order to increase production efficiency or to reduce production cost;

Innovative Capability

RD&E	The ability of a firm to carry out RD&E as reflected in the number and ability of personnel, the budget, and the research facilities;

Radical Product Modification/ New Product Design	The extent to which significant or major product improvements in terms of visual appeal, function, and performance resulting from changes in industrial, mechanical, and electronic design have been made;
Radical Process Modification/ New Process Design	The extent to which significant improvements in productivity have been realized due to major changes in operating procedures;
New Invention	The extent to which completely new products have been invented.

Second, following the factory visits by both engineers and economists, each firm was allocated a score from 0 to 5 for each of the categories mentioned above. In general, the scores were designed to capture the capability as demonstrated by local staff rather than foreign staff, so the scores are likely to be lower for firms where the level of Thai involvement is less. The scores, which were allocated according to the collective professional judgement of all researchers, were based on the following scale (see World Bank, 1980):

Score	Meaning
5 - excellent	Efficient practice, comparable to leading producing firms in industrial countries;
4 - very good	Practices slightly lower than top international standards but still adequate for export to all but the most competitive markets;
3 - good	Acceptable practices for expansion within local markets;

2 - fair	Acceptable practices for the low-end local market;
1 - not satisfactory	Unacceptable quality due to deficiency in production and analysis;
0	Absence of technological capability.

The analysis in the rest of this chapter is based upon the results of the above scoring system which are presented in detail for all firms in the Annex Tables. In order to obtain rankings of the four main types of technological capabilities, the individual scores were averaged and sometimes expressed as a percentage of the maximum possible score (namely 5) that would have been achieved if the firm reached the standards commensurate with the world technological frontier in the respective technology. The difference between this percentage and 100% represents the existing gap between the practice of the firm and best world practice for each type of technological capability.

3.3 Profile and Assessment of Acquisitive Capability

a) An overview.

The overall average score for acquisitive capability of the surveyed firms is 55.3%, with the scores for individual firms ranging from as low as 20% up to the maximum score of 80%. On average, therefore, the firms scored slightly higher than 50% with the the firm with the best acquisitive capability being comparable with average standard international firms.

The overall acquisitive capability score is further classified into its components in Table 3.10.

Table 3.10

Acquisitive Capability Scores Classified by Component

Acquisitive Capability Component	Average Score (%)
Search	54.4%
Assessment	59.4%
Negotiation	57.5%
Procurement	57.5%
Plant layout & design	50.0%
Installation & start up	52.5%
Overall average of acquisitive capability	55.3%

Source : Annex Table A1.7

From the Table, we can see that there are three components which are below the acquisitive capability of the overall average, namely search, plant layout & design, and installation & start up capabilities. On the other hand, there are also three components which are above the overall average, namely assessment , negotiation , and procurement.

This indicates that the firms surveyed need to upgrade their "search" capability. Some important infrastructure that could help strengthen this capability are information services, easy accesses to appropriate information sources. In addition it would appear that, once the necessary information is available, most firms are relatively capable of undertaking the assessment, negotiation, and procurement of technology, although further upgrading is also necessary.

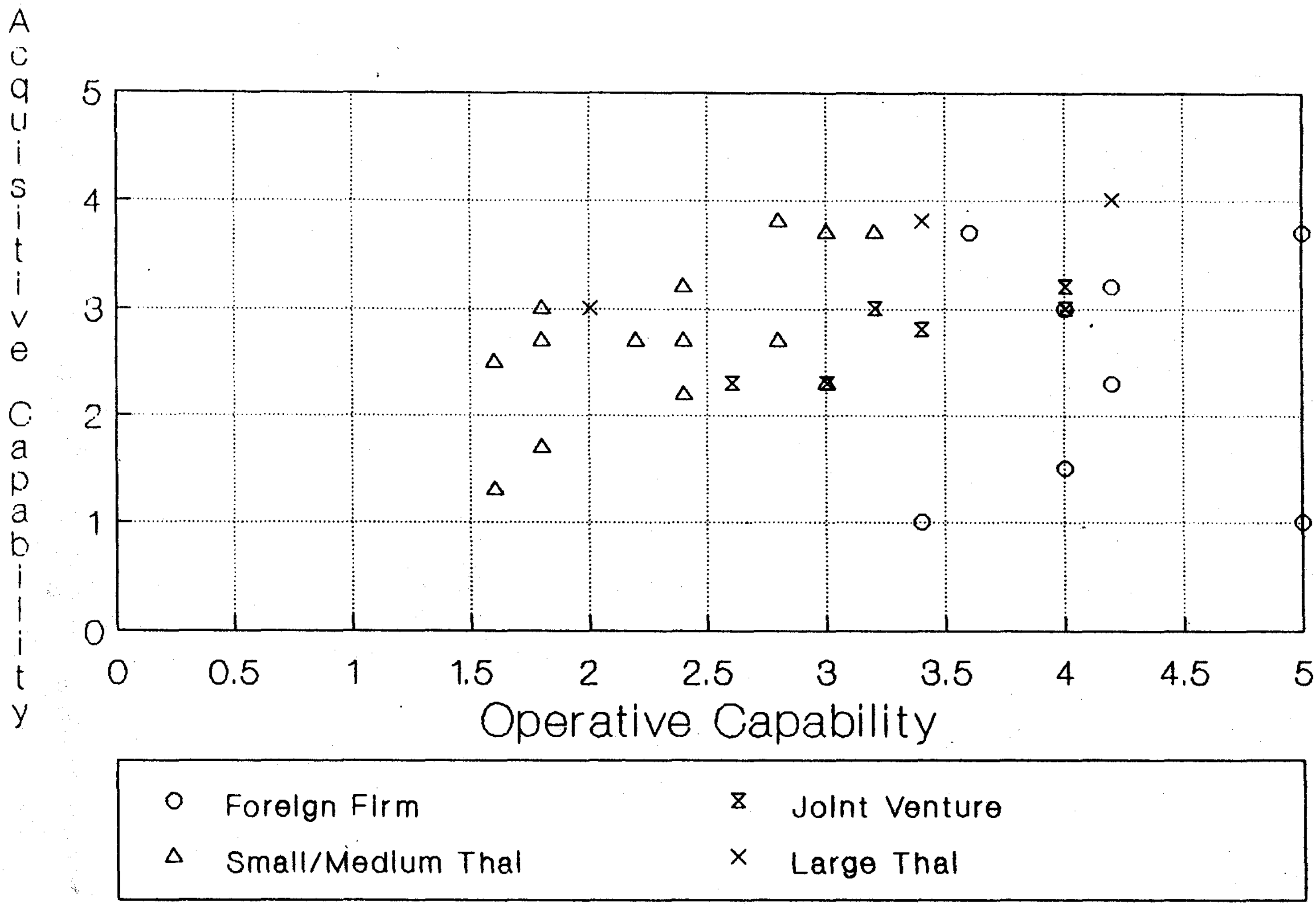
Furthermore, the capabilities in plant layout & design and installation & start up are relatively low. On this point the potential role of competent consulting firms in upgrading these capabilities will become evident.

b) Acquisitive capability and the firms' dynamism

Figure 3.7 shows a relation plotted between acquisitive capability and operative capability. In the Figure, the correlation for Thai firms can be distinguished from that for foreign and joint venture firms. While in the case of Thai firms, there exists a high correlation between the firm's acquisitive capability and its operative capability, no such correlation was found in the case of foreign and joint venture firms.

In the case of foreign and joint venture firms, the most modern production technology has usually been introduced resulting in medium to high scores for the firms' operative capability. However, when it comes to acquisitive capability, the scores are relatively low. This is because the firms in Thailand can have direct access to information from their mother companies and do not need to exercise their acquisitive capability. There are a few exceptions, however, where the local subsidiaries are allowed to independently search, assess, and negotiate by themselves. However, in most cases, important decisions still have to be authorized by the mother companies. Therefore, the acquisitive capability of foreign and joint venture firms shown on the Figure is evaluated on the basis of what is actually taking place. The acquisitive capability would be higher, if the high quality human resources working in these firms were given the opportunity to perform to their full capacity.

Figure 3.7
Correlation between Acquisitive Capability and Operative Capability



Source : Present Survey

On the other hand, the high correlation for local firms indicates that the capability to have access to information sources on technological and market trends, to negotiate wisely, etc., enables firms to adapt quickly and appropriately to environment changes. Though acquisitive capability may not be a sufficient condition for dynamism, it may be suggested that it is a necessary condition.

c) Profile of acquisitive capability by type of ownership

Table 3.3.2 shows profile of acquisitive capability by size and ownership.

Table 3.11

Profile of Acquisitive Capability by Size and Ownership

Type of firm	Number of firms	Average Score (%)
1. Small and Medium Thai	14	54.3%
2. Large Thai	3	72.2%
3. Joint Venture	6	55.6%
4. Foreign Owned	9	51.1%
All Firms	32	55.3%

Source : Annex Table A1.12

It is interesting to see that the large Thai firms have the highest acquisitive capability. On the other hand, the foreign-owned firms, when considering only capability of the local subsidiaries, have the lowest score.

3.4 Profile and Assessment of Operative Capability

When we classify operative capability of EIBI by size and ownership into foreign-owned firms, joint-venture firms, large Thai firms and small and medium Thai firms as in Table 3.12, we see that foreign-owned firms have the highest score, joint-venture and large Thai firms have comparable scores and small and medium Thai firms have the lowest score. This leads us to suspect that the operative capability depends on firm size more than anything else. The sample of large Thai firms, however, is rather small simply because there are not too many of them and the fact that they are large confirms that they must have reasonable operative capability.

When we divide the surveyed firms into export oriented and non-export oriented as shown in Table 3.13, we see that export oriented firms regardless of size and ownership score better than non-export firms. The degree of difference between the two categories can be explained by looking at the individual firms that are responsible because the sample size is not very large. There is only one non-export foreign-owned firm which is rather small. Joint-venture firms are almost equally divided between export and non-export. There is only one export large Thai firm and only two export small and medium Thai firms.

Table 3.14 shows the difference between BOI promoted and non-BOI promoted firms. While we expect promoted firms to score better, the reverse is true for joint-venture and large Thai firms. For foreign-owned firms, the only non-promoted one is the small, non-export one mentioned in the previous paragraph. Among joint-venture firms, there is one non-promoted firm that does very well. Large Thai firms have the same problem that the only non-promoted one does better than the others. Therefore, promotional status is not correlated with operative capability.

Table 3.12

Operative Capability by Size and Ownership

Type of Firm	Average Score(%)	Number
1. Foreign-Owned Firms	85.3%	9
2. Joint-Venture Firms	67.3%	6
3. Large Thai Firms	64.0%	3
4. Small & Medium Thai Firm	46.9%	14
All Firms	63.1%	32

Source : Annex Table A1.12 (b)

Table 3.13

Operative Capability by Export Orientation and Size/Ownership

Type of Firm	Average Score(%)	
	Export	Non-Export
1.Foreign Owned Firms	87.0%	72.0%
(No. of Firms)	(8)	(1)
2.Joint-Venture Firms	66.7%	68.0%
(No. of Firms)	(3)	(3)
3.Large Thai Firms	84.0%	54.0%
(No. of Firms)	(1)	(2)
4.Small & Medium Thai Firms	50.0%	46.3%
(No. of Firms)	(2)	(12)

Source : Annex Table A1.21 (b)

Table 3.14
Operative Capability by Promotional Status
and Size/Ownership

Type of Firm	Average Score(%)	
	Promoted	Non-Promoted
1.Foreign Owned Firms	87.0%	72.0%
(No. of Firms)	(8)	(1)
2.Joint-Venture Firms	64.8%	80.0%
(No. of Firms)	(5)	(1)
3.Large Thai Firms	62.0%	68.0
(No. of Firms)	(2)	(1)
4.Small & Medium Thai Firms	52.0%	44.8%
(No. of Firms)	(4)	(10)

Source : Annex Table A1.17 (b)

In analyzing the score of individual firms, it was found that some large IC assemblers have full marks because they are among the best firms in the world. Semiconductor firms in the United States rarely assemble their own ICs and, therefore, do not have such capability. The fact that the scores between joint-venture firms and large Thai firms do not differ much (69.2% versus 64%) implies that operative capability is not too difficult to acquire and Thai firms can also achieve good operative capability if they are properly managed.

The scores of small and medium Thai firms are rather low because some firms do not have continuous production runs. Therefore, they do not have a chance to practice production management techniques. Firms with low scores generally do not have maintenance schedules and quality control is only carried out at the final stage. Inventory problems are avoided by ordering completely-knocked-down kits and there is little effort to upgrade their own personal. In general, medium firms score better than small firms.

3.5 Profile and Assessment of Adaptive Capability

The adaptive capabilities in different areas of the electronics industry were evaluated as follows:

Table 3.15
Adaptive Capability by Industry Group

Industry Group	Average Score (%)	No. of Firms
Consumer Electronics	45.0%	8
Communications Equipment	51.1%	3
Computer Hardware	48.3%	4
Industrial Electronics	60.0%	4
Electronic Components	42.7%	10
Computer Software	73.3%	3
Overall Average	49.8%	Total 32

Source : Annex Table A1.9

Computer software firms show the highest score on adaptive capability. This is to be expected because software products have to adapted for local applications such as the use of Thai characters. Three out of four industrial electronics firms are Thai and two of them produce mainly for the local market. They must have capability to adapt their products for the local requirements. The majority of electronic components firms are subsidiaries of multinational companies and show the lowest levels of adaptive capability, largely because the semiconductor industry in Thailand involves only the labor-intensive back-end process of assembling the chips.

The capability scores of different components of adaptive capability are shown below in Table 3.16.

Table 3.16
Adaptive Capability Scores by Component

Adaptive Capability Component	Average Score (%)
Technological Digestion or Product Imitation	62.5%
Minor Product Modification	51.3%
Minor Process Modification	35.6%
Overall Average	49.8%

Source : Annex Table A1.9

The result shows that the electronics industry in Thailand has a relatively high capability to digest technology and to imitate products. The capability to modify products is smaller and that to modify processes even more so. This indicates that more attention to the development of this technological capability is necessary.

Analysis by firm size and ownership gives the following ratings.

Table 3.17

Adaptive Capability by Size / Ownership

Size / Ownership	Average Score (%)	No. of Firms
Small and Medium Thai Firms	49.0%	14
Large Thai Firms	64.4%	3
Joint Venture Firms	57.8%	6
Foreign-Owned Firms	40.7%	9
Overall average	49.8%	Total 32

Source : Annex Table A1.12 (c)

Large Thai firms show the highest adaptive capability. This may be because the large firms have more resources for promoting product development.

When the classification is mode into BOI-promoted and non-BOI-promoted firms, the adaptive capability scores are as follows:

Table 3.18

Adaptive Capability by Promotional Status

Promotional Status	Average Score (%)	No. of Firms
BOI-Promoted Firms	47.0%	19
Non-BOI-Promoted Firms	53.8%	13

Source : Annex Table A1.22 (c)

It is interesting to note that the non-promoted firms have higher adaptive capability. This suggests that BOI-promotion does not necessarily lead to development of the adaptive capability.

When the firms are considered by export-orientation, we have:

Table 3.19
Adaptive Capability by Export Orientation

Export Orientation	Average Score (%)	No. of Firms
Export-oriented firms	44.3%	14
Non-export-oriented firms	54.1%	18

Source : Annex Table A1.22 (c)

It is surprising to see that there is no correlation between adaptive capability and export-orientation. However, when the size and ownership of export-oriented firms and non-exported oriented firms are examined more closely, it can be seen that among export-oriented firms, large Thai firms showed the highest scores, whereas among non-export oriented firms, foreign firms have the highest capability. This phenomenon may be an exceptional situation since there exists only one sample in each category.

Table 3.20

Adaptive Capability by Size / Ownership and Export Orientation

Size / Ownership	Average Score (%)	
	Export	Non-Export
Small and Medium Thai Firms	50.0%	48.9%
(No. of Firms)	(2)	(12)
Large Thai Firms	60.0%	66.7%
(No. of Firms)	(1)	(2)
Joint-Venture Firms	53.3%	62.2%
(No. of Firms)	(3)	(3)
Foreign-Owned Firms	37.5%	66.7%
(No. of Firms)	(8)	(1)

Source : Annex Table A1.21 (c)

3.6 Profile and Assessment of Innovative Capability

(a) Innovative Capability By Firm Size and Ownership

Except for one foreign firm in communication equipment, the other low scores through firms seem to more or less have the innovative capabilities. Highest among them are the software industry; this is mainly because the software products are mostly developed on the job-by-job basis. Hence these firms have to be innovative to take care of both managerial and technical risks that tend to exist in each software product and process. Another innovative capability in software industry indicates in all Thai software products e.g. Thai language display, Thai word processors, Thai spread sheets, Thai data base management systems.

(b) Innovative Capability by Promotional Status

Computer hardware, industrial electronics equipment and computer software are mainly produced by non-promoted firms. For example, Phillips (Thailand) produces 16-bit MS-DOS mini computers which are designed by their own RD & E section; IRC although only a small Thai company produces a Thai plug-in cord display which is now in the process of converting into an ASIC. Firms in consumer electronics and other electronic equipment, which are the largest group under BOI promotion, have some small activities in industrial design of new products.

(c) Innovative Capability by Export-Orientation

In consumer electronics, although the firms are foreign owned,their products are mainly sold to the Thai market. Firms in industrial electronics equipment, such as Quasar who produces voltage regulators and Encorp who produces test equipment although rather innovative, do not export their products. The computer hardware and communications equipment firms also are mainly non-export oriented. The software industry which is innovative in nature is still for the local demands.

The non-exported firms are also mainly non-promoted, hence as they form the majority in the electronics and information technology-based industries in Thailand the score in innovative is higher than the others.

It is also noticed that the non-export firms have higher innovative capabilities regardless of size and ownership.

Table 3.21
Innovative Capability by Promotional Status
and Size / Ownership

Size / Ownership	Average Score (%) Promoted	Non-Promoted	Total Average (%)
Small and Medium Thai Firms	17.5%	22.0%	20.7%
(No. of Firms)	(4)	(10)	(14)
Large Thai Firms	12.5%	50.0%	25.0%
(No. of Firms)	(2)	(1)	(3)
Joint-Venture Firms	11.0%	5.0%	10.0%
(No. of Firms)	(5)	(1)	(6)
Foreign-Owned Firms	8.8%	45.0%	12.8%
(No. of Firms)	(8)	(1)	(9)

Source : Annex Table A1.17 (d)

Table 3.22
Innovative Capability by Export Orientation
and Promotional Status

Promotional Status	Export	Non-Export
1.Promoted	8.9%	19.0%
(No. of Firms)	(14)	(5)
2.Non-Promoted	-	24.6%
(No. of Firms)		(13)

Source : Annex Table A1.22 (d)

Table 3.23
Innovative Capability by Export Orientation
and Size / Ownership

Size / Ownership	Average Score (%)		Total Average (%)
	Export	Non-Export	
Small and Medium Thai Firms	10.0%	22.5%	20.7%
(No. of Firms)	(2)	(12)	(14)
Large Thai Firms	5.0%	35.0%	25.0%
(No. of Firms)	(1)	(2)	(3)
Joint-Venture Firms	10.0%	10.0%	10.0%
(No. of Firms)	(3)	(3)	(6)
Foreign-Owned Firms	8.8%	45.0%	12.8%
(No. of Firms)	(8)	(1)	(9)

Source : Annex Table A1.21 (d)

3.7 Profile and Role of Private Sector Supportive Agents of EIBI in Thailand

Since most of the electronics industries operating in Thailand are basically assembly firms which import most of the necessary components and have them locally assembled. Only a few items of parts and components are locally made for use in these firms. Therefore, there exists only a small number of supportive industries for electronics industries.

In our survey, two group of supportive industries are selected for factory visits and interviews. The first group comprises four small scale Thai firm which produce precision parts and plastic tube supplying major integrated circuits firms in the country. The second group covers three small scale local owned firms which produce power supply units and transformer supplying consumer electronics firms.

3.7.1 Integrated Circuit Industry Supportive Agents

Parts being locally produced and supplied to domestic IC firms are fewer than ten items. Some important ones are precision mechanical parts, IC tube, solder, packaging craft box, chemicals. Manufactures of two most important items, both in terms of value of products and their technological intensities, which comprise precision mechanical parts and IC tube are selected for factory visits and interviews.

a) Precision mechanical parts. Products for this industry group range from precision die punch, fixture, jig, and spare parts for machinery. Value of products which are supplied to major IC firms and two other components manufactures- Data General and Seagate - amounts to about 15 million baht in 1987. Profile of this industry group is summarized as shown in table 3.24.

Owners of and key engineers in these firms used to work for domestic IC industry for some years. They later quit and set up their own firms supplying mechanical parts for the industry.

Table 3.24

Profile of Precision Mechanical Parts Firms Supporting IC Industry.

firm	#1	#2	#3
established	1982	1985	1986
investment	7.mil.baht.	2 mil.baht	0.8 mil.baht (1)
eng : tech : worker	1:50:5	2:3:10	3:7:10
Value of products	6 mil.baht	3-4 mil.bath	n.A.
rejection ratio	30-40 %	20-30 %	n.A.
technological capability	~5 micron	n.A.	~5 micron
major products	die punch , jig , fixture , spare parts for automatic equipment		
major user	NS, CEI AT&T,Signetics Seagate,Hana.	NS,CEI,AT&T Signetics, Seagate	NS,CEI,AT&T Data General, Seagate

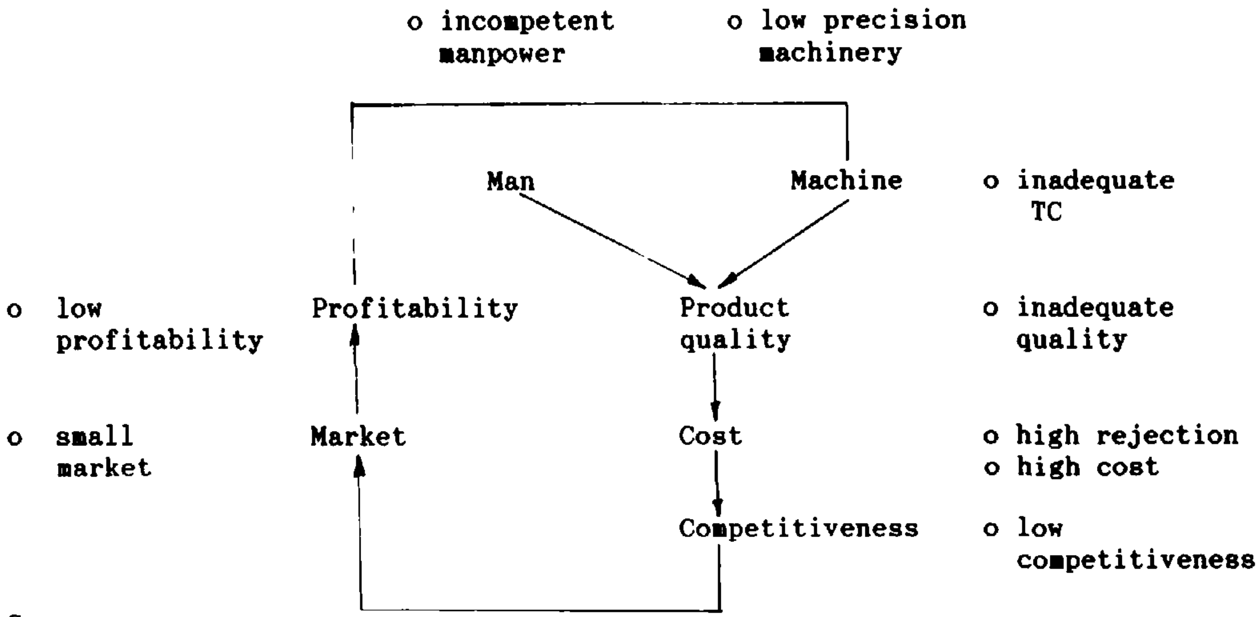
Source : Survey (as of March 1988)

Note : 1) only initial investment is given.

It is evident from the table that, quality of products is low with rejection ratio as high as 20 - 40 % .Interviews with chief engineers from two IC firms confirm this point. And they further pointed out that in many cases accuracy requirement for precision parts used in the IC firms is as high as +1 micron level. In such cases since all local firms can not comply with such stringent specification order have to be placed from Singapore, Taiwan, Korea or Japan. Owners and engineers of these producing firms admitted that quality of technician and capability of available machinery made further improvement of product quality difficult, if not impossible. They are badly in need of higher accuracy machinery which would help upgrade their capability and enable them to compete in market of higher value added product. Lack of fund and price of machinery which is unreasonably high due to existing tariff structure, are cited as two major obstacles preventing them from improving product quality which, eventually, would lead to market expansion . All these problems form into a 'vicious circle' of this supportive industry, which, though contain potentiality of growth, are badly handicapped by the lack of insight of the policy makers (see Figure 3.8).

Figure 3.8

The "Vicious Circle" in The Precision Mechanical Parts Industry



Source :

b) <u>IC packaging tube</u>. There exists only one firm which produces IC tube catering for domestic demand. The owner of the firm used to be an engineer in a domestic IC firm for a period of time. The firm was set up in 1987 with BOI promotion and 10 million baht registered capital. In the first year of operation , it turned out about 30 million unit of IC tube, less than a third of domestic demand, to major IC firms like AT&T, Signetics, NS and Chinteik Electronics Industries.

The firm produces two types of IC tube, namely antistatic (95%) and conductive (5%). Again, quality is one major weakness of this firm. Production has been carried out with major machineries imported from Korea, and with supervision and advice from a Korean supplier in few months period after start of operation. Initially, the rejection rate was as high as 70 - 80% but this was brought down and stabilized at about 6 - 8%. Presently, the firm is staffed with 4 engineers, 8 technicians, and 28 workers.

The market for IC tubes is certainly going to increase along with growth in IC industry. Domestic market for 1987 was around 100 million unit, while the growth rate is expected to be more than 15% for some years. Given this fact, combined with promise coming supply of raw material from the Eastern Seaboard 's NPC project, this industry contains potentiality not only for domestic demand but also for export market as well.

3.7.2 Consumer Electronics Industry Supportive Agents

Transformer is another electronics component, beside PCB (printed circuit board), which is produced domestically to cater local demand from consumer electronics producers. Firm surveys were carried out on two small transformer makers results of which are summarized in table 3.25.

Both are non promoted Thai firms. The first one was established in 1970 and produces a product mix covering printed circuit boards (40%), electronic enclosures (30%), power transformers (20%), and switching power supplies (10%). Annual turnover for 1987 was 10 million baht. The second firm was recently established in 1986 producing high voltage transformers with 1987 turnover approximated around 3.6 million baht.

Table 3.25

Profile of Transformer Manufactures

Supplying Consumer Electronics Industry

	#1	#2
established	1970	1986
investment	1.5.mil.baht.	0.5 mil.baht
eng : tech : worker	1:4:55	15
Value of products	10.0 mil.baht	3.6 mil.bath
major products	transformer PCB	transformer
major users	Consumer electronics manufactures	small public amplifier producers
imported parts/materials	copper enamel wire aluminium	copper enamel wire

Source : present survey 1988

These two local firms represent fairly real situation of Thai owned firms supplying electronics parts for consumer electronics producers. Most of the firms, producing either transformers or PCBs are small in size, occupy only a portion of market, and lack the necessary capital to expand.

Most of the major suppliers for electronics and electrical parts are joint venture firms. Supply of these products to local consumer electronics firms increased rapidly, but only in the last few years. The main reason was because Japanese joint ventures had changed their purchasing policy, which up to the last few years restricted local firms to buy from mother company The 50% increase of value of yen rendered this policy difficult to implement, if not impossible.

Table 3.26 summarizes the status of supportive industry for electronics consumer firms showing degree of widespread of supply and type of major suppliers. From the table, we can see that: (a) there exists no foreign firm producing electronics components for domestic demand; (b) a few items of electronics / electrical parts, which amount to less than 10% of the total parts value, are supplied mainly by joint ventured firms; and (c) Thai owned firms occupy a strong position with regard to the supply of mechanical parts.

Table 3.26

Status of Supportive Industry for Consumer Electronics Firms with Degree of Supply and Type of Major Suppliers

	Degree of Supply		Major Supplier		
	Widely	Partly	Foreign	J.V.	Thai
Electronics_/_Electrical_Parts					
AC Cord		*		*	
Printed Circuit Board		*		*	
Tuner		*		*	
Power Transformer		*			*
Capacitor		*		*	
Speaker	*			*	*
Coil					
Switch / Volume					
Degaussing Coil		*			*
Mechanical_Parts					
Metal Parts	*				*
Plastic Parts	*				*
Cabinet	*				*
Mould & Die		*		*	*

Source : present survey 1988

It should be stressed here that the above listed parts are just a small fraction of total parts necessary for consumer electronics products. The table, if anything, shows only how far we still are from being self-reliant even in this area.

3.8 Interaction between Producing Firms and Infrastructure in EIBI in Thailand

The interaction between producing firms and infrastructure in EIBI differs accordingly to firms' type of ownership and to nature of services provided. Focus will be made on this interaction in some important S&T activities, i.e. manpower training, equipment calibration, consultancy, adaptive and development works, and information services, and if remarkable differences exist among types of firms, they will be briefly analyzed.

3.8.1 Manpower Training

This is probably the strongest interaction existed between firms and EIBI's infrastructure, wherein all types of firms participate. The primary objective of this activity is to help upgrade manpower's operative capability. Major institutions providing this services are most universities with faculty of engineering and private non-profit organizations such as the Engineering Institute of Thailand (EIT) and the Technological Promotion Association (TPA).

Foreign firms are the most active and enthusiastic participants of this activity. Besides sending engineers and technicians to such training courses or seminars, some firms even make a contract with universities for more specific training. In August 1988, three IC manufacturers made a special contract with KMITL for the latter to train and upgrade their technicians. Similarly, a series of in-house training organized by Chulalongkorn University, had been carried out for months in early 1988 for an IC manufacturer.

Most of the training courses and seminars cover general topics in production technology and production management. Foreign firms and most joint ventures, if deemed necessary, can still turn to their mother companies or joint ventured partners for more specific and more technical training. This is not the case for Thai firms. These firms frequently found that available seminars and training courses, though useful, are not detailed enough to provide necessary indications for further productivity improvement. This is probably the major weakness of the existing informal education system.

3.8.2 Equipment Calibration

This type of linkage is not as strong as the previous one, however trend of growing interaction is quite evident. TISTR, Department of Science Services and TPA are three major organizations providing the equipment calibration services.

Thai firms, both large and medium ones, are the most active users of this services. Foreign firms and some joint ventures have most of their equipment calibrated abroad, in the United States, Japan and Europe. The reasons, quite understandable, are because:

- the traceability system in Thailand is not yet established. Although there are many standards that are traceable to international standards institutes, a national system for traceability still does not exist.

- it takes a relatively long time to have equipment calibrated in government laboratories, while private organizations which provide prompt service do not have high enough levels of accuracy

- foreign firms and most joint ventures can rely on their mother company or joint venture partners for such services.

All these weaknesses are expected to be improved very soon. Since the Government has paid much more interest to improve quality and standard of Thailand industrial products. In order to achieve such goals, the improvement in calibration services is essential. The Government succeeded to secure at least two aid programs, one from Japan's JICA and one through STDB , in order to help improve the present situation. It is likely that calibration services would play a more significant role in improvement and upgrading of Thailand's electronics industry.

3.8.3 Consultancy

Many joint ventures and large Thai firms and some medium Thai firms hire competent universities' professor as their part-time consultant. Consultancy usually covers a broad range of advice from productivity improvement, equipment maintenance, up to adaptation of products, and processes, and some development works.

There are cases where this kind of interaction prove to be very successful. In at least two joint ventured consumer electronics firms, a remarkable cost reduction was brought about through this kind of service.

3.8.4 Adaptive and Development Works

Interactions of this kind have increased rapidly in recent years. Most of the users are Thai firms, medium and large ones, while university laboratories are main suppliers. The activities range from the attempted duplication of some equipments/circuits, the adaptation of imported products, and development of new products.

Some conspicuous cases of this interactions are:

- joint research to develop microprocessor-based lift control system.

- adaptation and improvement of truck scale

- adaptation and improvement of animal feed mix control system

- development of small and medium scale PABX

The above mentioned projects are joint efforts between Thai firms and universities professors which most of them have already been commercialized. There are still many other development works of this kind that are still on progress, For example :

- development of programmable controller,

- development of sensors and transmitters for industrial and agro-industrial users,

- computerized X-ray tomography, etc.

3.8.5 Information Services

This interaction is probably the weakest one. There exist very few cases of producing firms utilizing available information services in the country.

Table 3.27 summarize profile of interaction between producing firms and EIBI's infrastructure.

Table 3.27

Profile of Interaction Between Producing Firms and Infrastructure in EIBI in Thailand

Item / Type	Foreign	Joint Venture	Large Thai	Small Thai
Manpower	@	@	$	$
Calibration	O	O	$	$
Consultancy	O	$	$	$
Adaptive & Development	O	O	$	$
Information Services	O	O	O	O

Source : present survey 1988

* : very active

@ : active

$: somewhat active

O : not active

3.9 Summary of The Profile of Technological Capability of EIBI in Thailand

This study of the profile of present technological capabilities of the electronics and information technology-based industries (EIBI) was conducted with the survey of a sample of 32 producing firms. The sample includes 8 consumer electronics firms, 3 communications equipment firms, 4 computer hardware firms, 4 industrial electronics firms, 10 electronic components firms, and 3 software firms. The survey was carried out through questionnaires, interviews, and factory visits.

The technological capabilities were assessed in each group of companies and the analysis was made with respect to the following characteristics : size, ownership, Board of Investment promotion, and export orientation.

Figure 3.9 shows the overall technological capabilities of the EIBI in Thailand with the following values :

Acquisitive capability	55.3%
Operative capability	63.1%
Adaptive capability	49.8%
Innovative capability	16.9%

The value indicate that the EIBI in Thailand on average has "good" operative capability, with the potential to compete internationally. The acquisitive and adaptive capabilities are just "fair". The industry has to make more improvements if it is to be at the world level. The innovative capability is rather poor. It accurately reflects weakness in the research and development situation in the industry, or in the country.

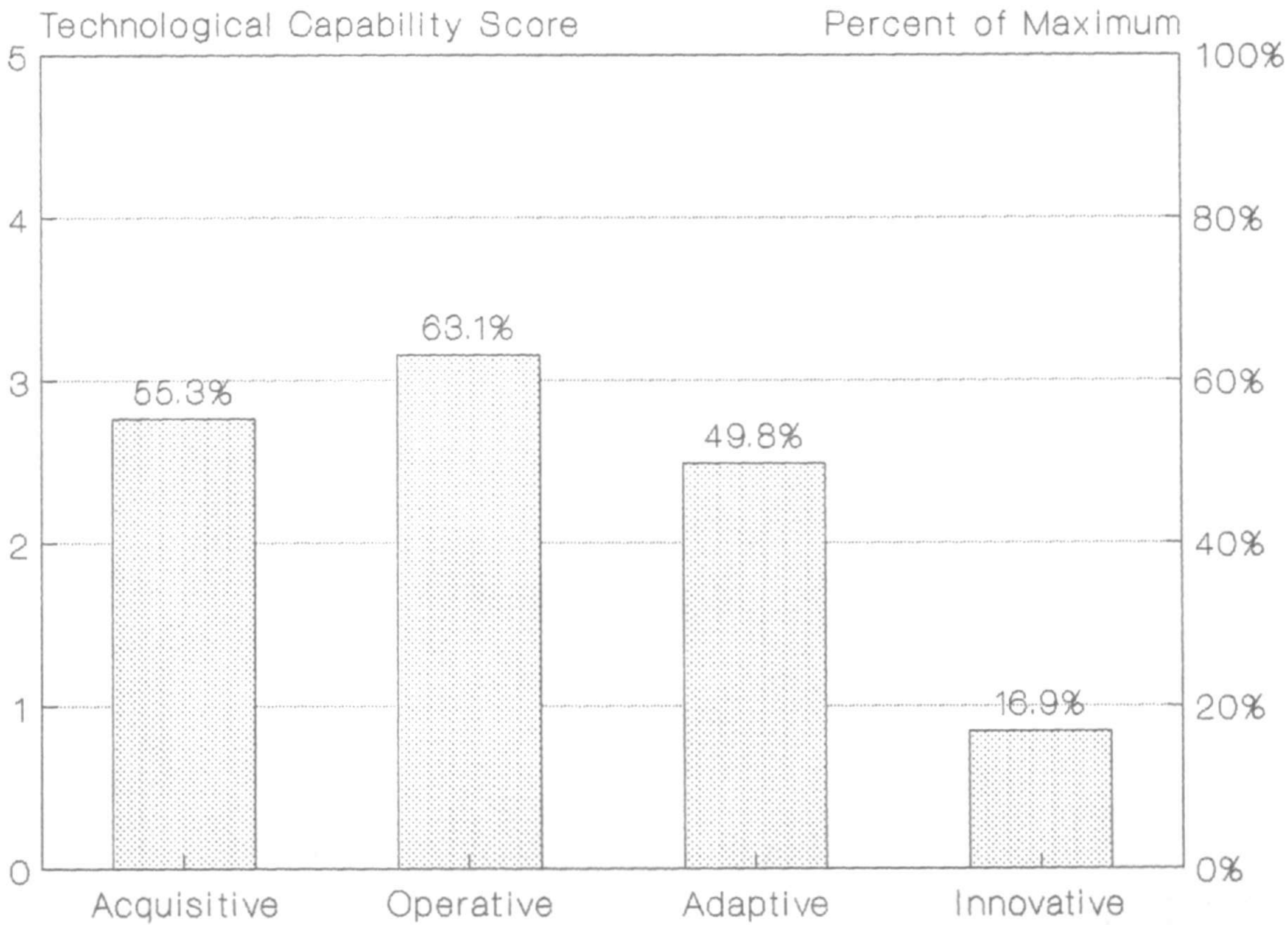
Figure 3.10 shows the overall technological capabilities by the industry groups with the following values :

(1) Consumer electronics	41.7%
(2) Communications equipment	51.1%
(3) Computer hardware	47.5%
(4) Industrial electronics equipment	50.4%
(5) Electronics components	48.8%
(6) Computer software	61.9%

Overall technological capabilities range from 41.7% to 61.9% which are in the middle range of the rating scheme. It is necessary to develop higher technological capabilities if performances are expected to be at the international standards.

Analysis by ownership shows that the overall technological capabilities of Thai firms, joint venture firms and foreign -owned firms are relatively the same, as show in Figure 3.11.

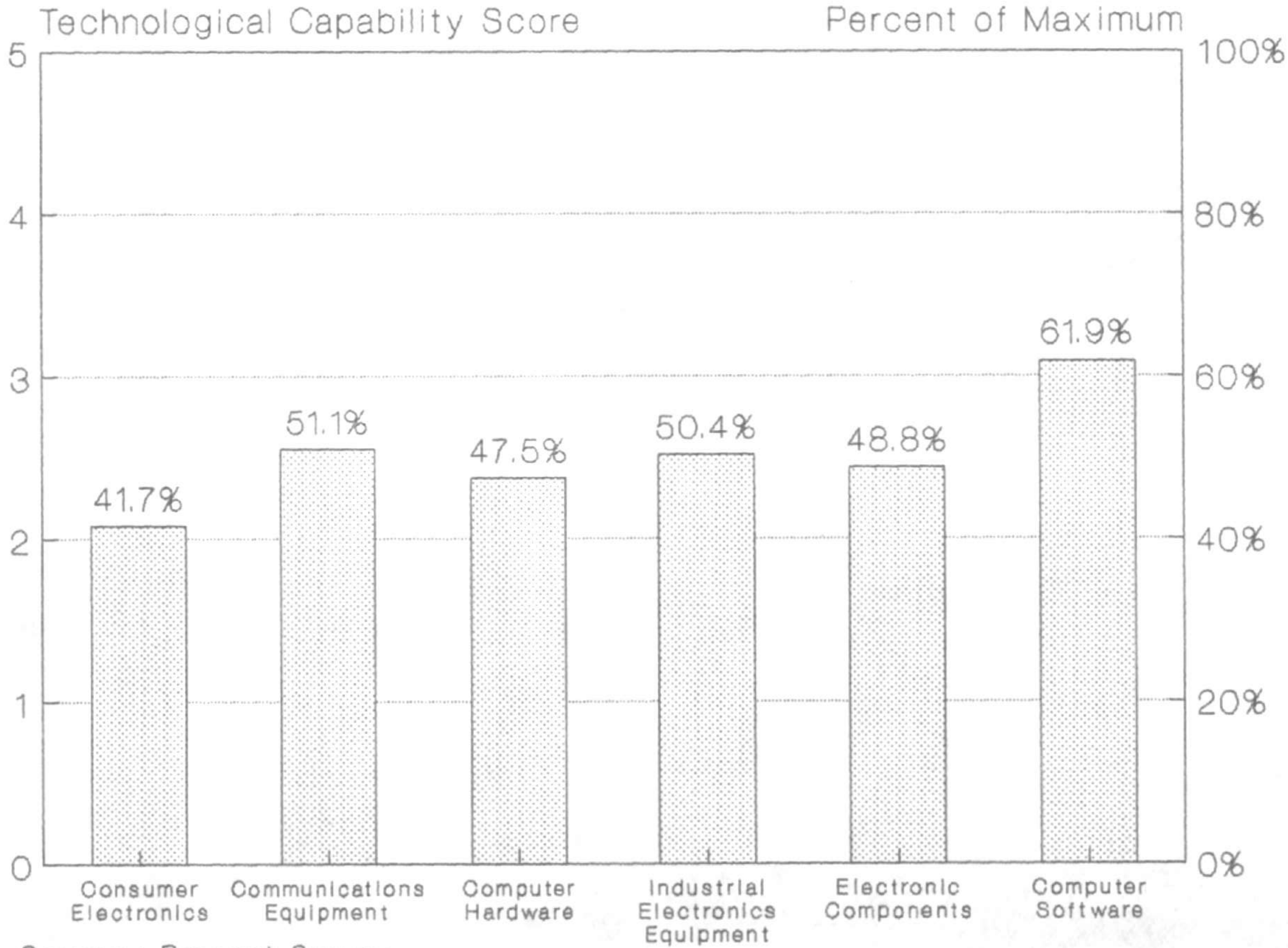
Figure 3.9
Technological Capability of All Electronics Firms



Source : Present Survey

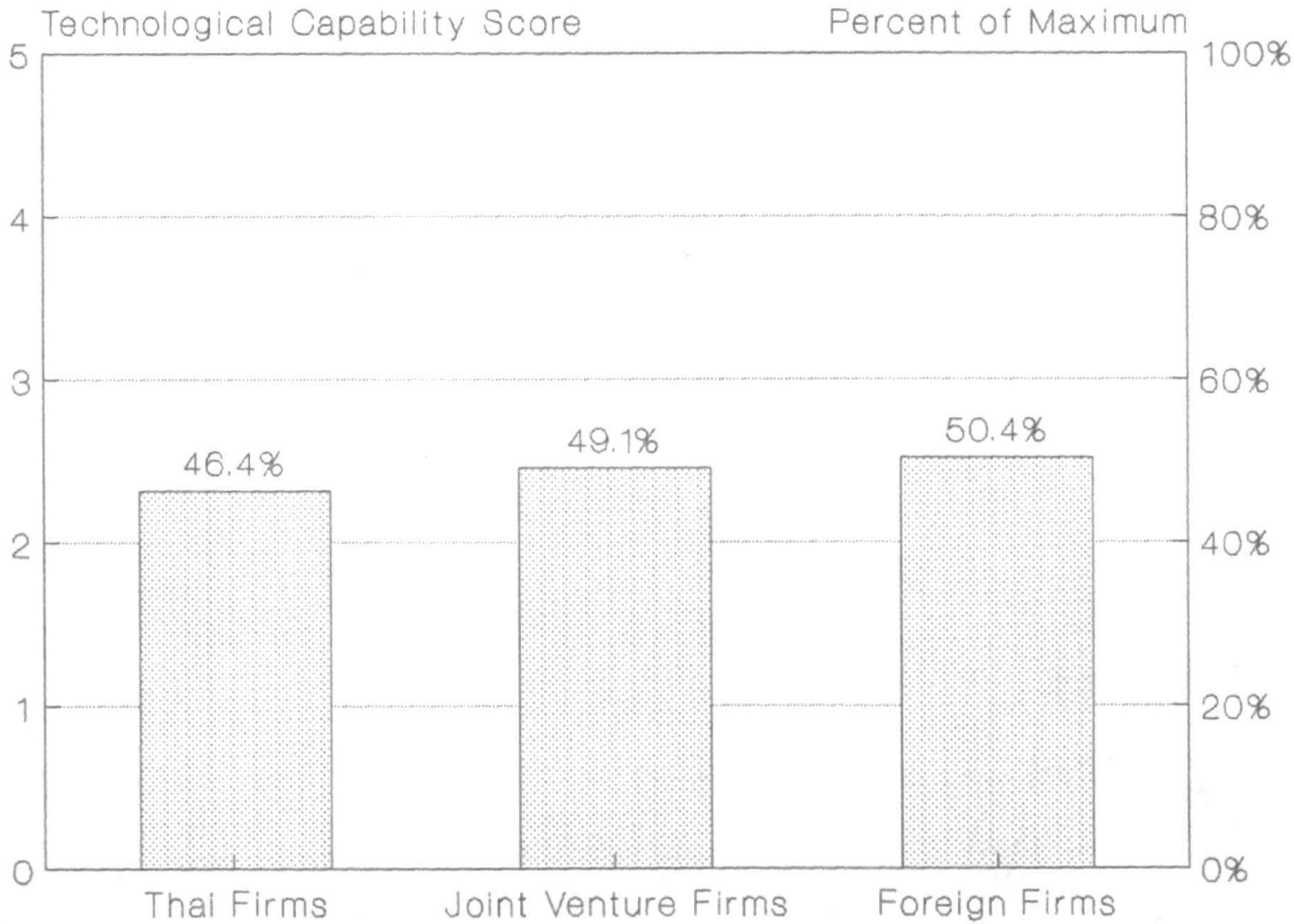
Figure 3.10

Gaps Of Technological Capabilities



Source : Present Survey

Figure 3.11
Overall Technological Capability By Ownership



Source : Present Survey

For the Thai firms, Figure 3.12 shows that the technological capability increases with the size of firms. Large Thai firms have "good" capability, which small Thai firms have "fair" capability which are capable only for the low-end local market. It demonstrates that small manufacturing firms need greater support for development of their technological capabilities.

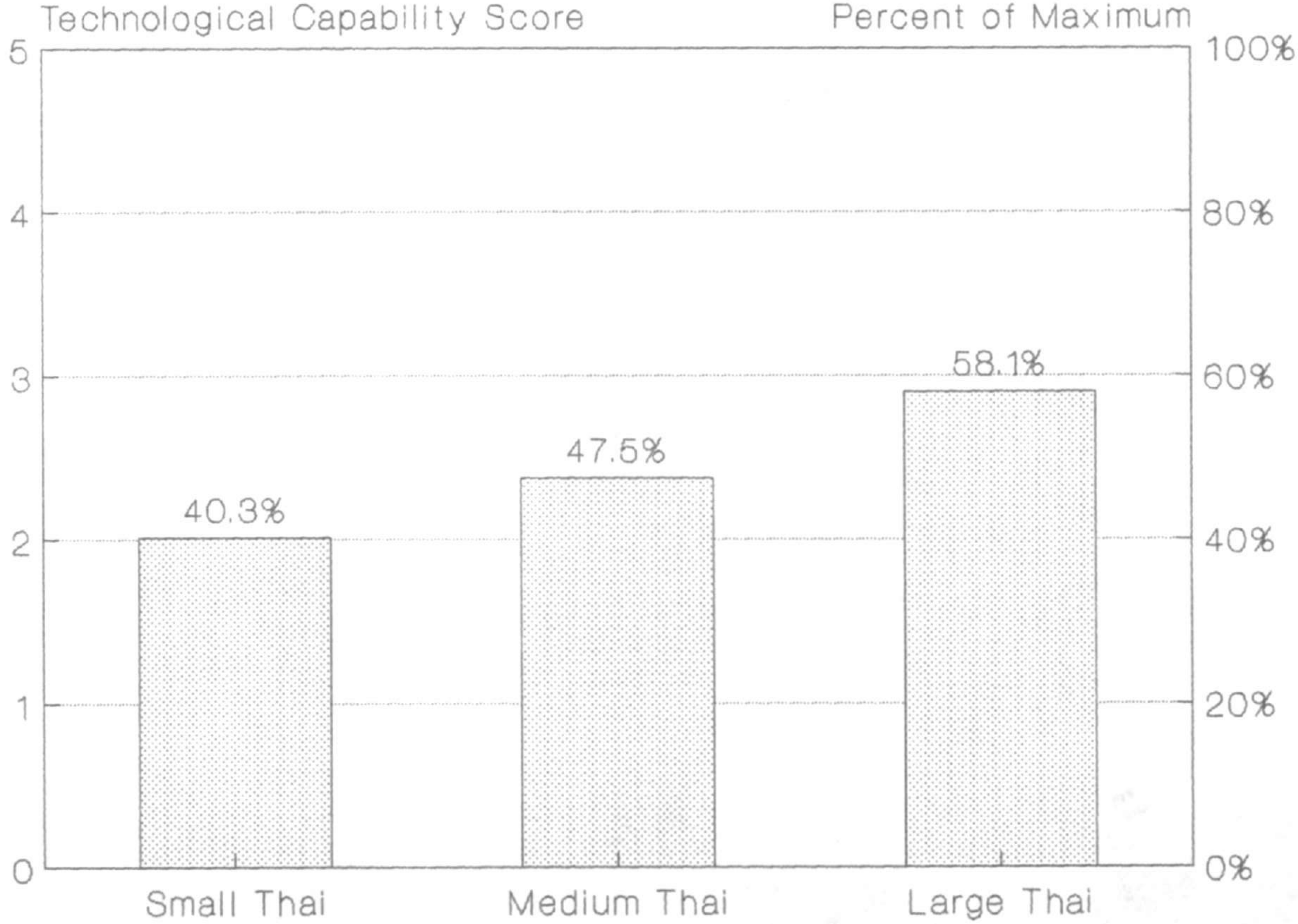
When the analysis is made by BOI-promotional status, it shows that promoted and non-promoted firms are not significantly different in their acquisitive technology. The differences are in the operative capability and adaptive capability. The promoted firms show "very good" operative capability which are much higher than the non-promoted ones. It clearly suggests that the BOI-promoted firms bring very good production technology into the country. However, the adaptive capability of the non-promoted firms is slightly higher than the promoted ones. Innovative capability is at the "unsatisfactory" level for both types of firms, although the non-promoted firms show a higher value. The higher values of adaptive and innovative capabilities of non-promoted firms confirm that they have more of their product design and development done locally, which the promoted ones have less effort locally. The analysis by promotional status implies that the BOI-promotion induces a very good technology transfer in the operative capability or the production technology, but only weakly introduces adaptive and innovative capabilities.

The technological capability by export-orientation of producing firms as shown in Figure 3.14 has a pattern similar to the technological capability by promotional status. This is because most export-oriented firms have BOI-promotion.

The analysis also discovers a correlation between acquisitive and operative capabilities of Thai firms. That is, a good acquisitive capability leads to a better operative capability. This phenomenon is not true in the case of foreign-owned firms. They make less effort in developing the acquisitive

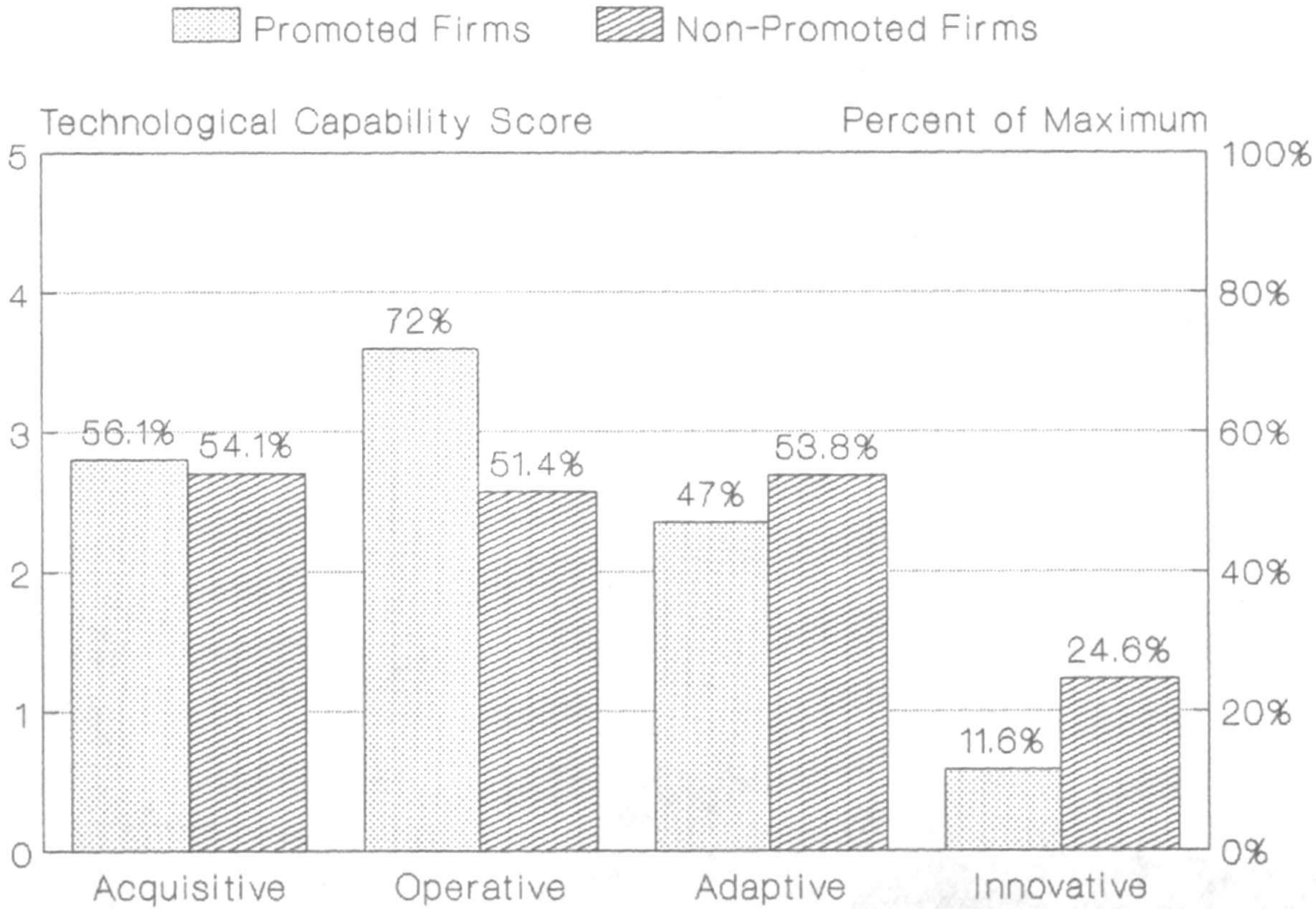
Figure 3.12

Technological Capability For Thai Firms



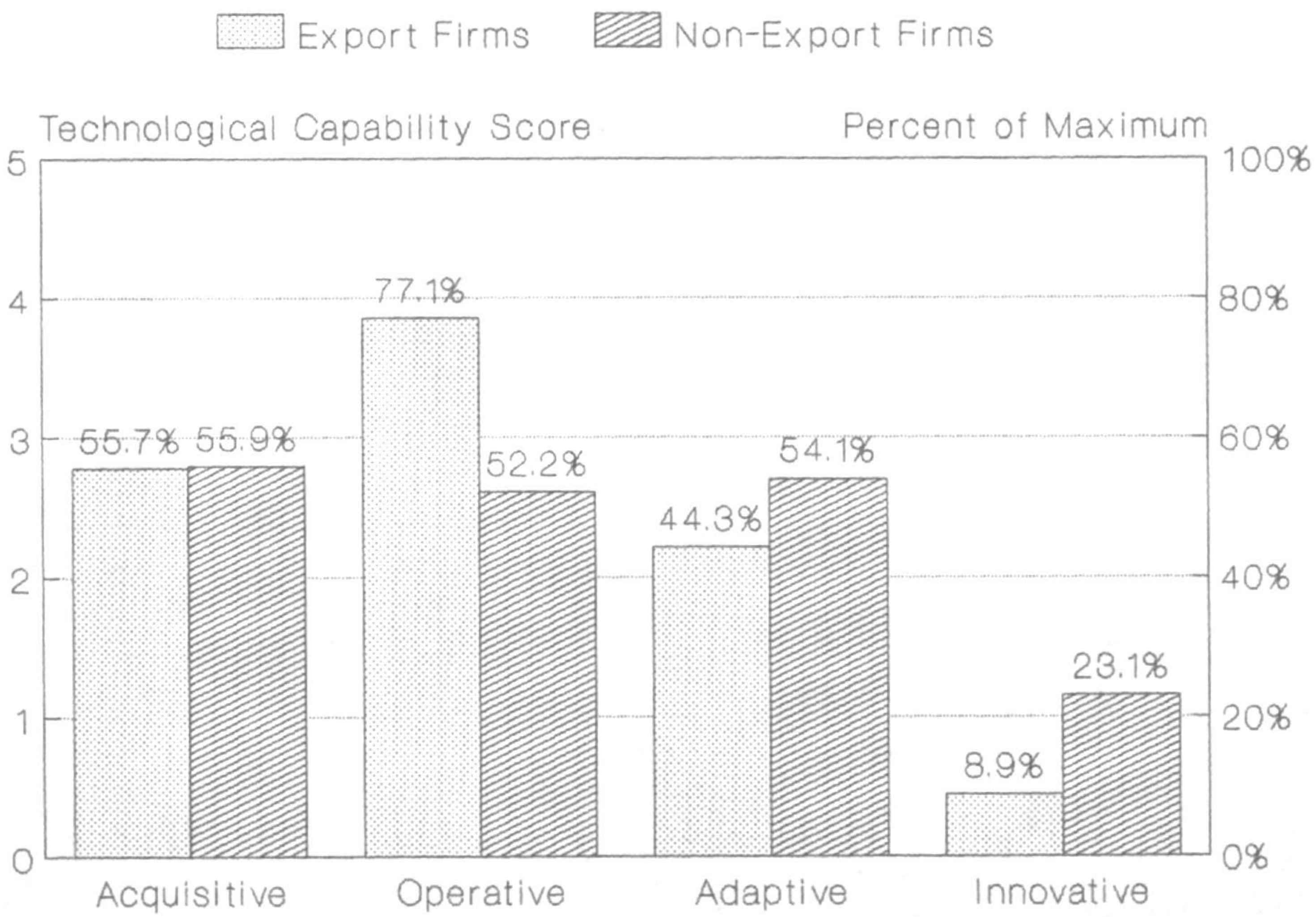
Source : Present Survey

Figure 3.13
Technological Capability By Promotional Status



Source : Present Survey

Figure 3.14
Technological Capability By Export-Orientation



Source : Present Survey

capability in their local subsidiaries, because all information and know-know are available in the parent companies.

The profiles of technological capabilities are summarized across industry groups and types of firm as shown in Tables 3.28 and 3.29.

Table 3.28

Profile of Technological Capabilities by Industry Group

Industry Group	Acquis		Operat		Adapt		Innov	
	%	Rank	%	Rank	%	Rank	%	Rank
1.Consumer	50.8	6	55.5	5	45.0	5	8.1	6
2.Communications	63.3	2	64.0	2	51.1	2	16.7	4
3.Computer Hardware	56.7	3	58.0	4	48.3	4	20.0	3
4.Industrial Equip	53.3	5	47.0	6	60.0	2	26.3	2
5.Components	53.7	4	77.2	1	42.7	6	10.5	5
6.Computer Software	65.6	1	64.0	2	73.3	1	45.0	1

Source : Annex Table A1.7, A1.8, A1.9, A1.10

Table 3.29

Profile of Technological Capabilities by Type of Firm

Type of Firm	Acquis		Operat		Adapt		Innov	
	%	Rank	%	Rank	%	Rank	%	Rank
1.Small/Medium Thai	54.3	3	46.9	4	49.0	3	20.7	2
2.Large Thai	72.2	1	64.0	3	64.4	1	25.0	1
3.Joint Venture	55.6	2	67.3	2	57.8	2	10.0	4
4.Foreign (Subsidiary)	51.1	4	85.3	1	40.7	4	12.8	3

Source: Annex Table A1.12

CHAPTER 4

FIRM BEHAVIOR AND ATTITUDES TOWARDS TECHNOLOGY

This chapter examines in more detail the processes by which firms in the electronics industry acquired the various technological capabilities detailed in section 1.5. The types of firm-level behavior or strategies that influence (in positive and negative ways) the development of technological capability will be examined in light of the apparent effects of such development on firm-level productivity or performance. Where possible, within the limitations of the data, the determinants of such behavior or the absence of it are examined in order to identify whether there exist market and policy failures that need to be addressed.

Since the present study aims to examine the extent to which Thailand (and Thai firms and manpower) has acquired technological capabilities, some consideration will be given to the nature of foreign involvement and its impact on the firm's behavior. In particular, the extent to which the various skills and capabilities are transferred to Thai staff, and the spill over effects to other firms in the economy occur, will be carefully considered. Other potentially interesting variables that may well influence the firm's behavior include the market orientation, the perceived competitive environment within and outside the firm, and the type of product that is being produced as well as the nature of the production process. Given the importance of the human capital element in the accumulation of technological capability, separate sections will be devoted to examining the manpower development policies of electronics firms and their management practices and strategies.

The basic approach that will be taken in this chapter will be one of selective, case-study interpretation of the qualitative information obtained from the firm visits discussed earlier in chapter 3 which were supplemented by a number of second-round follow-up visits. As such, the analysis will build on that of chapter 3 by explaining how the firms acquired the various capabilities. An attempt will also be made to look at the firm as one unit, where decisions with regard to adaptive capability for example may well significantly influence the operative capability of the firm, and the effectiveness with which the firm acquires the technology could well affect the success or failure of the firm in actually using the technology.

4.1 Past Behavior in Acquiring Technology

The initial acquisition of technology can take a number of different forms, ranging from a turnkey type of project implementation where the local staff may have no involvement at all to a technology licensing arrangement with more active local participation or reverse engineering by local engineers. Each of the various modes of technology transfer has advantages and disadvantages that differ depending on the technological characteristics of the product or process being transferred.

In practice, the actual acquisition process differed substantially depending both on the ownership structure and on the nature of the production process.

In general, foreign-owned subsidiaries and joint-ventures initially acquired their technology from the parent companies which generally transferred only as much as they felt was necessary to enable the Thai plant to produce and run efficiently. In most cases, there was little involvement of Thai staff in the various aspects of the acquisition process and correspondingly little development of acquisitive capability. This is not to imply that the choice of technology was incorrect only that the ability to search, evaluate, and install the technology in Thailand was not transferred to Thai engineers and technicians.

The situation tended to be somewhat different in cases where the company expanded the same product line or introduced new product lines. Consume4, for example, increasingly used local staff in the design and implementation of their expansion into electronic components and even the older foreign-owned integrated circuits companies make much greater use of Thai engineers and technical staff now than they did in the beginning. The latter is probably largely due to the fact that there is now very little integrated assembly taking place in the United States so for all practical purposes much of the technological expertise resides in their overseas plants.

One interesting example of a foreign firm that acquired a technology by taking advantage of its international linkages concerns Hardware4's printed circuit board assembly line. In this company, where the Thai management and engineering staff appeared to have been given more authority than elsewhere, the process began when Hardware4 set up a printed circuit board re-work line for boards rejected from assembly lines elsewhere. The company's engineers were involved in the design of the re-work line and were able to obtain a comprehensive understanding of both the product and the process before the assembly line proper was installed about one year later. The final assembly line was developed on the basis of the re-work line and some of the cost-saving accomplishments of the re-work line were transferred to the assembly line.

In the case of Commu3, we are faced with the novel situation of the parent company in Singapore essentially consisting only of a number of engineers that left AT&T/Bell Labs in Singapore to form their own company. The Thai subsidiary is their first foreign investment effort and the technology transfer process has been carried out in a very hands-on manner by the group of young engineers who have provided considerable assistance regarding the setting-up of machines and systems. It is too early to judge whether the presence and the methods of such a dynamic group of young entrepreneurs will provide a different exposure to the local technical staff but hopefully it will.

Several Thai companies in the consumer electronics fields obtained their initial technologies through technology and brand-name licensing arrangements with foreign producers. Consume3, for example, has signed a number of licensing agreements with foreign companies for a range of products over the years. The first agreement was seen as being rather successful and involved a number of foreign engineers being sent to advise on assembly, testing, and quality control. Just after that time, the firm employed a Japanese engineer who has subsequently settled down in Thailand and stayed with the firm as an advisor. The company felt that they benefitted by shopping around for the most advantageous deals although emphasized that such a process was quite intensive in management time and ability. Finally, after the managing director felt that his technological capacity had been developed to the required level through the series of licensing agreements and development of local design staff, the firm began to produce and export under its own brand-name.

One major Thai firm (Consume2) also started out very early on with a licensing agreement with a major Japanese electronics company which sent short term technical assistance from time to time. Spurred on by the enthusiastic technical input of the company's founder, the technology transfer was successful enough to enable the company to rapidly develop the capability to make significant design changes in some basic consumer products in the late 1960s and early 1970s (see below).

However, the technology transfer process with regard to the production of electrolytic condensers by one of Consume2's subsidiaries was less successful. The initial attempt to obtain the technology through a licensing agreement quickly ran into difficulties and a restructuring of the ownership to provide the Japanese licensor with joint ownership was concluded. The Thai side claimed that the Japanese did not fully support the initial attempt because they wanted a joint venture from the beginning and were not willing to properly transfer the technology though a licensing agreement alone. The Japanese, on the other hand, felt that the Thai counterparts did not possess the absorptive capability to enable the enterprise to get on the right track with a more complex technology than they had been used to and that additional Japanese input was necessary to guarantee success. The real picture probably has a bit of both sides but the resulting joint-venture has been able to successfully break into export markets and has recently been permitted by the BOI to provide their product to the local market as well.

In several of the Thai companies that moved into relatively higher technology areas such as printed circuit board fabrication and integrated circuits and did not desire any form of direct foreign involvement through licensing or joint venture arrangements, the method of transfer involved the import of engineers from countries in the region to install and start-up the factories.

Compo2 used their market contacts and friends to identify three experienced Taiwanese engineers who, together with their Thai counterparts, designed the specifications for the factory and worked in Thailand for some three years to get the process up and running smoothly and to transfer production know-how. At the time that they left the plant, management decided to drop production levels to ensure that the Thai engineers had adequately mastered the technological complexities of the process before gearing up to full capacity again. Judging by the number of world standard producers such as IBM, Plessey, Northern Telecom, GEC, and STC that have recognized Compo2 as a quality vendor, the process has been very successful. In a recent expansion project, the company's own technical staff were able to redesign of the existing layout on their own. In addition to their accumulated experience, they relied on information from their customers and machinery suppliers, as well as a comprehensive collection of technical magazines and other materials which were stocked in a comfortable library to enable all technical staff easy access.

Compo7 imported a number of Filipino engineers with experience in Stanford Semi-conductors to work with local engineers and technicians for a period of two years. While initial ideas were for the company to become a packaging design and assembly house, the former proved impossible due to lack of government and infrastructural support, especially on the manpower side. Consequently, the company concentrated on becoming an efficient, low-cost jobbing shop for integrated circuit assembly. As a result, the Thai counterparts who had been poached from other integrated circuit companies operating in Thailand were able to learn the assembly process very quickly and the foreign engineers did not actually stay for the whole two years. Since that time, in contrast to Compo 2, Compo7 has relied heavily on selected foreign staff at the very senior levels although has continued to ensure that local technical expertise is developed as much as possible. Another major channel of technology transfer for Compo7 has spun out of their trading subsidiary in the United States which, in addition to marketing services, provides a link with new developments in integrated circuit packaging technology through close contacts with customers and participation in the state-of-the-art technical shows and exhibitions.

The remainder of the smaller Thai companies in the sample obtained their technology principally by purchasing machines and undertaking some basic reverse engineering of both the product and the process. These methods were more or less successful, depending mainly on the personal role of the entrepreneur involved. Commul, for example, appeared to have acquired quite a reasonable understanding of the technology underlying the production of radio transceivers while Compo3 appeared to have very little acquisitive capability in the production of printed circuit boards.

In general, the evidence would seem to support the contention of Hoffman (1986) that, up to a certain level, the mode of technology transfer itself is perhaps less important than a range of other factors including: (a) the ability of the recipient to negotiate the terms of transfer and absorb the technology; (b) the quality of the institutional environment and supporting infrastructure; and (c) the structuring of the technology transfer process itself and the way it is monitored.

4.2 Evolution of Operative Capability

As in the case of acquisitive capability, the degree to which a firm had acquired the ability to operate the factory in an efficient manner also depended on a number of factors. The main dimensions involved: the complexity of the technology; the ownership of the firm; and the competitive environment within which the firm operated.

Linkages between operative capability and other capabilities

To a greater extent than with foreign-invested firms, the level of operative capability of Thai firms depended heavily on the effectiveness with which they had acquired the technology and/or the ability to adapt the technology to Thai conditions (see section 4.3). Foreign firms, on the other hand, were able to operate factories in Thailand in a rather efficient manner, taking advantage of resources elsewhere with regard to acquisition and adaptation. As a result, the behavior of Thai firms in devoting resources towards developing acquisitive and adaptive capabilities proved to be much more crucial with respect to their operating efficiency levels than was the case with foreign-owned firms. This correlation has already been noted in chapter 3 (see Figure 3.7).

Several foreign firms in the sample, notably Consume5 and Compo9, have adopted an explicit strategy in the early years of operation at least to provide only the training that is necessary to operate the machinery which is installed in configurations determined exclusively by engineers from the parent company's plants. Some of the older firms in the consumer electronics and integrated circuits sectors, however, reported that they had found that since their Thai engineers initially were unable to do much more than just run the machines, it made it very difficult for the factory to keep up with technological progress without continually having to inject expensive and lengthy doses of expatriate engineering skills. In certain cases, this recognition had led to the development of much more in-depth training programs to install a deeper understanding of the nature of the technology and the ways in which it is installed and modified. A good example of this is Compo8 which has instigated a number of fruitful training programs to foster the development of local engineering staff.

Subcontracting

The behavior of firms with respect to developing local subcontracting linkages generally had significant impacts on the efficiency with which they were able to operate. The ability to source locally frequently played a significant role in reducing input costs as well as the levels of required inventories. However, at the present time most firms, especially those in the higher technology sectors such as integrated circuits, complained that the general level of supporting industry was rather low and they sometimes had difficulties even in obtaining packaging materials and plastic parts, let alone complex parts and components. This observation is supported by Table 23 in Sibunruang and Brimble (1988) which shows that the electrical machinery sector exhibited the lowest local input ratio of all sectors in 1985 - just exceeding 5 percent overall with foreign firms from developed countries using considerably more imported inputs that those from less developed countries and Thailand.

Nevertheless, among foreign firms, Compo6 had devoted considerable attention to the identification of local firms that could supply them with a number of component parts. Although they have experienced some difficulties in this regard, especially with respect to quality and reliability, they reason that they are in Thailand for the "long haul" and that such investments in developing linkages now will pay off in the future. Their target is to reach 50% local content within two years. However, their aggressive strategy to identify and assist Thai subcontractors has not been entirely successful and they have increasingly resorted to the use of foreign-owned subcontractors or the production of components in-house. The weaknesses in the production capabilities of local firms that precipitated these courses of action characterize the state of supporting industries in Thailand and, to some extent, an ideal opportunity for developing niche industries to support a large new electronics industry has been squandered.

Commu3, the company producing telephones and run by young Singaporeans have taken a similar path to Compo6, although they have not yet been operating long enough to report much progress and have had severe informational problems in even identifying potential candidates. However, they have already established a subsidiary (albeit foreign-owned) to pack PCBs for Compo6.

Other firms with potential for subcontracting have adopted different strategies. Consume5, for instance, has brought along a number of its subcontractors from Japan to supply various microwave oven parts and has established a metal-working and treatment section in its assembly plant in Thailand to avoid the need for using outside services. They argue that the weaknesses of the "fundamentals" in Thailand, especially in supporting industry will be one of the major constraints to Thailand's future competitiveness. Compol has taken an even more extreme approach than Consume5, with an almost explicit policy to do everything in-house. This has manifested itself in the rapid diversification of the company from plastic injection moulding to metal-working and the production of steel balls to be used in ball-bearings.

The importance of foreign firm's efforts to develop subcontracting links are especially important for the Thai firms concerned as these relationships provide one channel for technology transfer and the transmission of training and other assistance to help the subcontractor reach the required standards. The linkages may even afford the subcontractor access to trends in international operating standards and procedures (see below). Given the great possibilities for linkages between the various parts of the electronics industries and the large potential spill over benefits, the already promising behavior on the part of certain foreign firms to establish linkages should be encouraged and efforts to improve the standards of the subcontractors stepped up.

Access to information on standards and operating procedures

Another area which proved critical in certain companies with foreign links was the ability to draw on the experiences of other subsidiary companies in the group regarding operating standards and procedures. This interaction between companies provided an invaluable yardstick upon which the Thai subsidiary could judge its operating performance and quickly identify areas where improvements could be made. The phenomena contained elements relating both to the flow of information and to the enhancement of the level of perceived competition. In certain cases, active participation in export markets and fruitful contacts with input suppliers contributed to updating the flow of information on standards and new production techniques.

Compo6 provided the most concrete example of the positive aspects of the phenomena regarding the flow of information between their Thai and Singapore plants. Following the successful start-up and operation of the Thai plant producing a similar product, significant improvements were made in the Singapore factory which attempted to reach the operating standards achieved in Thailand. These improvements occurred in a relatively short period of time, with the Singapore plant eventually improving efficiency in certain areas to levels higher than their Thai counterparts (or maybe we could say competitors). Similar stories were forthcoming from some of the integrated circuit companies as well. Compo8 has established a "Quality College" to ensure that workers ranging from operators to engineers are qualified to keep up with constantly changing production standards. Even in the event that the parent company had no other subsidiary producing a similar product, the ability of the multinational network to obtain the information on standards and procedures proved useful, as in the case of Compo9.

On the other side of the coin, it would appear that at least a part of the stagnation observed in Consume2 resulted from their inability to keep up with the operating standards of comparable companies both in Thailand and abroad. The Japanese joint-venture partner in their electronic component enterprise claimed that one of the main reasons why the initial wholly Thai controlled effort failed was due to the inability of the Thai side to just their own operating standards. Also, it was observed in several factories, such as Consume3, that inadequate testing and calibration procedures were being used in the incorrect belief that they represented the state-of-the-art. This may have been true at the time of installation but is no longer the case today.

The inability of Thai firms, especially those operating only in the domestic market, to keep up with changing operative practices in all areas of operations, ranging from process and quality control systems to testing and calibration and inventory controls, could perhaps be seen as one of the most critical problem areas. Efforts to disseminate information on these issues, such as those of the Technology Promotion Association, were reported by some firms to play an important role in assisting them to upgrade their operative capability. However, the extent of such programs is wholly inadequate and there is much room for expansion. In the same light, there is definitely a perceived need for the provision of more organized technological information services to provide information on a commercial basis to Thai firms that, alone, could not economically justify the expense of obtaining the information from abroad.

4.3 Evolution and Economic Significance of Adaptive and Innovative Capability

The development of adaptive capability in the sample firms can best be analyzed separately for improvements in products and improvements in processes.

In the case of advanced products such as electronic components and parts for computers, the level of complexity involved meant that there was very little evidence of (and very little scope for) any product modification at all. In most cases, any changes in product specifications or design would come from customers or R&D centers outside Thailand, even for Thai-owned firms such as Compo2 and Compo7 which primarily service export markets. The maximum extent to which most foreign subsidiaries have proceeded with regard to product-related design issues is to have some degree of freedom in sourcing a certain number of inputs. In the case of several integrated circuit companies, the development of the capability to source inputs from various suppliers and make minor adjustments to the products accordingly has contributed to cost saving efforts.

The situation is somewhat different with regard to adaptation to the production processes in these companies where there appeared to exist more scope for substantial improvements. Compo4, for example, instigated a special program to introduce a just-in-time system in their integrated circuit assembly plant. Entirely carried out by Thai engineers, the program succeeded in transforming what was previously a batch process into a more continuous process by revising the layout slightly, changing the guidelines, and modifying both engineers and operators' attitudes. The net result was a reduction in cycle time by an order of 50 percent and the adaptation was subsequently adopted by other plants owned by the same parent company. Compo8 reported similar exercises which they argued were quite necessary at the present time due to the fact that the parent company no longer has any assembly operations in the United States so any modifications had to be made in Thailand. In addition to local suggestions, both companies still sent large amounts of processing information back to their head offices for analysis.

In an effort to further stimulate the factory engineers in thinking about improving and adapting the processes, the managing director at Compo8 had set aside a relatively generous and easily accessible fund for engineering staff wishing to do some applied research or problem solving work. He reported that they had come up with some very interesting results but did not seem to be able to maintain the interest and motivation to carry the ideas through into practice on the factory floor. Machinery suppliers sometimes took the ideas and incorporated them into their new machine designs so the adaptations found their way to the factory floor in this way.

In another area, namely computer cable manufacture, engineers at Hardware4 made a significant process modification that significantly reduced inventory costs and reject rates as well as considerably speeding up the handling time. The process modification was made by a local Thai engineer who introduced a cable matching system that used light emitting diodes instead of colored cables and which carried out the connection testing procedure at the same time as the connection was made. The managing director claimed that, to his knowledge, this was the first time such an process modification had been made. He also implied that one aspect which contributed to stimulating such cost-saving efforts was a change in the parent companies policies with regard to the allocation of product lines among subsidiaries. Whereas previously, the allocation had been made on a more or less ad hoc basis, it was now based on a kind of competitive bidding where each new product would be allocated to the lowest cost production site. This type of within-company competition had already stimulated his engineers to search for more cost-efficient ways of producing keyboards so they could win the "bid" to produce them in Thailand.

In the consumer electronics and industrial electronics sectors, there was more evidence of product modifications. Some years ago, Consume3 introduced a number of modifications to the radios they produced in order to make them more functional in provincial and regional areas. At the time, this enabled them to capture a vast majority of the market and establish their own brand name in the Thai electronics scene. They subsequently attempted (not successfully) to design the board for a color television set but eventually had to send the design to Japan to be re-worked. However, they did acquire an adequate understanding of the componentry to enable them to source all of the parts for the TV set themselves instead of relying on expensive CKD or SKD kits. This apparently reduced the cost of the television sets by some 20 percent or so.

In general, the approach of all the firms in the sample towards research and development was somewhat passive. No foreign firm had established an R&D center in Thailand although Compo1, Compo9, and Hardware4 have expressed plans to do so in the next few years. All of them expressed reservations about both the supporting infrastructure and the quality and depth of experience of research personnel. In order to address the latter problem Minebea is presently in the process of training (or identifying candidates to be trained) some 50 engineers in Japan to form the basis for their planned R&D center in Thailand.

Among joint-ventures, Consume4/Compo5 (the company has both final product and component lines) has devoted resources to establishing a research center in recent years and some of the small Thai firms such as Ind1 and Commu2 have carried out a relatively large amount of R&D work. In the two latter cases, the main impetus came from the personal motivation of a technically well-trained entrepreneur.

On the computer side, three companies were identified that have devoted resources to RD&E. Hardware2, a small hardware house and computer dealer, has invested in the development of a fully-integrated Thai card which, in its final stage, will involve the design and fabrication (abroad) of an ASIC to perform the functions of most of the components on the present board. Hardware1 carried out much of the R&D which led to the introduction of a microcomputer system in the local market. Lastly, Software1 has established a rather large development section which is responsible for keeping up with the rapidly changing picture in the software industry as well as developing ways of using the new techniques in their software products. Several software companies have produced quite innovative applications packages although little real software engineering has yet taken place.

4.4 Human Capital Formation

There has been a tendency in the past to view one of Thailand's main advantages as being the abundant supply of cheap labor. However, in the electronics sector where the labor cost is a relatively low part of total cost, the importance of having a motivated, well-trained labor force generally outweighs the pure cost element. In the electronics industry which is generally regarded as being relatively skill-intensive, the lack of sufficient technical manpower is always a constraint on development. Indeed, Hoffman (1986) claims that "for many developing countries, the accumulation of a critical mass of skilled manpower will be the means of overcoming the key barrier to entry" in the electronics industry. Furthermore, as also pointed out by Hoffman (1986), the fact that the initial acquisition of skills in the high levels of electronics manpower requires a somewhat higher formal education component than in other sectors makes the role of training institutes and universities even more critical.

The importance of human capital development has been increasingly recognized as firms realize the potential improvements that can be made as a result of worker's suggestions and active participation in the process of technological capability accumulation. The increasing levels of competition for technical electronics manpower have intensified in recent years as a result of the upsurge of investment in the sector as discussed in chapter 1, and this in turn has heightened interest in developing more effective training programs to replace pirated technical staff. In many companies, growth itself has put considerable strains on existing in-house training facilities.

Particularly for lower level workers, the main part of the training process is carried out on the job. In some cases, firms provided an orientation session which ranged from little more than a technology pep talk for a day or two to intensive two-week sessions that provided workers with a comprehensive overview of the technology and product concerned and practical experience with a number of the processes with which the worker will be involved.

As expected, such programs tended to be most comprehensive in foreign firms, but also in newer firms as well. Commu3, for example, had developed a modern training package involving state-of-the-art methods and materials. They transferred to Thailand via a professional Thai trainer who had received instruction in Singapore.

Compo6 also had developed a comprehensive training program for new operators although they admitted that the program had been modified somewhat to process the huge additional throughput of operators that they required as the factory expanded rapidly. Compo9 in fact reported that their rapid expansion had resulted in significant lowering of operator standards and discipline due to inadequate training facilities. They were consequently in the process of improving their facilities, lengthening the initial training period, and requiring all operators to periodically take refresher courses.

At the engineering and management level in foreign-invested firms, the most common form of training involved short to medium term assignments to the parent company or other subsidiaries. In certain cases, these programs had developed significantly over time to the extent that the Thai engineers were in fact receiving training of a very high level. Compo4 has established a technology transfer/cross-training program that enables Thai engineers from the assembly plant to trade places with American engineers from the R&D and technical development sections in the United States for a period of time. Hardware4 has set up a comprehensive professional development program which enables the Thai engineers and management staff to meet and interact with other personnel from their factories around the world, thereby meeting many of the crucial players and obtaining insights about future trends. Few Thai firms were able to establish or afford training programs that even approach those of the large foreign multinationals.

Perhaps the most extensive training program that was encountered was that of the giant Compo1 group which had sent over 4,500 Thai employees, including mostly workers but quite a few engineers as well, to train overseas, mainly in Japan and to a lesser extent Singapore. The training periods, even for basic operators, were normally at least one year with some engineers being sent for more than two years. In addition to extensive practical experience on the production process, the workers apparently received considerable training in the Japanese language as well as exposure to the Japanese way of life (and loyalty to the company). As a result of these massive training activities at all levels of staff, Compol has been the source of supply of engineering staff for many other companies. It is not easy to evaluate the net effect of their training exercise, although several other companies felt that it was quite effective.

Linkages with educational institutions and outside training institutes

The large majority of the firms surveyed, both Thai and foreign, had little formal contact with any of the engineering programs at local universities. Indeed, many of the firms visited expressed considerable interest in beginning to form more concrete relationships, beginning with the project engineer in the interview team. Several of the larger companies such as Compo6, had actually made recruiting tours of the various campuses but most relied on word of mouth or newspaper advertisements. The worsening of the electronic engineer shortage was mentioned by many firms who reported increasing incidences of poaching and remarkably low response rates to classified advertising.

Partly as a result of these shortages and partly as a result of contacts made during the course of the present project, a number of foreign owned electronics companies have joined together with the King Mongkut Institute of Technology at Lad Krabang (KMITL) to establish special evening courses to provide advanced training for their technicians. It is hoped by the companies that this program will enable them at the same time to obtain better qualified staff and to provide their existing staff with an incentive not to leave to other companies. In fact, one of the original motivations by the American manager of the company was a desire to provide his Thai technicians with the opportunity to move ahead in an environment (run principally by Thais) that made it very difficult for technicians to advance without formal engineering qualifications. KMITL hopes to be able to access to some of the near state-of-the-art semi-conductor technology that these companies are using (although not creating - which is reserved for their R&D laboratories in the United States) as well as the possibilities for their students to obtain practical training experiences in the various factories.

Although this type of initiative is only just beginning, such far-sighted behavior on the part of the companies and the educational institute concerned should greatly contribute to the development of human capital in the electronics industry. Similar joint programs between foreign firms and educational institutions have proved very successful in Singapore. In addition to the provision of better training to the staff of the foreign firms concerned, the program also has an externality element in that Thai students at the educational institute will also benefit by gaining first-hand production experience and even a glance at the cutting edge of the respective technology (foreign firm permitting).

At the present time, the links between electronics firms and other types of technical and/or management training centers appear to be very weak. This seemed to result partly from a lack of knowledge about such programs and partly from the perception that they were not very useful or practical.

Pre-production training

One important aspect of human resource development which often facilitated the initial establishment of the plant as well as subsequent operation was the practice of pre-production training. As in the case of traditional post-production training, such training appeared to be inversely related to the foreign shareholding in the company which in turn was correlated with the ability and willingness of the technology supplier to allow the workers to enter their factories.

Local firms very rarely provided or allowed for any form of pre-production training, counting on either hiring experienced staff or letting young, inexperienced staff learn on-the-job as the company itself grew. Joint-venture firms did allow for higher levels of pre-production training although not to a very great extent. Compo10, Compo5, and Consume1 for example, sent one or two engineers to Japan in order to familiarize themselves with the technology in a Japanese factory before commencing production in Thailand. The length of such training ranged from one to three months.

Wholly-owned foreign firms generally provided much more carefully for pre-production training, although the training that was provided was normally restricted only to that which would be necessary for the production process in the Thai plant and no more. The Compo1 group, in addition to their extensive post-production training program, has a practice to establish a pilot plant in Japan before building the factory in Thailand. This plant is principally used to develop the technology to the production level but also serves the subsidiary purpose of providing a training ground for the engineers and technicians that will be setting up and working in the Thai plant. Prior to setting up its microwave oven factory, Consume5 sent a number of engineers and technicians to Japan to intensively study the production process so that they could return to Thailand and form the core of a training group to train production operators and technicians.

Employee spill overs

One of the main channels in which foreign investment may contribute to the development of indigenous technological capability is through the migration of technical manpower from foreign to local firms.

At the operator level, the relatively better working conditions and salaries at the foreign firms combined with the relative abundance of such labor means that turnover rates are very low and such migration insignificant. At the engineer and technician level on the other hand, many firms reported that they experienced very high turnover rates approaching 30-40 percent in some cases. However, given the increasing domination of foreign firms in almost all sectors of the electronics industry, the vast majority of such flows were from one foreign company to another. Indeed, Compo6 was mentioned as a very popular destination for Thai engineers from other American and Japanese (especially Compo1) companies.

The notable exception to the rule is the case of Compo7 which acquired a large number of experienced technical staff from the established integrated circuits companies, paying a considerable premium in the process. In fact, the spill over process even extended to the operator training level in that one of the trainers that had worked at one of the large integrated circuits companies had transferred to Compo7 and essentially modeled their training program on the one developed in the foreign firm.

However, with the exception of a few small companies producing some tooling for the integrated circuit industry, there were very few examples of Thai engineers leaving the established foreign factories to set up their own companies. This is in contrast to the situation in Taiwan and in Singapore where such leakages from foreign firms occur at a remarkably rapid rate following the establishment of the foreign subsidiary. A concrete case in hand is that of Commu3 which, as mentioned earlier, was founded by a number of young engineers who left AT&T/Bell Labs in Singapore. Perhaps the development of more possibilities for supporting industries and subcontracting linkages will stimulate this type of initiative to become more common in Thailand.

4.5 Managerial Capability, Entrepreneurial Attitude, and Business Strategy

In some sense, within the limitations of the economic and infrastructural environment, the extent to which firms acquire the various productive technological capabilities discussed above depends very much on the ability of the management staff to evaluate and address the needs of the company at any point in time. The success or failure of the firm in the market place will crucially depend on the ability of the entrepreneur or management staff to make judgements regarding the appropriate levels of investment in acquiring technological capabilities and absorbing new technologies. It is very difficult to identify generalizable and meaningful patterns of what influences the entrepreneurial and technological strategy of the firm and what determines success or failure. In most cases, the main question seemed to be one of how to make a good entrepreneur function more effectively. In other words, how to create an environment that will enable Thai entrepreneurs to function effectively, to absorb the technology from abroad, and to take steps to develop domestic technology where technologically and economically feasible.

Given the present foreign-dominated ownership of the electronics industry in Thailand, the issue of managerial capability and attitude largely revolves around the benefits provided by these firms in terms of: (a) the direct effects on employment, the balance of payments, and government revenue: and (b) the indirect spill over benefits in terms of technology transfer and human resource development.

The worrying nature of the problem is highlighted in a recent study carried out by the Nihon Keizai Shimbun and reported in Tradescope (1988). The study examines the extent to which production of a large number of products in Korea, Taiwan, Hong Kong, Singapore, China, Malaysia, and Thailand compared in quality and price with corresponding Japanese products. Each country was scored on a scale of one to five (with five representing "comprehensively superior to Japanese products" and one representing "will become equal to Japanese products in more than a decade") and the contribution of foreign equity was assessed. An important conclusion was the following: "The scores show that there is little difference between the products of locally based firms, and those with foreign affiliates in Korea, Taiwan, and Hong Kong, indicating that manufacturers in these so-called "model NIEs" (newly industrializing economies) have improved their production capabilities. On the other hand a large gap was found in the quality of products made by local firms and those made by foreign-affiliated firms in Singapore, Malaysia and Thailand." It should be added that the latter three countries were also characterized by much higher levels of direct foreign involvement than the former three.

The results of the study reported in Tradescope (1988) conform very closely to those of the present study. Very few of the major initiatives in the electronics industry actually resulted from Thai entrepreneurs, many of whom exhibited a rather stagnant approach to technology issues. In addition to improving the effectiveness with which information on successful firms is spread around, efforts should be stepped up to promote the effectiveness with which the existing foreign firms transfer the management skills and capabilities that they possess to Thais, either directly to in-house staff or indirectly to subcontractors. It is interesting to note that American firms seem to be generally much more progressive on both of these fronts than the Japanese ones. Compo6, for example, has reduced the number of expatriate managers remarkably quickly and, as mentioned above, have made considerable efforts to develop subcontracting links.

However, the technological inadequacy of local Singaporean firms cited above leads one to believe that efforts to maximize the spill overs from foreign firms alone may not generate the rapid development of technological capabilities and that other channels need to be developed, following to some extent the lessons that can be learned from Taiwan and Korea. The question of the overall strategy that should be adopted in order both to maximize the contribution of existing and future foreign investors as well as ensuring the development of a "dynamic" among local Thai entrepreneurs poses an as yet unresolved dilemma.

CHAPTER 5

THE FUTURE INDUSTRIES, TECHNOLOGIES AND CAPABILITIES

5.1 Future Scenarios

The electronics and information based industries are the prime mover that will push us into the Information Age and present quite different environments for human beings from the ones presently faced.

5.1.1 The Home Environment

Consumer electronics began to play an important part in home life since the first radio broadcast in 1923. This brought entertainment, news, and educational services into million of homes. Then, in 1939, the television came in. Needless to say, the impact of the visual picture is far greater than that of sound alone. Television literally forces members of family to spend hours in front of it, but it also provides a very powerful communication tool unavailable before. Today, radio and television broadcasting retains a strong influence in homes but there are other ways to obtain the audio and video programs. Record players and audio tape recorders gave us the freedom of programming and, if budget permits, a better quality sound. Video tape recorder is a good substitute for dull television programs. Other consumer products are electronics games, home video camera, home computer, home control, home education systems. In the near future, one can certainly imagine many new ways to stimulate our audio and visual sensory organs. We do not have to wait too long to use robots for many of the household chores. The one that will have more impact on our immediate future life style is the home computer.

We have used the home computer for recreation and hobbies. As it becomes more powerful in hardware and more intelligent in software, it is a really useful tool for working at home. The impact will be really felt when the home computer is connected by telephone lines to networks of computers and databases. One can shop, bank, mail and work from the home terminal.

5.1.2 The Office Environment

Electronics came late to the office. Not too long ago the office was strictly non-electronic as the typewriter, the telephone even the copying machine were mechanical or electromechanical. The computer was isolated in its own room. It was estimated that from 1950 to 1980 businesses spent only about US$ 2,000 for each employees and achieved a mere 4 percent gain in productivity.

With the advent of ICs and microprocessors, the office environment has begun to change. Word processing and data processing are being used on-line. Facsimile machines are becoming cheaper and faster. There are talks about office automation, office of the future, electronic office and paper less office. Although the office of the future is likely to be a less paper office than a paper less one, office automation promises us a better working office environment where tedious and repetitive work will be greatly reduced to enhance the creativity of individuals.

One can imagine the office of the future to be a clean, cool and quiet place with rather simple furniture. There is an integrated terminal (voice and data) on every desk. The terminals are connected to share common data processing and storage and to worldwide network for communication of data, text, image and voice. The use of computer will demand less manual skills with modern tools like mouse and tablet. With voice and image recognition, the typing can almost be eliminated. The secretary will perform administrative task and the mail room clerk will become involved in data storage and retrieval. The manager will have all the facts and figures presented in comprehensible forms for decision making and confer with other businessmen across the world via tele-conferencing.

5.1.3 The Industrial Environment

In a way, the change in the industrial environment due to the impact of information age will be less dramatic than the office. Industrialists from the 1950 to 1980 invested a yearly average of US$ 20,000 per blue-collar worker in the form of tools and support systems and realized a 95 percent improvement in individual output.

Electronics came into the factories a long time ago since the age of vacuum tubes. High-power vacuum tubes as well as gas filled tubes converted alternating current into direct current or vice-versa. The control was done by electromechanical devices such as relays and magnetic contacts until solid-state electronic circuit, can with stand the industrial environment which is dusty, hot, humid and vibrative.

At present there are two forms of electronics in the factory: one is power electronics. and the other is electronics control and instrumentation. Solid state power devices such as power diodes, power transistors and power thyristors have replaced all the vacuum tube counterparts and are more efficient and versatile in power conversion and variable-speed motor drive. In control, electronics has replaced all the electromechanical devices. Only the pneumatic system has some advantages in certain limited applications. In instrumentation, there are more and more electronic sensors. The displays are almost totally electronic. Analog electronic feedback control loops cannot compete with real time direct digital control in accuracy and flexibility.

Computers are being used at several levels. General purpose computers are used for indirect production functions such as inventory control, production data acquisition and control, production planning and production costing. Dedicated computers are used in specific jobs such as computer-aided design (CAD) and computer-aided manufacturing (CAM) including control of robots in direct production functions. Computer-integrated manufacturing (CIM) employs computers to integrate all the above mentioned tasks.

Some of us probably have seen unmanned factory or factory with very few workers on the production line. Automatic machines and robots do the processing and the assembling. Automatic trolleys running on guided paths deliver raw materials and put products into the stored room. What is not usually seen is a large pool of engineers and technicians that adjust, maintain and repair those machines. In some operations, a robot has already exceeded the productivity of a worker. But there are other operations that robots still lag far behind. Robots will certainly improve in the future in terms of speed, accuracy, power as well as intelligence. The future factory probably does not look too much different from the description at the beginning of this chapter. The requirement for human being will always be there. The same factory will be capable of producing a large number of identical products as well as a small number of different products with little loss in productivity.

Just a final reminder, the future factory described above needs not be an electronic manufacturing factory. It can be any factory at all.

5.2 Future Industries

5.2.1 Consumer Electronics

Traditionally, consumer electronics products are audio and video equipment for home use and personal product. For audio, we already see compact digital audio disk (CD) and the coming up digital audio tape (DAT). The product that has not come out of the laboratory is the switching amplifier for higher efficiency. Perhaps the development of the video side is more visible, television will have wider aspect ratio screens: about 5:3 over today's 4:3. Resolution will be higher. The high-definition television (HDTV) should be nearly ready for consumer introduction by the year 2000. Meanwhile, higher quality picture will come from video cassette recorders with Super VHS or extended definition Beta (ED Beta) or from laser video disks. Laser disk now has incorporated interactive technology which carries video, text and audio. Potential uses are a shopper catalog, a map for planning trips, a travelogue and educational programming of all kinds. Other video equipment for home are home video camera (camcorder) and home satellite receiving stations. Personal products includes calculators electronic musical instruments and equipment, microwave ovens, telephone answering devices and video games.

A new area of consumer electronics is home appliances which used to be electrical but now all have electronic controls. These appliances can become "robots" by using artificial intelligence. These will involve voice and image recognition plus adaptive signal processing.

Perhaps the biggest payoff to consumers will be individualization of product and services without the loss of the cost benefits of mass production. With flexible manufacturing systems (FMS), small production runs or even single run will be economically feasible for personalized shoes and clothes, made-to-fit furniture as well as other tailored services and information.

5.2.2 Communications Equipment

The future of communication equipment industry will move towards the integrated services digital network (ISDN) which will allow the transmission of voice, data, text and images over the same lines. Several leading telecommunication companies and organizations in US., Japan and Europe (ie. NTT of Japan, British Telecom, PTT of France, Deutche Bundespost of Germany, AT&T and GTE of U.S.) are now developing their industry along this new concept of ISDN. Nippon Telegraph of Telephone Corp. (NTT) of Japan for example has already introduced Information Network System (INS), which is more or less similar to ISDN, in 1984 and now in the process of testing to verify the system's technical feasibility and evaluate its market projects. The future ISDN communication equipments will include, for example, digital telephones phones and terminals, digital switches, broadband transmission systems, and satellite, radio, and fiber-optic systems. Some example of services provided by the terminal equipments are telephone, facsimile, videophone, video-conference, electronic mail.

The satellite industry will move towards producing small, highly flexible, modestly powered earth stations. The dishes at the stations will enable packet data communications networks. They can provide one-way and two-way services such as chain department store billing and inventory, data collection from remote areas.

Cellular radio will replace the older mobile telephone system It is expected that by 1990, there will probably be a link between these cellular radio system with the satellite.

5.2.3 Computer Hardware

The computer industry has seen the mainframe computer make its debut in the mid-1950s, minicomputer in the mid-1960s, and personal computers in 1975. Among these three types of computer industries, it is well-accepted that the personal microcomputer has been making the largest impact on our society since the first introduction of the Apple II machine in 1977. The decision of IBM to enter the personal computer market with the IBM PC in 1981, IBM XT in 1983 and IBM AT in 1984 has created not only a big market for IBM itself but generated other industries in IBM-clone machines and IBM-based software.

The hardware architecture of a personal computer has always been centered around a microprocessor, which is a microchip, acting as its central processing unit. Starting from an 8-bit performance, these chips have been rapidly developed into the higher performances in the forms of 16-bit and 32-bit chips. There are many manufacturers of these microprocessor chips but the products of Intel and Motorola are probably the most popular choices among the designers and manufacturers of the personal computers. The IBM and IBM-clone machines have been developed basing on the INTEL 's 8088, 8086 and 80X86 microprocessor chips, while the other group of machines consisting mainly of Apple 's Mac II, Commodore 's Amiga and the engineering work stations (e.g. SUN, APOLLO, HP-9000) has chosen the Motorola 's 68XXX chips.

The future of the hardware industry of personal computers will still see the development trends in these two lines of products. The processing speed will be faster with the 32-bit microprocessor working together with its coprocessor. The speed will be greater than one million-instruction per second. The available direct-access memory will increase from the 640 Kbyte now into the gigabyte region. The monitor will have higher graphics capabilities. The disk storage will move towards the gigabyte capacity using both magnetic and optical technology.

These will see the future market growth of the personal computers not only in its existing office and home markets but also in the engineering and scientific applications. The future personal computer will be even more user friendly in the sense that it will communicate with the user in human voice, human natural language and human hand-writing.

It is probably worth mentioning that the hardware personal computer industry come from almost all the Pacific basin country: Japan, South Korea, Thailand, Malaysia, Mexico, Singapore, Taiwan, and the Philippines. Since some countries tend to specialize in one kind of component or another, a hypothetical personal computer could be assembled in the United States from a U.S.-built center processor. Japanese disk drives, Korean monitor, Taiwanese main circuit board and case, and integrated circuits from Thailand. The future will see this international flows of this industry with shifting in locations depending on for example the policy of these countries. (Spectrum May 1986) The BOI policy of Thailand at the present time already see the export-oriented computer hardware industry in disk drives, keyboards, integrated circuits, monitors and terminal, printed circuit boards, connectors and wires. It is remained to be seen if an assembled personal computer industry will be possible in this country.

5.2.4 Industrial Electronics Equipment

The future products in industrial environments will see both computerized equipments and systems. Such products, which are aiming at increasing the productivity, are for example PLC (programmable logic controller), robots, vision systems, industrial computers, local-area network with Manufacturing Automation Product (MAP), product identification equipments etc. The products will be more of an integration between the mechanics and electronics which are probably known as "mechatronics".

After finding such application in the sequential control, the programmable logic controller products will emphasize on miniaturization, ease of linkage to other controllers for factory automation, and flexibility. Robots will find more markets in electronic assembly, automotive and machine tool industries. A recent forecast, for example, put the potential for the U.S. vision market in 1990 at around $460 million. (spectrum Jan 1987). The market for this vision products will be in the inspection of components, labels, and parts in electronic assembly. The images-taken by a vision unit will be processed by either the built-in image processing chips or a separate computer. The processing of images, as well as other data vital for manufacturing, demands increased use of new computers on the production floor. This kind of computers is known as industrial computers which are designed to withstand unfavorable conditions e.g. without air conditioning. The LAN (local-area networks) will be another future industrial electronics product. It will connect the programmable controllers and other data processing systems of key importance for manufacturing automation. The protocol for example MAP will also be adopted in this LAN. Pneumatic sensors, magnetic sensors, laser-based scanner, surface acoustic-wave sensors are also some example of the industrial electronics products. Finally, the computer-aide design (CAD), computer-aide engineering (CAE) and computer-aided design manufacturing (CAM) will find larger market in the manufacturing industry.

5.2.5 Electronic Components

In our discussion of the future industries for electronics components, we will categorize them into two major groups, namely supportive industries and new industries.

Supportive industries are those industries that form an important base for supporting existing electronics components manufactures which have bright future prospect and are considered to suit the country's comparative advantages.

New industries are those industries which still are not available in the country, but are considered to have beneficial linkages - technologically and industrially with the countries' existing firms.

In the following discussion, integrated circuit industry will be used as a core case in our examination of the future industries. Reasons for this are two fold. Firstly, it is because production values of integrated circuits forms the biggest share in total electronics components production values, both internationally and domestically, and the trend is that this share will increase overtime. Secondly, it is because, technological development in integrated circuit production has far reaching effects which in most case, influence development of other electronics components.

a) Supportive industries. According to our survey, there are at least three small to medium size firms producing die punches and precision jigs and fixtures supplying the existing IC industries. This sort of engineering firms constitute an important core for accumulation of high precision and automation technology. That is because this sort of production tools supplied to the IC industries have to be very precise. In most cases precision in the level of microns is required. Furthermore, production equipments used are essentially automated and therefore provide the firms with good access to this technology. Starting from this point, and with properly planned promotion, these firms could grow into engineering firms with sophisticated technology supporting the IC industries and other electronics components industries.

There are many other IC related production tools and equipments that could be localized. For example, auto stamping machines, auto die-attach machines, auto chips loader etc.

b) New industries. At least two important trends in IC industries should be noted. The first is that the industries is rapidly moving towards a clearer division of labour. Fewer firms could be able to operate a complete production line starting from raw material purification through devices design up to packaging and testing. Firms have to concentrate more to a particular process in the whole production line so as to establish their own competitive edges. In this evolving process, there exist areas where barrier of entry is relatively low for the new comers.

The second trend is the rapid growing demand for custom and semi-custom ICs. It is estimated that by the end of the year 2000, approximately 40% of the total IC will be semi-custom. These two conspicuous trends lead to a new possibility for the newcomer. A prospective industry which does not require intensive investment and at the same time can benefit from the country's well-trained engineers is VLSI design industry.

5.2.6 Computer Software

Since the first appearance of the mainframe computer in the mid-1950s until now, the software industry has developed into various aspect for example from batch-oriented processing towards the on line transaction processing, from centralized processing products in a main-frame towards the distributed products in personal computers. The birth of the personal computer has initiated and created several software products and software companies for example BASIC language by Altair in 1975, CP/M operating system by Digital Research in 1976, Word Star by Micro Pro International in 1979, MS-DOS operating system by Microsoft in 1981, Lotus 1-2-3 by Lotus Corporation, Dbase III by Ashton-Tate in 1984 etc.

The future microcomputer software industry may be divided roughly into three main lines of development. The first product group has been developed around the MS-DOS operating system which is adopted by IBM and IBM-clone machine. The second group will be developed around the UNIX operating system which now found in the engineering work station e.g. SUN, APOLLO and HP-9000. The third group is more of a proprietary operating software e.g. Mac II of Apple Computer Inc., Amiga of Commodore and Atan.

The future software industry will also see more and more of intelligent software products. The so-called user-friendly software using menus , windows and graphics will become more human-oriented products. The users will in the future be able to instruct the computer through the natural language. The software products which are now available to translate texts between, for example, English and German will be able to translate between any two languages. A human being can consult a computer which is acting as an expert in various professional fields. This is made possible through the new artificial intelligent software products The fore-runners of these software products are LISP and PROLOG languages and expert shell in personal computers.

The software products in Thailand for local market will have to take the Thai language into account. The one-byte Thai character codes will be developed into the two-byte ones. Thai voice, Thai hand-written recognition, Thai natural language processing are also new areas of software industry for the local markets. (NB However, one must not forget to take into account the effects of the copy right law which is yet to be reinforced in this country.)

The future industry in Thailand will also see more foreign-owned company which manufacture both general and customized packages in Thailand for markets in Europe and Japan. This kind of companies will have the leverage in the low cost of software development in Thailand and the high price of software products in Europe and Japan.

5.3 Future Technology

5.3.1 Consumer Electronics

At the beginning of the electronic age, the vacuum tube is the key component that performs all kinds of electrical signal processing, for example, amplification at audio and radio frequencies, modulation of audio signals onto radio signals and demodulation of audio signals from the modulated radio signals. The solid-state transistors reduce the size and power requirement of a radio. They substitute but not change the function of vacuum tubes in radios which are analog signal processing. The same holds true for television. With the exception of the picture tube, technologies of television circuits, though more complicated is the same as those of radios. It can be generally concluded that the key electronic technologies for radio and television are firstly, active components which have evolved from vacuum tubes to transistors to integrated circuits (IC) and secondly, circuit technologies such as amplification, modulation and demodulation. Record players audio and video tape recorders use essentially the same electronic technologies.

It is not until the advent of microprocessors in 1970's that digital electronic technologies began to invade consumer electronics It came in three forms:

1. Peripheral features of the equipment. Programmability is created by adding a versatile digital timer to existing equipment mainly to control the on and off time. This is found in video tape recorder, microwave even, washing machine and rice cooker.

2. New products. Advancement of digital and IC technologies creates these products. The astronomical decline in their prices pushes them into homes. Examples are electronic

calculators, digital watches, electronics games, home video cameras and home computers.

3. Digital technologies for signal processing. Analog technologies have consistently improved the performance of consumer equipment can produce acoustic signals with the spectrum wider than the perception range of the ear and with very high signal-to-noise ratio. Stereophonic technique simulates the orchestral effect. Television screens now have Colorado pictures with ever improving quality. But we are not satisfied with that. Because noise, no matter how small, always exists in the system. We want to reduce noise further and digital technologies give us the flexibility to do so by trading large storage capacity and fast processing for better quality signal. This technology is being used for audio compact disk (CD), digital audio tape (DAT) and compact video disk (CD-V). More digital signal processing will be employed in the upcoming digital television.

Therefore, it is expected that the dominant future technology for consumer electronics will be digital semiconductor technology. We will see larger and cheaper memory chips and faster digital signal processing chips. Another area is the mass data storage in either optical or magnetic media. Consumer products will also benefits from computer technology and the application of artificial intelligence.

5.3.2 Communications Equipment

The ISDN communication system will be based upon the future of the following technology e.g. electronics, technology, optical technology and digital technology.

The electronics technology has generated devices such as transistors (in 1950), integrated circuits (in 1960), microprocessor and semiconductor memory (in 1970-80). These devices have in tern been used to develop the communication equipments and systems such as terminals, switching equipments, transmitter and receivers, satellite etc.

The optical technology will see the optical fiber replacing the copper cable especially in the large volume of transmission. The semi-conductor laser technology will play an important role as the devices for transmitting-receiving the light wave through the optical fiber.

The digital technology will responsible for the processing of signal e.g. signal modulation, channel filtering, signal modulation, and detection.

5.3.3 Computer Hardware

The future computer hardware technology will enhance the following basic features ; faster processing speed, higher addressable memory, larger density and faster access in disk storage, higher resolution graphics monitor and flatter screen monitors, faster printer with flexible character fonts and graphics, intelligent man-machine interface e.g. voice, natural language, handwriting, and communication between computer.

Scientists and engineers have always expected the speed performance of their computers to increase by an order of magnitude about every five years. However, the supercomputer built around a single processing unit - the CRAY-1, the NEC SX-2, the Fujitsu VP200 - may already be within an order of magnitude of their technological limit. This theoretical upper boundary, some 3 gigaflops (billions of floating - point operations per second) is established by the length of time it takes electrical signal to propagate, traveling through the wires at about half the speed of light. To overcome this problem, a new computer structure known as the parallel architecture is seen as one of the alternative technologies. Such a computer will have many processors working in parallel to share the work load. This parallel architecture may be constructed not only in one dimension but also in two, three, or in fact n-dimensions which are known as the hypercube machines. This hypercube machine has already been experimented and already shown to execute billions of operations a second. One interesting point about this hypercube is that each processor is in fact may be the available low-cost 32-bit microprocessors. Although it needs further development especially in working together with its software, some of these hypercube machines are already testing the market (Spectrum June 1987).

On the microcomputer products, the immediate technology which will make it speed faster and addressable memory higher lie in the 32-bit microprocessor technology. The emerging RISC (reduced-instruction-set-computer) chips has already demonstrated the faster MIPS (million instruction per second) rate. The new megachip RAM will also be available to reduce space on the main board while increase the capacity of memory. With regard to reducing the main board space, the "glue" chips e.g. those apart from the microprocessor and RAM/ROM chips will be reduce into a single chip known as an ASIC (application specific integrated circuit) chip. This ASIC technology is also seen as a technology to discourage any attempt to imitate the product.

The optical technology especially laser will replace the magnetic technology in the disk products. It will provide faster access, larger density, quiet operation and also no-mechanical contact. This same technology will also replace the mechanical mechanism in the printer products. Apart from a quiet and non-mechanical contact operation, the laser printers are faster and versatile in the sense that both character and graphics can be printed in any forms.

Borrowing from biology, neural networks are seen as a promising new information processing technique for pattern recognition for example voice recognition, image reconciling, hand-written character reader, spoken-language translator (Spectrum March 1987). The hardware technology that supports neural networks is in fact the aforementioned parallel processors.

The LAN (local area network) which links microcomputers and peripherals together still has many features to be improved. It is involved not only the data communication technology but also the industrial protocol standards that have to be settled down before the products can attract more markets.

Finally, the present monitor industry, which is mainly based on the cathode ray tube technology will see the additional technology in liquid crystal display (LCD) and plasma display for the flat screen monitor products.

5.3.4 Industrial Electronics Equipment

In a similar trend as other products, the future industrial electronics equipments and systems will be based on the technology of microprocessors and microcomputers. A good example is the microprocessor technology in the programmable logic controllers. The technology of digital signal processing e.g. image processing chips will play an important role in the vision systems. The technology of charge-coupled device (CCD) will enhance the performance of the camera unit of the vision systems. The artificial intelligence technology e.g. the knowledge representation will be used to understand an image (spectrum January 1987).

An important future technology in industrial environments is the flexible manufacturing system (FMS) which is a group of advanced devices, such as industrial robots, numerical controlled (NC) machine tools, machining centers, automatic measuring instruments, and unmanned transport vehicles, integrated under computer control. A factory employing such a system is termed as a flexible manufacturing facility, and is one step towards the completely automatic factory of the future.

(Mechatronics the Policy Ramifications, Asian Productivity Organization Tokyo 1985).

5.3.5 Electronic Components Technologies

Three important technologies are crucial key for successful development of the previously discussed industries. They are: high precision technology, photolithographic technology and VLSI design technology. We will briefly discuss these technologies as follows.

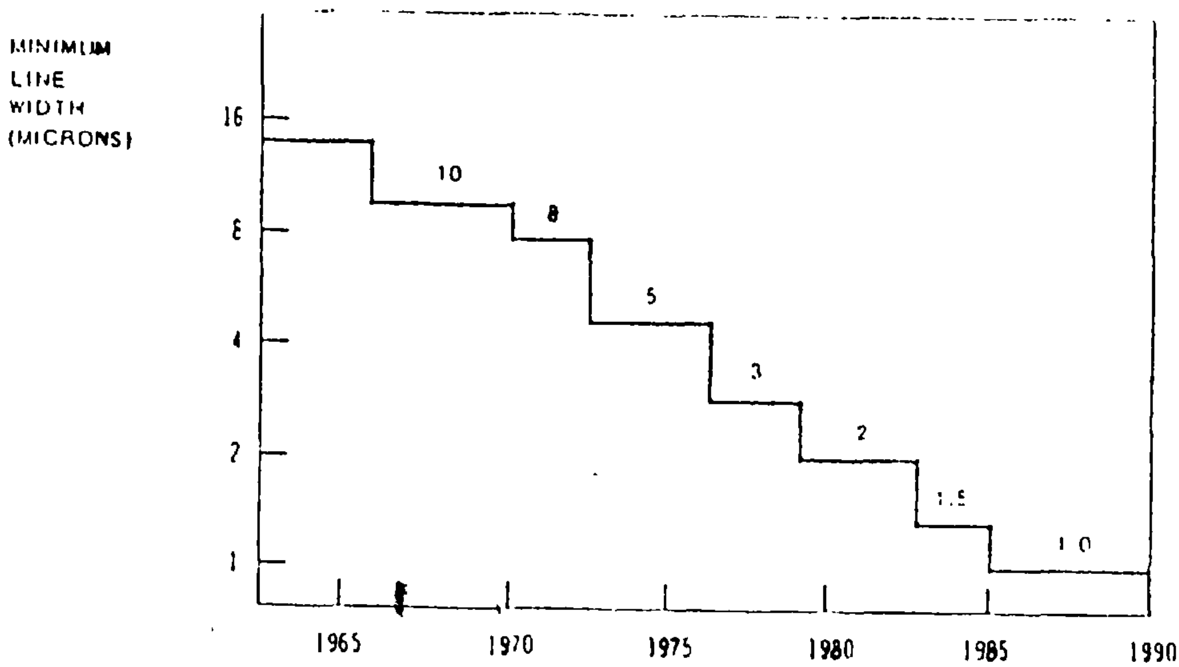
a) High Precision Technology. This technology is a body of knowledge comprising disciplines ranging from material preparation, high precision measurement to high precision material processing etc. The technology forms an important groundwork upon which IC technologies have been developing

An imminent trend of IC technology is rapid increase of components integration. Presently, VLSI chip would contain more than 100,000 components compared to about 100 components when the IC first made its debut. The trend essentially lead to decreasing line width as shown in figure 5.1. This development of IC technologies eventually effects other related electronics components, for example, printed circuit board, resistor, capacitor, interface cord etc.

From this fact, it is clear that the high precision technology will not only sense as supportive technology for IC industries but also for other related electronics components as well.

Figure 5.1

Decresing trend of IC's / minimum line width over the past decades.



Source : Semiconductor Industry OECO,1985.

b) Photolithographic technology. Basically this technology can be defined as a part of high precision technology. But it deserves to be discussed separately. The technology constitutes a core technology for wafer processing, and print and etch processes in IC and PCB production respectively. On top of that, there are many applications of the technology in the production of other precision parts. Some important parts are IC lead frame, small resistor slider, springs for super micro-switches, magnetic head cores, headphones electrode, shadow mask for color CRT etc.

A basic flow chart of this technology is shown in figure 5.2.

Figure 5.2

Basic Flow Chart of Photolithographic Technology

Pattern Drafting	Pattern is drawn at the designated degree of magnification. Accuracy or less than + 10 microns is common
↓	
Precision Reduction Camera	Original pattern is reduced by a precision reduction camera
↓	
Multiple printer	Multiple printer is used to mass produce the patterns used in photo -etching
↓	
Coating Printing	A photosensitive resin is coated onto a metal surface
↓	
Developing	After exposure of the metal plate it passes on to the developing process
↓	
Etching	The surface of the exposed metallic material is etched
↓	
Inspection	The finished product is inspected

c) <u>VLSI Design Technology</u>. A series of courses in integrated circuit design using computers introduced by Carver Mead and Lynn Conway (Mead 1980) to students at Caltech in 1976 and MIT in 1978 has led to a new concept of VLSI design industry. At present it is widely practiced in the industrialized and newly industrialized countries. A VLSI designer now does not have to belong to any wafer fabrication house. With the available power of a computer known as an engineering work station together with its appropriate software packages, the designer is able to design both semi-custom and full-custom VLSI. The design patterns recorded in a magnetic tape are then dispatched for fabrication. The design firms and the fabrication factories are therefore separately from one another. A design firm in Taiwan may send its design pattern to foundry in the Silicon Valley in USA, Europe or Japan as the case may be. A developing country like Thailand should find no problem in entering into this type of industry as it does not require the large investment as in the case of wafer fabrication factory. The needs are mainly in trained engineers and the appropriate VLSI-CAD tools which are now available would wide. The existing electronics and computer industries in Thailand can use this kind of technology to miniaturize their circuits. Hence, the increase in production reliability and the reduction in cost per unit. In fact, some activities in this VLSI design have already been imitated by NECTEC in cooperation with the government universities. However, a kind of promotional scheme is probably needed to accelerate its contribution towards industry.

5.3.6 <u>Computer Software</u>

The AI (artificial intelligence) is seen as the future technology for software industry. A computer has so far been presented as a dumb machine which is programmed to process the data stored in its memory. The AI technology will however turn the computer into a knowledgeable machine which, together with the stored knowledges in its memory will be able to do inference and cognitive jobs. The expert-system software products and the machine translation products now available in certain markets are cited as samples resulted from these AI technology.

The technology for the development of zero-defect software products is still being search for (Spectrum March 1966). It is expected that the on-going research using AI concepts will eventually lead to an automatic program generating machine. The quality of a software product in the immediate future will still have to depend on the software engineering methodology which is divided into the following steps: requirements analysis, specification, coding, integration and test, delivery and maintenance.

The technology of pattern recognition , speech processing, image processing will become more eminent in the future. The mathematical intensive software technology, for example the image reconstruction algorithm, will support the future products in medical imaging using X-ray and nuclear magnetic resonance effects. The technology of digital signal processing will see its debut in this kind of software industry.

Finally, it should be mentioned that industrial standard also play an important role along side the software technology. The communicable standard protocol e.g. OSI (open system interconnection) and the Thai standard on character codes are good example of this equally important factor in the software industry.

5.4 Future Capability

It is quite obvious that there are gaps between the future technology and the present levels of technology in Thailand. Eventually, most of us would like to see these gaps become narrower say in the next ten years through the concepts of acquisition, operation, adaptation and innovation. Various strategic methods and steps must be established to achieve the goals.

Thailand is now attracting many foreign investment through the BOI mechanisms. This is seen as a necessary and appropriate step to bring the technological activities within reach of the local people. The operation and acquisition can then take place. However through the survey one may notice this rather obvious gaps at the present time. Firstly, most industries are more of labor intensive nature or in another word very little involvement in future technology. Distinguished among these examples are the local integrated circuit assembly industries which have never developed themselves into the technological level of fabrication and design for more than ten years of operation in Thailand. Secondly, most foreign-owned companies have excellent acquisition and operation of technology in their own international network. However, the mechanisms of transferring this acquisitive and operative capabilities to trigger off any further chain of local industries have yet to be adopted. The gaps in adaptation are even wider and the innovation is virtually non-existent in the present local industry. The reasons are probably obvious that the present industry in Thailand is being promoted toward the competitive edge in labor cost, however it will not be long before the country will inevitably have to enter the "hi-tech value-added" steps.

Followings are some descriptions of the gaps between the present and future technology in the six areas of the electronics and information-based industry.

5.4.1 Consumer Electronics

The foreign-owned or joint-venture companies consumer electronics will be able to extend their products with any kind of future technology if they wish to do so. One large Thai-owned company in consumer electronics which did very well at the beginning find it difficult to compete in the market at the present time. One factor may be the inability to catch up with the state of the art of the world technology as mentioned earlier on.

5.4.2 Communications Equipment

A Thai-owned communication equipment has been found to be competitive and even innovative in some extents. However, it is noticed that the technology employed is mainly analog technology while the foreign companies are probably producing digital equipment already. The optical fiber which is vital for the future industry and in fact obviously needed by Thailand to expand the telecommunication services is non-existent. The local mobile telephone industry and technology are probably in a similar situation.

Another case of interest is that a newly-established company, which produce cordless telephone successfully for export, is looking for a local technology in the CAD for VLSI which is unfortunately not strong enough to response.

Considering as a major consumer of communication equipments which are badly needed for the country infrastructure, Thailand is still far behind in this aspect of technology and industry.

5.4.3 Computer Hardware

The computer peripheral industry in Thailand is growing very rapidly. Recently, it has been reported how a large promotional company find its success in manufacturing disk drive in Thailand. Other peripherals e.g. keyboards, monitors, printers, wires and connectors are also locally produced for export

From the survey, it has been found out that a few Thai firms are capable of following the microcomputer technology to the level that they can produce the main-board or even the complete systems by themselves. However, it is a major issue of discussions why the microcomputer assembly industry in Thailand does not grow.

Although, no Thai-owned firms can produce the peripherals equipment yet one should notice why a few Thai firms and some University researchers has been able to keep up with the main board technology. One good reason may be the low-cost availability of the imported 8-bit and 16-bit microcomputers locally.

Thailand is still a long way from the technology of the hardware super-mini and mainframe computer which however could be established once the microcomputer technology is more widespread locally.

5.4.4 Industrial Electronics Equipment

The technology of industrial electronics equipments in Thailand is rather primitive when one observes from the products which are for example power supplies, panel meters, potentiometers etc. Numerical control (NC) machines, computerized numerical control (CNC), robotics, programmable logic controller for example are still absent. The technology to support this kinds of industry are sensors, microprocessors, microcomputers, motors and motor controls, software, power electronics devices.

5.4.5 Electronic Components

The major issue which could probably be raised here again is that Thailand is still far behind in the integrated circuit technology which has been around in industrialized countries for three decades and recently taken up by the newly industrialized countries. It should be repeated here that one way of "leap-frogging" into this industry is to adopt the computer-aided-design (CAD) in the very large scale integrated circuit (VLSI). Although some University laboratories have just started in VLSI-CAD activities already, means should be found to accelerate them toward industrial applications. ASIC which is the major products of this technology is now booming in Taiwan.

It is also reminded here that after more than a decade of assembled integrated circuits industry, the country should carefully consider the benefits of entering the technology-intensive wafer fabrication industry.

5.4.6 Computer Software

Computer software is definitely the potential products of Thailand. However, this industry is still waiting to be promoted by the concerned organizations. The software technology in Thailand is mostly in the programming levels. The others which are still lagging behind are the development and maintenance technology e.g. methodology, development tools, managerial techniques. A few foreign-owned firms are establishing their "software factory" in Thailand and export these software products to Europe and Japan. If more of this industry could be promoted, then the local people can acquire not only the technological knowledges but also the skills in market and management.

It should also be reminded that software industry is human intensive, sufficient supply of trained software personnels are still the major drawbacks at the present time and the future to come.

Future capabilities to bridge the technology gaps will depend on several mechanisms which will be described in the next chapter.

5.5 Summary of Future Industry, Technology and Capability

5.5.1 Summary of Future Industry

Although we have already narrowed down the industry and technology of electronics and components into six aforementioned areas, it is probably necessary to be more specific as much as we especially for the next five and ten year in Thailand.

By observing the world wide statistics of the electronics and computer markets (1988 Edition Electronic Market Data Book), one could probably list out the products that are presently active and also have the tendency to be so during the next decade as in Table 5.1. For example, television products based on the conventional technology still captures the market but will eventually evolve into the newly arrived products based upon the new technology of high definition and digital televisions. The computer storage equipments will change from the magnetic type towards the optical type which have already proved to be more efficient as far as the capacity is concerned. The industrial equipments will definitely see more of automation products such as machine vision, robotics, CAD/CAM/CAE etc. Medical electronics and laser products will also playing a major role. The electronic components will still be in the area of electron tubes, solid state products and electronic parts. The CAD tools will spread out the ASIC (Application Specific Integrated Circuit) industry from the major wafer fabrication companies towards the smaller wafer companies. Before the arrival of the exciting superconductors, gallium arsenide will help speeding up the electron transport in integrated circuits.

The future industry of electronics and computer in Thailand during the next decade may also be derived from the survey of the existing firms and also those receiving the Board of Investment promotion. They are listed in the forms of products in Table 5.2. The main difference from the world industry are that at this stage Thailand still does not seem to have firms which will produce the world future products, namely very large scale integrated circuits (VLSI), optical fibers and optical products, major telecommunication equipments, microcomputers and larger computer, industrial automation equipments, high definition and digital television. These missing industries are seen as the significant ones if Thailand is willing to be among the world leading electronics and computer producers.

5.5.2 Summary of Future Technology

In chapter 3, we have already indicated that each individual products in the six groups of electronics and computer products may be categorized into six levels of production e.g. materials, components, circuit boards, equipment, systems, and software. It is also shown that the technology supporting these production levels may also be divided into two main areas the product design technology and the production technology (see Table 3.2, chapter 3). The product design technology includes mainly the electronics and computer technology while the production technology also includes mechanical, industrial, chemical, electrical technology.

The future technology for Thailand and in fact world wide will still be in these two main areas. However, the newly discovered technology will be embedded further into the product design and production to increase the added value and the productivity. As it is rather tedious to list technology for each products, only the outstanding common technology which will enhance the future products in Thailand in the next decade are summarized here and also listed in Table 5.3.

1) Materials and devices

The main materials will be silicon, gallium arsenide and superconductors which are the basis for the various electronics devices such as transistors, diodes, display devices etc.

2) Microelectronics and VLSIs

Integrated circuits technology may be divided into two major areas: the fabrication technology and the design technology. A country like Thailand can enter into the design quite readily as it does not need so large capital investment. It can be used to produce the increasing popularly type of integrated circuits known as the ASIC (Application specific Integrated Circuits) which bring out such a dedicated microchip called digital single processing (DSP) chip.

3) Artificial intelligence (AI) and Man-Machine Interface

This technology will be integrated in probably every electronics and information-based products. The fore runner of this AI technology are the knowledge-based expert systems, which will imitate the various human experts, and the machine translation which will translate texts and speech among different human natural language. Other kinds are man-machine interface technology such as voice, vision, hand-written characters.

4) Opto-electronics

Outstanding among this opto-electronics technology are optical fiber, and laser which will generate for example communication industry, industrial electronics and medical equipments, computer storage and printing equipments etc.

5) CAD/CAE/CAM

Computer-aided-design (CAD), computer-aided-engineering (CAE) and computer-aided-manufacturing (CAM) are probably the technology that increase the industrial productivity. The design, engineering and manufacturing will be faster, more accurate, higher complexity when using this CAD/CAE/CAM technology.

6) Automation and Robotics

This technology is also seen as the efficient way to increase the productivity. Robotics and automation will make an industrialized country even more competitive.

7) Software

The future products of electronics and information-based industry will mostly have microprocessor as an integral part. It is most obvious that these products will always feature the programmability. Hence software technology at all levels are necessary for the future.

The microelectronics and VLSI technology is for example seen as essential for the production. To increase reliability and economy of scale, the board assembly firms will have to adopt the hierarchical technology of SMD (surface mounted devices), hybrid IC (integrated circuit), semi-custom IC respectively. Artificial intelligence is seen as the added value for the product design to be competitive in the future market.

As the semiconductor wafer fabrication industry is always regarded as a major industry that Thailand must acquire, Table 5.4 list an example of the production technology of this industry (T.E. Dillinger, VLSI Engineering, Prentice-Hall International, 1988)

5.5.3 Summary of Future Technological Capability

So far we have summarized the future industry and technology for Thailand, in this section we will attempt to outline the future technological capability e.g. acquisitive capability, operative capability, adaptive capability and innovative capability.

1) Acquisitive Capability

To acquire the technology, one must look for the sources of technology which many either be within the country or outside the country. The technology sources in the country may be the technological information center acting as a body providing the necessary information, the university laboratories, the firms which are using the technology in producing the products, and the consulting firms. Although at a very early stages, Thailand has already set up new center at the Ministry of science Technology and Energy e.g. the Department of Technology Transfer, the Science and Technological Information Center. The STDB (Science and Technology Development Board) is also in the process of setting up the TIAC (Technical Information Access Center). It is still remained to be seen if these centers will be effectively supporting the future acquisitive capabilities in electronics and computers. From the survey there is only one university that officially has a center providing consultancy to private companies. The private consulting companies acting as the information sources and acquiring technology are virtually non existent. Normally the trading companies representing imported equipments will offer the procurement, plant layout design, installation and start up. These types of trading companies are for example the computer agencies and process equipment agencies. However, a neutral consulting firms are generally needed to provide unbiased technical information and advice.

In conclusion, it is strategically necessary that the local sources for acquiring the technological capability must be established both in quantity and quality to enable the Thai-owned firms to start up their factories. The foreign-owned and joint-venture firms normally acquire their technology from the mother companies outside Thailand.

2) Operative Capability

The future operative capability will partly depend on the acquired technology and the man power. For Thailand, man power especially at the engineering and technician levels are much below the present demand. This due mainly to the rapidly growing number of firms receiving the promotion from the Board of Investment. The estimated demand is around four thousand engineers per year while the supply of engineering graduates is only half of the figure. Although the survey shows that there are sixteen universities that offer bachelor degrees in electronics and computer (See Table 2.1, chapter 2), only half of them (mostly government Universities) do actually produce the largest portion. It is strategical that the government must promote the production of engineers by investing more in this kind of education. Alternatively, incentives must be offered to the private universities to start the engineering education programs.

The training programs offered to various firms will help updating the awareness and technological skills in operation e.g. quality control, productivity, new equipments, new processes etc.

As the number of investment from abroad in increasing rapidly in Thailand, these firms may be upgraded in the future as providing the technology to the local firms through their operation. The employees of these foreign-owned or joint-venture firms which are generally excellent in their operative capabilities can acquire their skills in technology, management and markets. Hence, these firms many be regarded as a strategic organizations that provide the acquisitive capability.

Finally the uses of modern equipments such as computers for management and automation equipments for manufacturing should also be encouraged to enhance for example productivity and quality.

3. Adaptive Capability

The adaptive capability may be made effective if three main strategies are laid down. First of all, the components and parts must be made plentiful locally. This is seen as a necessary basic factor that will stimulate the imitation of products. Trial and error can therefore be attempted at a low cost by the local entrepreneurs. The second factor which is regarded as important to achieve the adaptive capability is the engineering knowledges. This will enable digestion of technology in order to understand the products and processes to a certain extent. The minor adaptation of the products and processes may then follow. Thirdly, the firms must be encouraged to set up their engineering divisions in charge of all technical experiments to acquire this adaptive capability.

4. Innovative Capability

The innovative capability may be achieved through the real knowledges and skills in RD&E (Research, Development and Engineering). First of all, the local universities must offer sufficient programs in Master and Doctor of Engineering. From the survey of the sixteen local universities. only two offer Doctor of Engineering program and only half offers Master of Engineering program. This is seen as too small to be effectively in producing the man power at this level. It is also seen as to small to produce any significant RD&E results by the universities themselves. Secondly, it is also an important strategy that a kind of liaison offices acting as a go-between the university RD&E laboratories and the private firms must be established. This will enable the effective use of the RD&E resources. Thirdly, it is also seen as an important measure to set up a national RD&E

organization which will serve the local firms directly to innovate new products and processes. This national RD&E organization must run as a professional non-profit company (e.g. equivalent to for example the ERSO - Electronics Research and Service Organization and the III - Institute for Information Industry of the Republic of China). Finally, it is also always the obvious aim that the firms must be encouraged to have their own RD&E divisions. In industrialized countries, it is always true that the RD&E expenditure is approximately 90% in the private firms and only 10% in the public organizations.

It should probably noted here that the country has already seen two main funding agencies for RD&E in electronics and computers e.g. the National Electronics and Computer Center (NECTEC) of Ministry of Science Technology and Energy, and the Science and Technology Development Board (STDB) (see chapter 2).

Table 5.1

Future electronics and computer industry in the world

1. Consumer Electronics

1.1 Video Equipment

Color Television
High Definition Television
Monochrome TV
Projection TV
LCD Television
Digital TV
Video Systems
Video Cassette Recorders, Players and Cameras
Videodisc Systems
Video Software
Videotex Systems
Satellite Earth Stations

1.2 Audio Equipment

Audio Components
Add-on Components
Packaged Audio Systems
Audio Tape Equipment
Autosound
Portable Audio
Radio

1.3 Home Information Equipment

1.4 Personal Electronics

- Health Care Products (e.g. electronic thermometers calory counters, pulse checker etc.)
- Home Security Systems

2. Communication Equipment

- Fiber Optics
- Satellite Communications
  - o VSAT (Very Small Aperture Terminals)
  - o Earth Stations
- Facsimile
- Microwave Transmission
- Telephone and Answering Machines
- Cable Television
- Cellular Radio
- PABX
- Data Communications
  - o Modems
- Local Area Networks
- Teletext/Videotex
- Land Mobile Radio
- Integrated Services Digital Network (ISDN)

3. Computer Hardware Equipment

3.1 Computers

- Supercomputers
- Mainframe Computers
- Minicomputers
- Microcomputers

3.2 Peripheral Equipment

Magnetic Storage Equipments and Media (e.g. floppy disk, hard disk, tape cartridge)
Optical Disk Equipment
Computer Terminals
Printers
Computer Communications Equipment

3.3 Office Automation

Word Processing
Desktop Publishing

4. Industrial Electronics Equipment

4.1 Industrial Automation

Industrial Control
Electronic Temperature Controls
Robotics
Machine Vision
Material Handling (e.g. bar coding etc.)
CAD/CAM/CAE

4.2 Testing, Measuring and Analyzing Equipment

4.3 Power Supplies

4.4 Nuclear Electronic Equipment

4.5 Medical Electronics

Diagnostic Equipment
Therapeutic Equipment
Surgical and Medical Instruments
Patient Monitoring Equipment
Consumer Medical Electronics

4.6 Lasers

Military Lasers
Commercial Lasers

5. Electronic Components

5.1 Electron Tubes

Television Picture Tubes
Microwave Tubes
High Vacuum Tubes
Gas and vapor Tubes
Electro-Optical Tubes
X-Ray Tubes

5.2 Solid State Products
Discrete Semiconductors
Integrated Circuits

5.3 Electronic Parts

Capacitors
Resistors
Networks
Switches and Relays
Connectors
Transformers
Quartz Devices
Filters
Printed Circuit Boards
Wire and Cable

Source : 1988 Edition Electronic Market Data Book, Electronic Industries Association, USA.)

Table 5.2

Future electronics and computer industry in Thailand

1. Consumer Electronics

1.1 Video Equipment

Color Television
Monochrome (B&W) TV
Video Tape (VHS)*
Video Tape Recorder*

1.2 Audio Equipment

Radios
Car Radio
Car Tape Cassette-Radio
Cassette Tapes*
Radio Cassette Recorder
Power Amplifier
Clock Radio
Compact Disc Player*
Equalizer Booster*
Mini Stereo with Head Phone*
Portable Stereo*
Stereo/Monaural Radio Cassette*

1.3 Personal Electronics

Digital Watch
Electronic Calculators
Electronic Toys
Electronic Watch
Home Stereo
Microwave Oven

Automatic Cameras
Clock & Alarm Clock*
Electronic Typewriter*
Radio Control Toys*
Remote Control Toys*

2. Communication Equipment

Citizen Band Transceivers
Cordless Telephone
Key Telephone Systems
Paging Receiver
Radio Transceivers
Telephone Receivers
Transponder
Facsimile*
Modular Telephone Hardware*
Radio Transmitter & Receiver*
Satellite Antenna*
Satellite Receiver Set*
Switching Equipment*
Telephone Answering Machines*

3. Computer Hardware Equipment

3.1 Computers

Microcomputer

3.2 Peripheral Equipments

Computer keyboard
Floppy Disk Drive
Hard Disk Drive Component
Hard Disk Drive
Paper Feeden
Printers

Thai Card
Computer Cases*
Modems*

4. Industrial Electronics Equipment

4.1 Industrial Automation

Servomotor*
Stroboscope (Electronic Flash)*

4.2 Testing Measuring and Analyzing

Equipment
Kilowatt-hour Meters
Potentiometers
Multi Meter*
Panel Meter*
Electronic Cash Register*

4.3 Power Supplies

Power Line Conditioners
Power Line Stabilizers
Switching Power Supplies
Uninterruptible Power Supplies
Coil & Transformer
Solar Cell Module
Solar Cell Panel
Module
Solar Panel

4.4 Medical Electronics

Diagnostic X-Ray Equipment

5. Electronic Components

5.1 Electron Tubes

Color Picture Tubes (CRT)*

5.2 Solid State Products

LED*
LED Clock Display*
LED Lamp*
LED Numeric Display*
Small Signal Transistor*
Integrated Circuit Assembly
IC Heat Radiation Panel*

5.3 Electronic Parts

5.3.1 Capacitors

Ceramic Capacitors
Electrolytic Capacitors & Parts
Power Capacitors*
Mylar Capacitors

5.3.2 Resistors

Variable Resistor
Fixed Resistors*

5.3.3 Networks

5.3.4 Switches and Relays

Magnetic Relay
Microwave Oven Time Switch*

Reference Time Switch*
Electronic Control Devices

5.3.5 Connectors

Connectors*

5.3.6 Transformers & Coils

Coil for Electronic Watch
Power & Output Transformers
Flyback Transformers
IF Transformer
Instrument Transformers
Microwave Transformers
Deflection Yoke

5.3.7 Quartz Devices

Crystal Oscillator
Quartz Crystal & Tuning Fork
Oscillator Circuits*
Piezo Transducer*

5.3.8 Filter

L-C Communication Filter*

5.3.9 Printed Circuit Boards

PCB Assembly
PCB
Clock and Watch PCB*
Flexible Printed Circuit Board*

5.3.10 Wire and Cable

Cable Harness
Computer Cord
Electronic Wire & Cables
Flat Type Cable
Interface Cord
Keyboard Cord
Power Supply Cord Assembly

5.3.11 Others

Actuator & Parts Assembly
Analog Watch Components
Cabinet for Radio & TV SET
Electronic Watch Components
Fan & Stepping Motors
Ferrite Circulator & Isolator
Floppy Disk Drive Head
Head Gimbal Assembly
Loudspeaker
Magnetic Recording Head
Metal Parts of Microwave Oven
Micro Speaker
Microwave Circulator & Isolator
Plastic Electronic Components
Printer & Disk Drive Components
Small & Miniature Ball Bearings
Strain Gauge
Transducer
TV & Radio Tuner & Parts
VTR and Car Stereo Parts
"E" Block Assembly
Condenser Discharge Ignitor *
Electronic Ballast *
Gas Circuit Breakers *
Head Gimbal Coil Winding *

Magnetic Tapes *

Multilayer Laminated Part*

Regulator/Rectifier *

Thin Laminate *

Transistor Magnetic Ignitor *

Source : Survey

Table 5.3

Future common electronics and computer technology for Thailand

1. Materials and Devices Technology

1.1 Materials

Silicon
Gallium Arsenide
Amorphous Materials
Superconducting Materials
Ceramics
Plastics

1.2 Devices

Diodes
Transistors
Light Emitting Diodes (LED)
Liquid Crystal Display (LCD)

2. Microelectronics and VLSI

Printed Circuit Board
SMT (Surface Mounted Technology)
Hybrid IC
Semicustom IC
Application Specific IC
Full Custom IC
Design Technology
Fabrication Technology

3. Artificial Intelligence and Man-Machine Interface

- Character Recognition
- Pattern Recognition
- Voice
- Graphics
- Expert Systems
- Machine Translation

4. CAD/CAE/CAM

- CAD (Computer-Aided Design)
- CAE (Computer-Aided Engineering)
- CAM (Computer-Aided Manufacturing)

5. Opto-electronics

- Optical Fiber
- Laser
- Optical Disks
- Compact Disk (CD)
- Compact Disk Video (CD-V)

6. Automation and Robotics

- Controllers
- NC (Numerical Control Machine)
- CNC (Computerized NC)
- Robotics
- FMS (Flexible Manufacturing System)
- Computerized Manufacturing System

7. Software

Thai Character Code Standard
Thai Word Processing
Thai Desktop Publishing
Database Technology
Development Tools

Table 5.4

VLSI technology as an example of future production technology for Thailand

1. Diffusion

2. Ion Implantation

3. Oxidation

4. Chemical Vapor Deposition (CVD)

5. Physical Deposition Techniques

   - Evaporation
   - Sputtering
   - Spin Coating of organic Polymers

6. Wet Etching and Cleaning Techniques

7. Dry Etching Techniques

   - Plasma Etching
   - Reactive Ion Etching
   - End-point Detection

8. Conventional Photolithography

   - Mask Manufacture
   - Mask Materials
   - Mask - Wafer Alignment
   - Photo resist

9. Advanced Photolithography

   - Electron Beam Exposure
   - X-ray Lithography

10. Annealing

11. Test Process and Yield Evaluation

12. Contamination and Reliability Control

13. Packaging

Table 5.5

Future strategic technological capability

1. Acquisitive Capability

   - Technical Information Center
   - University Laboratories
   - Manufacturing Firms
   - Consulting Firms

2. Operative Capability

   - More engineering educational programs
   - Encourage more engineering programs in private universities
   - Training programs
   - Uses of modern equipment e.g. computer and automation

3. Adaptive Capability

   - Availability of parts and components
   - Engineering knowledges
   - Set up engineering division in firms

4. Innovative Capability

- Knowledges and skills in RD&E
- More post-graduate educational programs especially in engineering, doctoral degrees.
- Linkages between university RD&E laboratories and firms
- Set up a national RD&E organization as a professional and efficient non-profit company
- Set up RD&E division in firms

CHAPTER 6

MAJOR STRATEGIES FOR GAINING NEEDED FUTURE CAPABILITIES FOR EIBI

If we want to enhance technological capabilities in the EIBI, the industry itself has to be developed for the technological capabilities to reside in. At the present time, advantage should be taken of the current investment boom and growth in the export industry to find ways of building up higher levels of technological capability and increasing technological value-added. Concurrent medium- and long-term measures must also be prepared in order to strengthen the technological capabilities in other supporting technical agents which facilitate the growth of EIBI. These supporting activities will help to develop the flexibility required to cope with the rapidly changing technology in the industry and propel Thailand into the "Information Age" in an efficient and cost effective manner.

Given the nature of technology in the EIBI, the most effective way to build up technology is to learn from abroad. Accordingly, measures must be taken to increase Thailand's capacity to absorb and digest foreign technologies, both directly from foreign sources and through the spill overs from foreign firms already operating in Thailand. In order to do this effectively, it is essential that indigenous technological capability be developed in parallel with the absorption process.

A crucial factor in achieving the above goals concerns the availability of high quality S&T manpower. The process absolutely requires greater numbers of higher level scientists, engineers, and technicians than currently exist. In order to produce these crucial human resources, planning and investments have to be made a number of years in advance. The higher the caliber of personnel needed, the longer is the period of training that is required. For example, a good researcher needs more than 10 years of training and practice.

Our approach in this chapter is to draw on the analysis in the report thus far to identify the major policy strategies that are required to develop the technological capability of the EIBI in Thailand. Other strategies, although helpful, are not explicitly dealt with for fear of distracting attention from the main issues. It is hoped that the strategies could be more concretely incorporated in a comprehensive policy oriented master plan for the development of the EIBI in the near future, something which is presently lacking.

The strategies to gain needed future capabilities in EIBI that will be outlined in more detail below are as follows:

1. Using export industry to promote technological capability enhancement and increase technological value-added.

2. Using the local market to develop technological capabilities

3. Absorbing foreign technology and developing indigenous R&D capability.

4. Planning and investing for S&T manpower.

6.1 Using Export Industry to Promote Technological Capability Enhancement and Increase Technological Value Added

Thailand presently holds a considerable comparative advantage in the production of high quality electronic components. Table 1.10 showed that 73 of the 104 electronics firms promoted by the BOI from January 1987 to June 1988 were component manufacturers, of which almost 100 percent were in the export sector. These operations usually involve the large scale production of small devices using expensive and sophisticated automatic machinery and very little local material. Thailand's comparative advantage lies not in low labor cost per se, since the labor cost component of such industries is rather low, but in the availability and effectiveness of all types of manpower, including workers, technicians, engineers, support staff, and managers.

The electronic components export industry has often been criticized as only a user of labor. It is alleged that the only thing Thailand gains from this industry is the labor cost which is only a small percentage of the export value. The fact is that we do gain more than that and, if a proper strategy is followed, it will be possible to use the present export boom to stimulate the accumulation of needed technological capability and lead to more technology-intensive exports and higher value added exports in the future.

6.1.1 Gains in Technological Capability from Export Activities

In order to export, one must be competitive in the world market in terms of price and quality. However, by offering considerably greater scope for taking advantage of economies of scale than the limited domestic market, export markets permit the producer to cut his costs by producing at high volumes.

As shown in Chapter 3, the first technological capability that exporters must achieve is operative capability. They must be able to operate and maintain machinery at full efficiency and implement a quality control (QC) and testing system that guarantees that the final product meets the buyer's standard in terms of performance and reliability with low reject rates. Inventories need to be carefully monitored and kept as low as possible to reduce cost. To achieve this, a diverse range of manpower skills with differing mixes of training and experience are required.

After some period of operation, firms were shown to gain acquisitive capability. New machinery or technology purchases may be partly assessed, evaluated and negotiated and the installation and start up of new machinery are often done by local staff. Some joint-venture and foreign firms were seen to allow considerable flexibility to their subsidiaries with regard to sourcing some components and raw materials independently.

To be competitive in the world market, there is no doubt that the operation must have world-frontier technology. The United States head offices of the IC producing companies have shifted virtually all their final assembly operations off-shore. As a result, they have lost their leadership in assembling technologies and need to rely on the off-shore subsidiaries for much of the basic development work. Many adaptations to both products and processes are now done locally without much input from overseas. One consumer product exporter indicated that in the next phase of their operations in Thailand, some product and feature design work will be done locally to expedite responses to customer's requirements. Therefore, Thailand's adaptive capability and eventually, innovative capability, are also enhanced through the export industry.

6.1.2 Measures to Promote Technological Capabilities through Exports

Although it is indicated in the previous section that the export industry does improve technological capability levels in industry, there are a number of ways to utilize the export industry to accelerate and strengthen the development of technological capabilities.

a) Promotion of supporting industries. The EIBI needs supporting industries in order to reduce capital investments for parts making and in providing locally made parts and components more cheaply and in a more timely and reliable manner than imports. As discussed in Chapter 2, present supporting industries include PCB fabrication, die making, mold making, plastic injection, metal part stamping, die casting, cabinet making, silk screening, paint spraying, electroplating, transformer winding, packaging material making, labeling material making, etc. Most of these are subcontractors but some products are available in the market.

Some recently established exporters complained that Thailand does not have sufficient supporting industries in terms both of quantity and quality. Supporting industries are able not only to increase the local value added in the export industry, but also to accumulate various specialized technologies and, as pointed out in Chapter 4, can provide an effective channel for dissemination of technology. Successful subcontractors must possess at a minimum excellent operative capability, good acquisitive capability and good adaptive capability.

Recommended policy measures to promote subcontracting are:

1. The acceleration of the process to introduce a value-added tax (VAT) which will remove the multiple taxation feature from the tax structure which discriminates against subcontracting;

2. Push forward the proposal from the JPPSCC to reduce import tax on measuring and testing equipment to help the supporting industries who are mainly small in acquiring better equipment to up-grade their products.

3. The designation by the BOI of certain critical supporting industries for the development of electronics industries as being eligible for promotion. For example, the molds and dies industry is very essential not only for electronics industry but for all manufacturing industries. Then, the machinery to make molds and dies should be exempted from import tax for a certain period of time.

b) Promotion of downstream integration. Components can be assembled into sub-assemblies at the board level and final downstream products to achieve a greater enhancement of value-added. In so doing, there are many opportunities for design activities such as electronic circuit design, PCB layout design, and the design of various mechanical parts, cabinets, front panels, features, etc. Even when the designs are supplied by the buyers, there is still room for minor design modifications. The development of design and engineering (D&E) activities will provide excellent opportunities to develop electronic circuit and system technologies and boost the levels of acquisitive and adaptive capabilities.

Furthermore, the sub-assembly and final products production will require a large number of electronic components. When the production attain a certain size, it will become an indirect export market that the newly promoted component manufacturers cannot ignore. The production of local component manufacturers and subcontractors can be expanded and the linkages between component and product manufacturers will become stronger, leading to more local value-added.

One recommended policy measure to promote downstream integration involves the creation of component sourcing companies to act as buffers between component manufacturer and assembler to foster the linkages mentioned above and to lower the price of components by buying in large volume.

6.2 Using the Local Market to Develop Technological Capabilities

With a population more than 50 million and a rapidly growing GNP of 1.2 trillion baht or 48 billion US$ in 1987, Thailand possesses a sizable internal market that cannot be ignored. Although the import substitution of consumer electronics products succeeded to a certain extent, the second phase import substitution in the components industry is just starting for some radio and television components (Boonyubol, 1985 and 1988(b)). Thailand still imports a large quantity of radio and television components for assembling into products as well as large quantities of electronic equipment, especially industrial product such as telecommunications equipment, computers, educational equipment, and measuring and testing equipment. The market for telecommunication equipment alone amounts to tens of billions of baht a year. This offers considerable scope for the selective expansion of import substitution industries provided proper protection and promotion measures and procurement procedures are practiced.

6.2.1 Development of Component Industries for the Local Market

Although the electronics industry in Thailand started with the assembling of radios and televisions about 25 years ago, such activities still import 90 percent of the value of their component requirements. This is because there are too many manufacturers and models in the small domestic market making it uneconomical to produce components. Furthermore, government protection policy in the past has favored the import of CKD kits for assembly into final products for the local market. This, combined with other anomalies in the tariff code, has resulted in the stagnation of second phase import substitution in the component industry and hampered the development of a "component-oriented" electronics industry.

Recognizing the problem, the BOI and the Electrical, Electronics & Allied Industries Club (EEAIC) of the Federation of Thai Industries (FTI) began to study the feasibility of establishing a plant to manufactured color television picture tubes for all television manufacturers in Thailand in 1985 (Boonyubol, 1985). This study resulted in the establishment of Thai CRT Co., Ltd, which is a joint-venture between Mitsubishi Electric Corporation and Siam Cement Co., Ltd., with most of the local major television manufacturers participating as share holders. The plant will have a capacity of 1 million tubes a year. Most of them will be utilized locally by all local television manufacturers while some will be exported either as picture tubes or in assembled television sets.

Furthermore, in 1987, the BOI submitted a proposal for tax restructuring of electronic products and components to the Customs Tariff Committee (Boonvubol 1988(a)). The result was the Announcement of the Ministry of Finance to change the tariff rates as discussed in Chapter 2. The changes essentially modified the rates on the components of radios and televisions to a level of 40% on the final product, 30% on components that are being produced domestically, 10% on components that are not produced domestically, and 10% on materials. Moreover, the import tariff rates on certain semiconductor components such as integrated circuits, transistors, and silicon rectifiers were unconditionally decreased to 10 percent.

In order to encourage investment in certain prospective components, the Announcement immediately increases the tariff rate of the components that are being manufactured in Thailand to 30 percent to provide move protection for local component manufacturers. The tariff rate for components that are not being manufactured in Thailand is decreased to 10 percent to reduce the cost for electronic products, but there is a time table to raise the tariff rate to an eventual 30 percent.

Table 6.1

Time Table for the Increase of Import Tariff Rate for Components

Component	Import Tariff Rate (%)			
	1 Jan.1988	1 Oct.1988	1 Oct.1989	1 Oct.1990
Electrolytic Capacitors	30	30	30	30
Speakers	30	30	30	30
Printed Circuit Boards	30	30	30	30
Coils and transformers	10	30	30	30
Telescopic antennas	10	30	30	30
Television tuners	10	10	30	30
Picture tubes	10	10	10	30
Deflection Yokes	10	10	10	30
Fly back transformers	10	10	10	30

To Chap 2

Following this announcement, the EEAIC conducted another study on feasibility for the production of tuners, fly-back transformers and deflection yokes for color televisions (Boonyubol, 1988(b)). It is now applying for BOI privileges for the establishment of such a factory which will be a joint investment of all main television manufacturers with a foreign technology supplier.

Although it seems that the measures taken by the Announcement work well, there are not many components left on Table 6.1 that represent a sizable investment due to the limited size of the domestic consumer electronics industry. Hence, the strategy can only work well for a period of one to five years, but in the long term (5-10 years) the component industry with its inherent large economies of scale must export to operate at high efficiency. Eventually, the component industries developed for the domestic market should cater for the same market as those in section 6.1 and should be just as efficient.

6.2.2 Creating a Conducive Environment for Technological Innovation and Commercialization

One characteristic that distinguishes the electronics industry from the metal working industry or even the electrical industry is the availability of standard components in the world market. There are millions of components that are freely available in the market at very competitive prices. Therefore, the best area for small entrepreneurs to develop is in circuits and systems design because one does not need much investment to buy a number of components to design into a product. It was found in the present survey that small Thai firms are most innovative. Steve Jobs started the Apple Computer Company in the 1970's in his garage. We are sure we have some Steve Jobs in our populace but the environment has to be right. The first requirement is that a large variety of electronic components should be freely available in the market at a low price.

At present, electronic components in Bangkok are expensive and only basic types for audio products are available. Components needed for research often have to be brought through friends in foreign countries. It is hoped that in the long term, the electronics industry that used to cater only for the local market will improve its efficiency to the extent that it can also be competitive in the world market. When that time comes, the protection for domestic industry is no longer needed and the tariff rate in general can be lowered to no more than 10-15 percent (Westphal, 1982). The government, of course, can continue to nurture selected infant industries but the protection must be selective and time-limited. When the tariff rate for components is very low, a large variety of components will be available in the market and this will stimulate the research and production of electronic equipment by a large number of small entrepreneurs. It was in this kind of environment that Steve Jobs invented the Apple Computer in the United States and Stanley Shih started Multitech in Taiwan.

Two other important areas which need to be more carefully examined concern financing and intellectual property rights. Firstly, the role of venture capital financing in the electronics industry in developed countries and the NICs has been seen to be crucial and efforts to facilitate the growth of such activities in Thailand should be considered. Secondly, the legal aspects of patents and copyright laws as they affect both hardware and software products need to be carefully examined and appropriate legal reforms implemented to provide protection to the parties investing resources in RD&E.

6.2.3 Using Procurement Regulations for Strategic Products

The potential for government procurement to be used as a tool to develop technological capability in the electronics industry is greatest in the strategic field of telecommunications equipment. The importance of telecommunications lies beyond the fact Thailand has a rapidly growing domestic market for such products. In the 1960's, the government built a large network of roads and pushed Thailand into the export market for agricultural products. In the case of telecommunications, it seems that the policy is to wait for the demand before installing the circuits. Telecommunication facilities serve as the nerve network of the economy much as roads are analogous to blood vessels. Indeed, the improvement of the "nerve network" of telecommunications facilities will be a crucial factor in determining Thailand's transition into a modern state as the information revolution begins to reach into all aspects of our lives.

State enterprises such as CAT and TOT should begin to see themselves not just as suppliers of telecommunications services but as crucial players in the promotion of technological capability in the telecommunications industry. They need to establish R&D centers with budgets that are programmed to rise over time, starting at say 1 percent of total turnover. It should be emphasized that these centers are not to manufacture products to substitute for the imported ones. Rather, they should concentrate on cultivating the required personnel to specialize in advanced telecommunications technology, on providing the operating agencies with long-term technical support, including network planning, system design and technology evaluation, and on technology transfer to the domestic telecommunications industry in upgrading design and manufacturing capabilities.

Normally, state enterprises purchase equipment through tendering. If they see themselves as promoters of industry, future requirements for equipment should be announced well in advance. Detailed specifications and even prototypes developed at the R&D Centers may be given to manufacturers. At the time of tendering, samples of products submitted by the manufacturers should be fully checked for compliance with specifications.

For more complicated equipment where there is no local know-how, the state enterprises may negotiate with the technology supplier for licensing to local manufacturers (Sripaipan, 1982). At the very least, joint-venture manufacturing with foreign firms should be preferred to wholly-owned subsidiaries and, definitely, to trading firms.

In similar ways, the purchase of equipment for education and for medical use can be used to create and support a local manufacturing industry For instance, if the Ministry of Education decides that computer literacy is a must for the next generation of students, then a market of several thousand microcomputer a year can be used to create a local microcomputer industry. Particularly, when several computer components and peripheral are being manufactured in Thailand.

6.3 Absorbing Foreign Technology and Developing Indigenous R&D Capability

Technology essentially resides with man and institution. This and the following section accordingly look in turn at the development of institutions and the development of manpower.

Most of the technological capability of the industry logically lies in the factory: in the machinery and equipment, in the process, in the documents, in the system and in the personnel. However, there are 3 kinds of institutions that can help the industry solve technological problems and enhance technological absorptive capability, namely: (1) R&D Laboratories in the public and private sector, (2) information services including libraries, information centers and the proposed TIAC of STDB; and (3) consultancy services in the public and private sector.

Needless to say, all these three groups of institutions are weak and have few systematic linkages with industry. Strategies to develop and use these institutions to support the objective of enhancing the technological capability of the industry are discussed below.

6.3.1 Using R&D Laboratories to Absorb and Generate Technology

R&D activities in electronics and information based industry are found mainly in university laboratories and a few private companies. Although these activities do not reach the standards of the developed countries, they do cultivate a group of people who can follow the current technology trends in their field. For example, although the solar cells developed in university laboratories can never be commercialized, the scientists and engineers who worked on them have the foundation to absorb any advanced solar cell technology. Since successful technology transfer depends heavily on the absorptive capability of recipient, the use of R&D activities to develop this capability is deemed important.

To actually generate technology requires a much higher level of input in terms of manpower, equipment and time. There have been instances of products that were developed in universities being transferred to industry for production (Hooker and Brimble, 1988). But the technology developed is of very applied nature similar to that can be developed in the R&D units of the industry itself. To accumulate knowledge and experience, we need dedicated electronics research and development laboratories in the public sector. Universities cannot fulfill the role of a research institute due to the lack of continuity and the absence of a "critical mass".

In fact, as already discussed, the stock of R&D manpower in EIBI is very limited. The availability of research funds from STDB and NECTEC rapidly occupies all the researchers in universities. A research laboratory with some 30-40 research engineers should be established, perhaps under NECTEC if sufficient flexibility can be guaranteed, along the same lines as the Microprocessor Laboratory of the Hong Kong Productivity Centre. It can absorb and transfer foreign technology as well as generate appropriate technology for local industry, by organizing training courses, developing products and providing consultancy services. In the future, this research institute should be expanded to reach the level of the Electronic Research and Service Organization of Taiwan which presently employs in excess of 1,800 research engineers. A possible model in Thailand that may be followed is that of the Energy Conservation Center which is jointly sponsored by the Federation of Thai Industries and the National Energy Administration. A few things to be stressed are that the pay scale must be comparable to that of the private sector, the government should not expect it to be self-supporting in the early stages and, most important of all, it should not be expected to produce world frontier technology in the first 10 years.

For the private sector, the best way of stimulating R&D is to provide incentives such as

1. The provision of import tax exemptions on research, measuring, testing and analytical equipment and samples and research materials

2. The provision for accelerated depreciation of the above mentioned equipment and,

3. The provision of tax benefits to firms undertaking R&D activities.

6.3.2 Development of Technical Information Services to Support Industries

When industries want to develop their acquisitive capability, the first thing they need is information. The only organization operating this kind of service is the Technological Promotion Association. However, its Technological Data Project is operating at a low level with a budget of only 1 million baht a year. The proposed Technical Information Access Center (TIAC) of STDB will provide a network of linkages to technology sources overseas. It will be a boost to the technical information services in Thailand, but it has yet to convince FTI of its usefulness and it certainly cannot be expected to be self-supporting until public attitudes towards the value of information changes. It will need a sizable staff and budget to collect, format, and distribute information electronically. In fact a number of information centers each specializing in a particular area are required. Their information should be stored in certain standard format that is possible for electronic retrieval and exchange.

6.3.3 Development of Technical Consultancy Services to Support Industries

Like subcontracting, consultancy services help industry to reduce investment yet maintain performance. In Thailand, there are no private consulting firms in the electronics field. A number of universities have established certain units to provide technical consultancy services to industry including Chula Unisearch of Chulalongkorn University, UNISERV of Chiang Mai University, the Center of Operations for Research and Development of KMITT, the Technology Development Center of KMITN, and the Computer Research and Service Center, Electronics Research Center, Engineering Service and Development Center of KMITL. Others provide services without any formal units. Private sector companies providing consultancy services to the manufacturing industry have yet to be developed in Thailand. The BOI should examine the possibility of providing incentives to such activities to stimulate their establishment.

6.4 Planning and Investing in S&T Manpower

Of all the resources necessary for technological capability development, human resources are undoubtedly the most important. This explains why some countries with very few natural resources are among the world leaders in terms of technological achievements, while others with abundant natural endowment remain dependent on foreigners to operate the countries' facilities.

In Thailand, the problem of S&T manpower development has been ignored for more than one decade for fear of high investment costs. The shortage of S&T manpower was envisaged at the beginning of the 5th Plan period which called for 10 percent increase in S&T manpower per annum. However, a mere 4 percent per annum average increase during that period was actually achieved.

In the background paper for the 6th Plan, Petchsuwan et al. (1986) indicated the likely shortages of electronics engineers and the possible shortage of appropriately trained electronics technicians (certificate and diploma technicians combined). The 6th Plan accordingly called for a 20 percent increase in S&T manpower per annum, but no action has been taken.

As pointed out in Chapter 2, the quantum jump in investment since 1986 dramatically increases the demand for S&T manpower and turns all the predictions into considerable underestimates. Indeed, the electronics investment projects approved by BOI in 1987 and January to June of 1988 propose to employ more than 50,000 workers. With an electronics engineer to workers employed ratio of about 1:48, this will generate an incremental demand for more than 1,000 engineers. This figure does not include the demand for electronic engineers in other industries which is also rapidly growing as new electronics based industrial machines are becoming prevalent.

On the supply side, Thailand is currently producing about 2,500 graduates in engineering a year including 786 electronics engineers. The demand of the electronics industry alone for electronics engineers is already far more than the supply. A study by the Petroleum Institute of Thailand showed that the petroleum industry needed 891 engineers in 1988 and 1,198 engineers in 1989. In addition, we still have not taken into account the expansion of domestic industries which did not apply for BOI promotion such as the Siam Cement Group, the Chareon Phokphand Group, the Sahapatanapibul Group, etc. Furthermore, if manufacturing firms are expected to undertake RD&E activities, the ratio of engineers to workers would be about 1:5-10, some 5 to 10 times the present level.

Despite the recognized crisis of engineer supply, no concrete steps have yet been taken by the government. The Council of Deans of Engineering held a seminar on the "Manpower Crisis and the Development of Thai Industries: the Demand for Engineers in Industry" on the 2nd September, 1988. The seminar confirmed the severe shortage of engineers in the chemical, petroleum, textile, automobile, iron and steel, construction material, food, computer, and electrical and electronics industries as well as governmental enterprises such as the Petroleum Authority of Thailand, the Communication Authority of Thailand and the Electricity Generating Authority of Thailand.

The present manpower crisis will certainly have severe impacts on the social and economy development of Thailand. It will tend to slow down the rate of growth of investment as investors find they can no longer obtain required manpower. In addition, the quality of technology transfer will be greatly reduced and the building up of technological capability in industry will be very difficult without qualified manpower. Significant RD&E activities will not even be possible.

Although it is too late to completely eliminate the manpower problem at present and in the near future, the adverse effects should be minimized and efforts should immediately be made to start building up the needed manpower for the future. These targets can be achieved through a two-pronged approach to undertake both stop-gap measures in response to the present crisis and more concrete steps to develop the resources needed to produce the S&T manpower to sustain the development of the country.

6.4.1 Stop-gap Measures in Response to the Present Crisis

Actions should be immediately taken by existing educational institutions to set up:

1. Short-courses on particular aspects of manufacturing technologies such as quality control, inventory management, or specific technologies such as PCB technology, and metal working technology. The courses should be conducted in the evening for 2-3 hours, 3-5 evenings a week for periods of 3-12 months. The participants should be workers in factories that need to be upgraded in certain technologies. University lecturers can teach the basics with experts from industries teaching the specifics.

2. Programs to upgrading technicians to be engineers. Diploma technicians after another two years in KMIT can become graduate engineers. KMITL has already started special training programs for AT&T (Microelectronics) Co., Ltd., Data General Thailand Co.,Ltd., and Signetics (Thailand) Co., Ltd. in the evenings.

3. Programs to make engineers out of scientists. Graduates in physical science should be able to graduate as engineers after an additional two years of training. Chulalongkorn University is considering starting such a program.

4. Programs to double engineering graduates by doubling intakes. Universities can double the number of graduates by starting twilight course on week day evenings and on weekends using existing staff and facilities.

All the proposed courses above can be started unilaterally by educational institutions without waiting for budget allocations or even approval from the government. Sufficient fees can be collected to pay for lecturers, technicians and other support staff at market prices, to replace all the consumable materials, and to allow for depreciation of equipment.

It is understood that these measures may put severe strains on the already insufficient manpower of educational institutions. But each institution must consider its own strength and only set up courses that it can handle and only for the time necessary to address the present shortages of supply. It is hoped that with cooperation from all concerned parties, the investment boom will not fizzle out prematurely because of such technical manpower shortages.

6.4.2 Building up S&T Manpower to Sustain the Long-term Development of the Country

Electronics S&T manpower is needed not only in electronics manufacturing industry and supportive infrastructure like R&D laboratories, information centers and consultancy companies but also in the sale and service of electronic equipment, in the public sector communication authorities and other government agencies, in educational institutions, and in other manufacturing industries. Thailand will need at least 10 times more S&T manpower than it possesses at the present time in order to move into the ranks of the more industrialized economies. This manpower will not only to work in factories but will operate all the modern facilities necessary in the Information Age to improve our quality of life.

To build up such a amount of S&T manpower, We need people, money, and time. Heavy investment from the government has be committed continuously. The following steps need to be made:

1. Revolutionizing the public technical education system. Universities must be given more autonomy in their administrative structure, curriculum development and, most importantly, pay scales. University staff, which are actually civil servants, are paid much below their social status and the majority of them have to earn extra income to maintain their standard of living. The severe brain drain of university staff to the private sector has already been mentioned. Steps must be taken to work out more satisfactory

remuneration packages as well as providing higher quality facilities for the university staff to use in their research and teaching activities. More training programs and overseas scholarships are needed to upgrade facilities as well as support staff. At the same time, there should be an evaluation system to make sure that only the best people are employed.

2. Building more educational institutions. To have more graduates in S&T, the government has to invest in building more universities in S&T either by allowing existing universities like Thammasat University and Ramkamhaeng University to establish engineering faculties or by building new ones in other provinces. The standards of engineering graduate, however, must be maintained, possibly by introducing an examination requirement in order to qualify as a professional engineer.

3. Promoting private investment in educational institutions. If educational institutions can be regarded as industry whose output is manpower, then BOI should promote this industry by providing similar privileges as they do to manufacturers. This will encourage the private sector to invest in establishing private universities in S&T. Such institutes can be Thai-owned, joint ventured or foreign subsidiaries. Exemptions of import taxes on educational equipment would lower the investment cost. Allowing the importation of expatriates would facilitate the use of high quality foreign lecturers to fill gaps or shortages in certain areas. The production which initially would aim for the domestic market (import substitution) may even become "export oriented" by admitting foreign students.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 By Way of Conclusion

Before presenting the policy recommendations of the study which are listed in Table 7.1 along with the proposed implementing agency and an approximate time frame, this section summarizes the major findings of the research project to provide a basis for the recommendations.

1) It is indisputably true that the electronics and information based technology and industry will play an increasingly important role in the social and economic development of Thailand. In order to maximize the benefits to be obtained from them, policy makers need to be able to understand the general trends in the electronics technology and industry. This should help them to formulate sensible electronics industry development plans which coordinate well with S&T policies and manpower policies and which link in with the overall development plan.

2) Studies of electronics industry development in many countries show that a number of various policies have been followed, namely the so-called leapfrogging strategy, the latecomer's strategy and the market niches strategy. In practice, successful countries tend to implement a carefully chosen mix of these strategies that is appropriate for the conditions in the country and which direct the development of the electronics industry on the right road.

3) In the case of Thailand, there still exists no explicit industrial development policy for the EIBI. On the other hand, an explicit S&T policy was first incorporated in the

country's fifth plan (1982-1986) and appeared again in the sixth plan (1987-1991), although the policy statements have been rather vague and sometimes even contradicting.

4) At the implementation level, the lack of coordination and cooperation between the relevant government agencies constitute the major problems. However, the quality of manpower who are implementing the existing policy is also a matter of serious concern.

5) A critical issue for the development of the EIBI in Thailand concerns the severe weaknesses in the quality of the supporting infrastructure. Especially important is the situation with regard to human resources, the most important component of successful development in this sector. Indeed, a prolonged and worsening S&T manpower shortage in the electronics area has been hardly addressed at all. Other supporting services such as testing, calibration, consultancy services, and input suppliers also leave a lot to be desired.

6) Overall, the EIBI is characterized by its heavy reliance on imported components, technology and machinery, its increasing domination by foreign companies, and the lack of linkages both between various electronics industry sectors and between the EIBI and other industries.

7) In terms of existing technological capability, most firms are relatively strong on operative capability which reflects the basic skill and ability of Thai workers, technicians and engineers. However, acquisitive, adaptive and innovative capabilities vary a lot according to the type of firm and most firms are generally weak in these areas. However, recent developments in some companies in the foreign-owned components sector indicate that Thai engineers are developing these capabilities to a greater extent and are able to perform very well when given the opportunity.

8) The growing domination of foreign and export-oriented firms in the EIBI poses both a threat and an opportunity at the same time. Most of the firms possess world frontier technology which could help upgrade the country's overall levels of technological capability. On the other hand, the inability to absorb and adapt these technologies would limit the impact of these foreign firms to an enclave and reduce the possibilities of Thai firms developing in the industry. Indeed, the crucial question is one of attempting to deal with foreign investors in a fair way but one which guarantees the maximum possible spill over benefits to the Thai economy.

9) However, Rome is not built in one day. The development of the EIBI in Thailand, which is crucial to social and economic development, requires much more than simply lip service. Serious commitments in terms of finance, political support, and much hard work is required in order to enable the EIBI better to play its core role in the country's industrial sector as Thailand enters the Information Age.

Table 7.1

Strategies, Recommendations, Implementing Agencies for

Gaining Needed Future Capabilities for EIBI

Strategy	Recommendation	Implementing Agency	Time Frame '89	'90	'91	'92	'93	'94	'95	'96
1.Overall Guideline for EIBI	- Formulation of Industry Development Policy	JPPSCC or NESDB	---							
2.Using export industry to increase technological value added	a)Promotion of supporting industries									
	1.Introducing VAT	MOF	---							
	2.Reducing import tax on measuring and testing,and other related equipments	BOI,MOF,EEIAC	---							
	3.BOI promotion for certain key supporting industries	EEIAC,BOI,MOF	---	---						
	b)Promotion of downstream integration by creating component sourcing companies	EEIAC,BOI		---	---					
3.Using the local market to develop technological capabilities	a)Development of component industries for local market	EEIAC,BOI,MOF	---	---						
	b)Creating a conducive environment for technological innovation									
	1.Reducing proctection for domestic industry	MOF,BOI		---	---	---	---			
	2.Developing venture capitals	BOI,MOF	---	---	---					

Table 7.1

Strategies, Recommendations, Implementing Agencies for

Gaining Needed Future Capabilities for EIBI

(continue)

Strategy	Recommendation	Implementing Agency	Time Frame '89	'90	'91	'92	'93	'94	'95	'96
	3.Proclaiming patent right and copyright laws	MOC,MOSTE			---					
	c)Using Procurement Regulations Strategic Products	NESDB								
	1.Telecommunication Equipment	TOT,CAT etc.				---				
	2.Educational Equipment	MOE,MUA		---						
	3.Medical Equipment	MOPH			---					
4.Absorbing foreign technology and Developing endogenous R&D capability	a)Using R&D Laboratories to absorb and generate technology									
	1.Import tax exemption on research equipment and	EEIAC,BOI	---							
	2.Accelerated depreciation of research equipment	MOF	---							
	3.Tax benefits to firms undertaking R&D activities	MOF	---							
	b)Establishing dedicated R&D laboratories	MOSTE		---	---					
	c)Development of technical information services	MOSTE,STDB	---	---	---					
	d)Development of technical consultancy services	BOI	---	---	---					

Table 7.1

Strategies, Recommendations, Implementing Agencies for

Gaining Needed Future Capabilities for EIBI

(continue)

Strategy	Recommendation	Implementing Agency	Time Frame '89	'90	'91	'92	'93	'94	'95	'96
5.Investing and Planning of S&T	(a)Stop-gap measure to response to the present crisis									
	1.Short courses on manufacturing technologies	Educational institutions	---	---	---					
	2.Upgrading technicians to engineers	Educational institutions	---	---						
	3.Making engineers out of scientists	Educational institutions	---	---						
	4.Doubling engineering graduates by doubling instakes	Educational institutions	---	---	---	---				
	(b)Building up S&T manpower to sustain the development of the country									
	1.Revolutionize the public technical education system	MOE,MUA				---	---	---	---	---
	2.Building more educational institutions	MOE,MUA	---	---	---	---	---	---	---	---
	3.Promoting private invesment in educational institutions	BOI	---	---	---					

7.2 Policy Recommendations

1) A comprehensive development policy for the EIBI should be clearly and concretely spelled out so as to provide an overall guideline for the formulation of general industrial policies, S&T policies, manpower policies, and so on. It is suggested that the JPPSCC and the NESDB, in cooperation with the MOI, formulate a package of industrial policies to promote the development of the EIBI, supported by an expert committee which will advise on factual and technological matters.

2) The BOI, as a promotional agency with the authority to override existing government regulations when necessary, should give special consideration to promoting supporting industries that will enhance the competitiveness of exports of final products. The importance of identifying an appropriate mix of the three types of development strategies mentioned above should be borne in mind when formulating promotional criteria and selecting industries and companies to be promoted. The development of subcontracting linkages by facilitating component firms to indirectly export their output should be considered in light of the importance of these linkages to the growth and competitiveness of the EIBI.

3) The MOF should expedite the implementation of the value added tax (VAT). It is hoped that the new tax structure will help to promote the development of subcontracting and well as other local electronics firms.

4) One of the most important financial instruments necessary for supporting technological innovation, something which is crucial to maintain dynamism in the EIBI, is venture capital. The MOF should help in setting an appropriate framework to encourage the development of such companies and

the BOI can help in granting promotional privileges to the venture capital company itself or the new start-ups that it supports.

5) The MOE and the MUA should immediately apply stop-gap measures to alleviate the present manpower shortage problem. At the same time, planning and investment must be made for medium term and long term S&T manpower requirements.

6) Apart from supporting R&D activities in universities, dedicated research institutions should be created to absorb and generate technology in the electronics field. Fiscal policies of the MOF and incentives of the BOI should be implemented in order to encourage private firms to undertake greater investments in RD&E activities.

7) The MOC and MOSTE should cooperate in a detailed study of the effects and the implementation program of the patent and copyright laws which are currently under consideration of the Parliament.

7.3 Roles of Principal Implementing Agencies

7.3.1 JPPSCC or NESDB

The JPPSCC and the NESDB would be the main forces behind the proposed electronics and information industries development policy, working in close cooperation with the MOI. Thev should formulate a coherent overall policy for development of the EIBI, and periodically review and evaluate the progress of policy implementation. A supporting group of experts and industrialists in the EIBI should be formed to provide necessary information, technical advice, and informed comments to assist in the policy formulation process.

7.3.2 MOF

The MOF is in the position to devise fiscal mechanisms and manipulate the tariff structure in order to support the development of a domestically and internationally competitive EIBI.

Their functions should include:

1) the prompt introduction of the VAT.

2) the reduction of import tariffs on measuring and testing instruments and other related equipment, and the allowance of accelerated depreciation on these equipment.

3) the restructuring of tax and tariff structure so as to generate a conducive environment for investments in the import substitution of key mechanical and electrical/electronics components.

4) the introduction of tax incentives to firms carrying out RD&E activities.

5) the further reduction of protection for domestic industry in order to induce these firms to be more dynamic in the face of growing competition from abroad.

6) guiding and supporting the organization of venture capital companies to serve as financial resource for high risk and technologically oriented "market niche" type firms.

7.3.3 BOI

With its present authority, the BOI is capable of the prompt implementation of a number of industry development polices that would effectively influence the course of development of the EIBI.

It is recommended that the BOI focus on the following issues:

1) the prioritization of items of mechanical and electrical/electronics parts to be promoted by the BOI. This would include the enumeration of promotion conditions and periods as well as the formulation of a more rational plan to promote the development of indirect exporters as a means of encouraging the growth of supporting industries.

2) the introduction of promotion privileges to RD&E projects both in promoted and non-promoted firms.

3) the expansion of promotion privileges to cover such strategic services as venture capital, consultancy services, and private technical educational institutions.

4) the preparation of a plan to enhance the extent to which Thailand can benefit from the rapid inflow of promoted, foreign-owned, export-oriented industries in the electronics sector. This process should involve closer dialogues with related government agencies on the likely infrastructural and manpower needs of firms which have received promotion and are likely to set up factories in the short to medium term.

7.3.4 EEIAC

As an industries club within the FTI, the EEIAC can be very helpful in providing firms hand, up to date information on the technological, market, and financial needs of the EIBI.

The following main roles are recommended for the EEIAC:

1) the financing of studies on issues that are useful and relevant to the clubs members and which support the club's efforts to promote needed policy reforms. The results of the studies should also provide a source of useful information for government agencies involved in the development of the EIBI.

2) the channel for public-private sector dialogue on EIBI-related issues, including the establishment of R&D priorities and guidelines.

3) the implementation and planning of private sector organizational and financial involvement in projects of major importance to the development of the EIBI (such as Thai CRT for example).

7.3.5 MOSTE

MOSTE's role in the development of the EIBI, a fast moving technology-based industry, can still be greatly expanded.

It is recommended that MOSTE should at least have the following functions:

1) the promotion of R&D activities in electronics and information-based technology areas. This should include the establishment of a dedicated and flexible R&D laboratory and services center for the EIBI .

2) the development and promotion of information services to support the needs of the EIBI.

3) acting as a coordinating body with the MOC in the deliberations of the advantages and disadvantages of patent rights and software rights for the development of the EIBI.

This should involve the preparation of Thai versions of patent and software rights bills that best serve the country's interest.

7.3.6 MOE and MUA

These two ministries which are responsible for Thailand's education system must work closely together to help alleviate the most serious S&T manpower shortages the country has ever had.

The recommendations are as follows :

1) the introduction of prompt (meaning immediate) measures to address the widening gap between S&T manpower supply and demand in the country.

2) the implementation of a large scale reform of the country's technical education system, in terms of curriculum, functions, flexibility, etc. This is to make the system more responsive to the needs of the private and public sectors in light of the extremely rapid technological changes in the EIBI.

3) the investment in new or existing institutions to increase the numbers of student intakes. The establishment of new education institutions of various types, both for technicians and engineers, is essential.

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ANNEX

A

TABLE A1.1
TECHNOLOGICAL CAPABILITIES OF CONSUMER ELECTRONICS PRODUCING FIRMS

FIRM NAME	CONSUME 1		CONSUME 2		CONSUME 3		CONSUME 4		CONSUME 5		CONSUME 6		CONSUME 7		CONSUME 8	
SIZE OF FIRM	M.J.V.		L.T.		M.T.		L.J.V.		L.F.F.		M.T.		M.T.		M.J.V.	
EXPORT ORIENTATION (YES/NO)	NO		NO		NO		NO		YES		NO		NO		NO	
PROMOTED STATUS (YES/NO)	YES		YES		YES		YES		YES		NO		NO		NO	
CAPABILITY	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL
I ACQUISITIVE		14		18		19		18		9		10		16		18
1 SEARCH	2		3		3		3		2		2		2		3	
2 ASSESMENT	3		3		3		3		2		2		3		3	
3 NEGOTIATION	2		3		4		3		1		2		3		3	
4 PROCUREMENT	2		3		3		3		2		2		2		3	
5 PLANT LAYOUT DESIGN	2		3		3		3		1		1		3		3	
6 INSTALLATION AND START UP	3		3		3		3		1		1		3		3	
II OPERATIVE		15		10		12		16		20		9		9		20
7 PROCESS OPERATION	3		2		3		3		4		2		2		4	
8 MAINTENANCE	3		2		2		3		4		2		2		4	
9 QUALITY CONTROL	3		2		2		3		4		2		2		4	
10 INVENTORY CONTROL	3		2		3		3		4		2		2		4	
11 MANPOWER DEVELOPMENT	3		2		2		4		4		1		1		4	
III ADAPTIVE		7		9		8		11		1		4		4		10
12 TECHNOLOGY DIGESTION OR PRODUCT IMITATION	2		3		3		4		1		2		3		4	
13 MINOR PRODUCT MODIFICATION	3		3		3		4		0		2		1		3	
14 MINOR PROCESS MODIFICATION	2		3		2		3		0		0		0		3	
IV INNOVATIVE		0		4		3		5		0		0		0		1
15 R&D OR ENGINEERING	0		2		1		3		0		0		0		1	
16 RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	0		2		2		2		0		0		0		0	
17 RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	0		0		0		0		0		0		0		0	
18 NEW INVENTION	0		0		0		0		0		0		0		0	
GRAND TOTAL		36		41		42		50		30		23		29		49
PERCENTAGE OF MAXIMUM RATING (90 POINTS)		40.0%		45.6%		46.7%		55.6%		33.3%		25.6%		32.2%		54.4%

NOTES :
L.F.F. : LARGE FOREIGN FIRM
L.J.V. : LARGE JOINT VENTURE
M.J.V. : MEDIUM JOINT VENTURE
S.J.V.:SMALL JOINT VENTURE
L.T. : LARGE THAI FIRM
M.T. : MEDIUM THAI FIRM
S.T. : SMALL THAI FIRM

TABLE A1.2

TECHNOLOGICAL CAPABILITIES OF COMMUNICATIONS EQUIPMENT PRODUCING FIRMS

FIRM NAME	COMMU 1		COMMU 2		COMMU 3	
SIZE OF FIRM	S.T.		M.T.		L.F.F.	
EXPORT ORIENTATION (YES/NO)	NO		NO		YES	
PROMOTED STATUS (YES/NO)	NO		YES		YES	
CAPABILITY	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL
I ACQUISITIVE		16		22		19
1 SEARCH	3		4		2	
2 ASSESMENT	3		4		4	
3 NEGOTIATION	3		4		3	
4 PROCUREMENT	3		4		4	
5 PLANT LAYOUT DESIGN	2		3		3	
6 INSTALLATION AND START UP	2		3		3	
II OPERATIVE		12		15		21
7 PROCESS OPERATION	2		3		4	
8 MAINTENANCE	2		3		4	
9 QUALITY CONTROL	3		3		5	
10 INVENTORY CONTROL	3		3		4	
11 MANPOWER DEVELOPMENT	2		3		4	
III ADAPTIVE		7		6		10
12 TECHNOLOGY DIGESTION OR PRODUCT IMITATION	3		2		4	
13 MINOR PRODUCT MODIFICATION	3		2		3	
14 MINOR PROCESS MODIFICATION	1		2		3	
IV INNOVATIVE		3		7		0
15 R&D OR ENGINEERING	1		3		0	
16 RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	1		3		0	
17 RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	1		1		0	
18 NEW INVENTION	0		0		0	
GRAND TOTAL		38		50		50
PERCENTAGE OF MAXIMUM RATING (90 POINTS)		42.2%		55.6%		55.6%

NOTES : L.F.F. : LARGE FOREIGN FIRM
L.J.V. : LARGE JOINT VENTURE
M.J.V. : MEDIUM JOINT VENTURE
S.J.V.:SMALL J
L.T. : LARGE T
M.T. : MEDIUM
S.T. : SMALL T

TABLE A1.3
TECHNOLOGICAL CAPABILITIES OF COMPUTER HARDWARE PRODUCING FIRMS

FIRM NAME	HARDWARE 1		HARDWARE 2		HARDWARE 3		HARDWARE 4	
SIZE OF FIRM	L.F.F.		S.T.		S.T.		L.F.F.	
EXPORT ORIENTATION (YES/NO)	NO		NO		NO		YES	
PROMOTED STATUS (YES/NO)	NO		NO		NO		YES	
CAPABILITY	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL
I ACQUISITIVE		22		13		15		18
1 SEARCH	4		2		3		3	
2 ASSESMENT	4		2		3		3	
3 NEGOTIATION	4		3		3		3	
4 PROCUREMENT	4		3		3		3	
5 PLANT LAYOUT DESIGN	3		1		1		3	
6 INSTALLATION AND START UP	3		2		2		3	
II OPERATIVE		18		12		8		20
7 PROCESS OPERATION	4		2		2		4	
8 MAINTENANCE	4		2		2		4	
9 QUALITY CONTROL	3		3		1		4	
10 INVENTORY CONTROL	3		2		2		4	
11 MANPOWER DEVELOPMENT	4		3		1		4	
III ADAPTIVE		10		7		5		7
12 TECHNOLOGY DIGESTION OR PRODUCT IMITATION	4		3		2		3	
13 MINOR PRODUCT MODIFICATION	4		3		2		0	
14 MINOR PROCESS MODIFICATION	2		1		1		4	
IV INNOVATIVE		9		7		0		0
15 R&D OR ENGINEERING	4		3		0		0	
16 RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	4		3		0		0	
17 RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	0		0		0		0	
18 NEW INVENTION	1		1		0		0	
GRAND TOTAL		59		39		28		45
PERCENTAGE OF MAXIMUM RATING (90 POINTS)		65.6%		43.3%		31.1%		50.0%

NOTES :
L.F.F. : LARGE FOREIGN FIRM
L.J.V. : LARGE JOINT VENTURE
M.J.V. : MEDIUM JOINT VENTURE
S.J.V. : SMALL JOINT VENTURE
L.T. : LARGE THAI FIRM
M.T. : MEDIUM THAI FIRM
S.T. : SMALL THAI FIRM

TABLE A1.4
TECHNOLOGICAL CAPABILITIES OF INDUSTRIAL ELECTRONICS PRODUCING FIRMS

FIRM NAME	IND 1		IND 2		IND 3		IND 4	
SIZE OF FIRM	S.T.		M.T.		S.J.V.		S.T.	
EXPORT ORIENTATION (YES/NO)	NO		NO		YES		YES	
PROMOTED STATUS (YES/NO)	NO		NO		YES		YES	
CAPABILITY	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL
I ACQUISITIVE		18		16		14		16
1 SEARCH	3		3		2		3	
2 ASSESMENT	3		3		2		3	
3 NEGOTIATION	3		3		2		3	
4 PROCUREMENT	3		3		2		3	
5 PLANT LAYOUT DESIGN	3		1		3		2	
6 INSTALLATION AND START UP	3		3		3		2	
II OPERATIVE		9		14		13		11
7 PROCESS OPERATION	1		2		3		2	
8 MAINTENANCE	1		3		3		3	
9 QUALITY CONTROL	2		3		3		3	
10 INVENTORY CONTROL	2		3		3		2	
11 MANPOWER DEVELOPMENT	3		3		1		1	
III ADAPTIVE		12		11		7		6
12 TECHNOLOGY DIGESTION OR PRODUCT IMITATION	4		4		3		2	
13 MINOR PRODUCT MODIFICATION	4		4		3		2	
14 MINOR PROCESS MODIFICATION	4		3		1		2	
IV INNOVATIVE		10		6		4		1
15 R&D OR ENGINEERING	3		3		2		1	
16 RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	4		2		1		0	
17 RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	2		1		1		0	
18 NEW INVENTION	1		0		0		0	
GRAND TOTAL		49		47		38		34
PERCENTAGE OF MAXIMUM RATING (90 POINTS)		54.4%		52.2%		42.2%		37.8%

NOTES :
L.F.F. : LARGE FOREIGN FIRM
L.J.V. : LARGE JOINT VENTURE
M.J.V. : MEDIUM JOINT VENTURE
S.J.V. : SMALL JOINT VENTURE
L.T. : LARGE THAI FIRM
M.T. : MEDIUM THAI FIRM
S.T. : SMALL THAI FIRM

TABLE A1.5
TECHNOLOGICAL CAPABILITIES OF ELECTRONIC COMPONENTS PRODUCING FIRMS

FIRM NAME	COMPO 1		COMPO 2		COMPO 3		COMPO 4		COMPO 5		COMPO 6		COMPO 7		COMPO 8		COMPO 9		COMPO 10	
SIZE OF FIRM	L.F.F.		M.T.		S.T.		L.F.F.		M.J.V.		L.F.F.		L.T.		L.F.F.		L.F.F.		L.J.V.	
EXPORT ORIENTATION (YES/NO)	YES		YES		NO		YES		YES		YES		YES		YES		YES		YES	
PROMOTED STATUS (YES/NO)	YES		YES		NO		YES		YES		YES		YES		YES		YES		YES	
CAPABILITY	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL
I ACQUISITIVE		14		23		8		22		19		6		24		22		6		17
1 SEARCH	2		4		1		3		3		1		4		3		1		3	
2 ASSESMENT	2		4		2		4		4		1		4		4		1		3	
3 NEGOTIATION	2		4		2		4		3		1		4		4		1		2	
4 PROCUREMENT	3		4		2		3		3		1		4		3		1		3	
5 PLANT LAYOUT DESIGN	3		3		1		4		3		1		4		4		1		3	
6 INSTALLATION AND START UP	2		4		0		4		3		1		4		4		1		3	
II OPERATIVE		21		14		8		25		20		25		21		25		17		17
7 PROCESS OPERATION	4		4		2		5		4		5		5		5		5		4	
8 MAINTENANCE	4		0		2		5		4		5		4		5		4		4	
9 QUALITY CONTROL	5		4		2		5		4		5		5		5		4		4	
10 INVENTORY CONTROL	4		4		1		5		4		5		4		5		4		3	
11 MANPOWER DEVELOPMENT	4		2		1		5		4		5		3		5		0		2	
III ADAPTIVE		2		9		2		11		9		2		9		10		2		8
12 TECHNOLOGY DIGESTION OR PRODUCT IMITATION	2		4		2		4		4		2		4		4		2		4	
13 MINOR PRODUCT MODIFICATION	0		4		0		3		4		0		3		3		0		4	
14 MINOR PROCESS MODIFICATION	0		1		0		4		1		0		2		3		0		0	
IV INNOVATIVE		2		3		1		6		2		1		1		5		0		0
15 R&D OR ENGINEERING	2		3		1		3		2		1		1		3		0		0	
16 RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	0		0		0		0		0		0		0		0		0		0	
17 RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	0		0		0		3		0		0		0		2		0		0	
18 NEW INVENTION	0		0		0		0		0		0		0		0		0		0	
GRAND TOTAL		39		49		19		64		50		34		55		62		25		42
PERCENTAGE OF MAXIMUM RATING (90 POINTS)		43.3%		54.4%		21.1%		71.1%		55.6%		37.8%		61.1%		68.9%		27.8%		46.7%

NOTES
L.F.F. : LARGE FOREIGN FIRM
L.J.V. : LARGE JOINT VENTURE
M.J.V. : MEDIUM JOINT VENTURE
S.J.V. : SMALL JOINT VENTURE
L.T. : LARGE THAI FIRM
M.T. : MEDIUM THAI FIRM
S.T. : SMALL THAI FIRM

TABLE A1.6

TECHNOLOGICAL CAPABILITIES OF COMPUTER SOFTWARE PRODUCING FIRMS

FIRM NAME	SOFTWARE 1		SOFTWARE 2		SOFTWARE 3	
SIZE OF FIRM	L.T.		M.T.		S.T.	
EXPORT ORIENTATION (YES/NO)	NO		NO		NO	
PROMOTED STATUS (YES/NO)	NO		NO		NO	
CAPABILITY	RATING	TOTAL	RATING	TOTAL	RATING	TOTAL
I ACQUISITIVE		23		22		14
1 SEARCH	4		4		2	
2 ASSESMENT	4		4		2	
3 NEGOTIATION	4		4		2	
4 PROCUREMENT	4		4		2	
5 PLANT LAYOUT DESIGN	4		3		3	
6 INSTALLATION AND START UP	3		3		3	
II OPERATIVE		17		16		15
7 PROCESS OPERATION	4		4		3	
8 MAINTENANCE	3		3		3	
9 QUALITY CONTROL	3		3		3	
10 INVENTORY CONTROL	3		2		3	
11 MANPOWER DEVELOPMENT	4		4		3	
III ADAPTIVE		11		11		11
12 TECHNOLOGY DIGESTION OR PRODUCT IMITATION	4		4		4	
13 MINOR PRODUCT MODIFICATION	4		4		4	
14 MINOR PROCESS MODIFICATION	3		3		3	
IV INNOVATIVE		10		10		7
15 R&D OR ENGINEERING	3		3		2	
16 RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	3		3		2	
17 RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	2		2		2	
18 NEW INVENTION	2		2		1	
GRAND TOTAL		61		59		47
PERCENTAGE OF MAXIMUM RATING (90 POINTS)		67.8%		65.6%		52.2%

NOTES : L.F.F. : LARGE FOREIGN FIRM
L.J.V. : LARGE JOINT VENTURE
M.J.V. : MEDIUM JOINT VENTURE
S.J.V.:SMALL J
L.T. : LARGE T
M.T. : MEDIUM
S.T. : SMALL T

TABLE A1.7
ACQUISITIVE CAPABILITY OF THE ELECTRONICS INDUSTRIES

INDUSTRY AREA	NUMBER OF FIRMS	AVERAGE RATINGS: SEARCH	ASSESSMENT	NEGOTIATION	PROCUREMENT	PLANT LAYOUT & DESIGN	INSTALLATION & START UP	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 CONSUMER ELECTRONICS	8	2.50	2.75	2.63	2.50	2.38	2.50	2.54	50.8%
2 COMMUNICATIONS EQUIP.	3	3.00	3.67	3.33	3.67	2.67	2.67	3.17	63.3%
3 COMPUTER HARDWARE	4	3.00	3.00	3.25	3.25	2.00	2.50	2.83	56.7%
4 INDUSTRIAL ELECTRONICS EQUIP.	4	2.75	2.75	2.75	2.75	2.25	2.75	2.67	53.3%
5 ELECTRONIC COMPONENTS	10	2.50	2.90	2.70	2.70	2.70	2.60	2.68	53.7%
6 COMPUTER SOFTWARE	3	3.33	3.33	3.33	3.33	3.33	3.00	3.28	65.6%
ALL FIRMS	32	2.72	2.97	2.88	2.88	2.53	2.63	2.77	55.3%
PERCENTAGE OF MAXIMUM SCORE		54.4%	59.4%	57.5%	57.5%	50.6%	52.5%	55.3%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.8
OPERATIVE CAPABILITY OF THE ELECTRONICS INDUSTRIES

INDUSTRY AREA	NUMBER OF FIRMS	AVERAGE RATINGS						PERCENTAGE OF MAXIMUM POSSIBLE RATING
		PROCESS OPERATION	MAINTENANCE	QUALITY CONTROL	INVENTORY CONTROL	MANPOWER DEVELOPMENT	OVERALL AVERAGE	
1 CONSUMER ELECTRONICS	8	2.88	2.75	2.75	2.88	2.63	2.78	55.5%
2 COMMUNICATIONS EQUIP.	3	3.00	3.00	3.67	3.33	3.00	3.20	64.0%
3 COMPUTER HARDWARE	4	3.00	3.00	2.75	2.75	3.00	2.90	58.0%
4 INDUSTRIAL ELECTRONICS EQUIP.	4	2.00	2.50	2.75	2.50	2.00	2.35	47.0%
5 ELECTRONIC COMPONENTS	10	4.30	3.70	4.30	3.90	3.10	3.86	77.2%
6 COMPUTER SOFTWARE	3	3.67	3.00	3.00	2.67	3.67	3.20	64.0%
ALL FIRMS	32	3.31	3.09	3.34	3.16	2.88	3.16	63.1%
PERCENTAGE OF MAXIMUM SCORE		66.3%	61.9%	66.9%	63.1%	57.5%	63.1%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.9
ADAPTIVE CAPABILITY OF THE ELECTRONICS INDUSTRIES

INDUSTRY AREA	NUMBER OF FIRMS	AVERAGE RATINGS: TECHNOLOGY DIGESTION/ PRODUCT IMITATION	MINOR PRODUCT MODIFICATION	MINOR PROCESS MODIFICATION	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 CONSUMER ELECTRONICS	8	2.75	2.38	1.63	2.25	45.0%
2 COMMUNICATIONS EQUIP.	3	3.00	2.67	2.00	2.56	51.1%
3 COMPUTER HARDWARE	4	3.00	2.25	2.00	2.42	48.3%
4 INDUSTRIAL ELECTRONICS EQUIP.	4	3.25	3.25	2.50	3.00	60.0%
5 ELECTRONIC COMPONENTS	10	3.20	2.10	1.10	2.13	42.7%
6 COMPUTER SOFTWARE	3	4.00	4.00	3.00	3.67	73.3%
ALL FIRMS	32	3.13	2.56	1.78	2.49	49.8%
PERCENTAGE OF MAXIMUM SCORE		62.5%	51.3%	35.6%	49.8%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.10
INNOVATIVE CAPABILITY OF THE ELECTRONICS INDUSTRIES

INDUSTRY AREA	NUMBER OF FIRMS	AVERAGE RATINGS: RESEARCH, DEVELOPMENT & ENGINEERING	AVERAGE RATINGS: RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	AVERAGE RATINGS: RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	AVERAGE RATINGS: NEW INVENTION	AVERAGE RATINGS: OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 CONSUMER ELECTRONICS	8	0.88	0.75	0.00	0.00	0.41	8.1%
2 COMMUNICATIONS EQUIP.	3	1.33	1.33	0.67	0.00	0.83	16.7%
3 COMPUTER HARDWARE	4	1.75	1.75	0.00	0.50	1.00	20.0%
4 INDUSTRIAL ELECTRONICS EQUIP.	4	2.25	1.75	1.00	0.25	1.31	26.3%
5 ELECTRONIC COMPONENTS	10	1.60	0.00	0.50	0.00	0.53	10.5%
6 COMPUTER SOFTWARE	3	2.67	2.67	2.00	1.67	2.25	45.0%
ALL FIRMS	32	1.59	1.00	0.53	0.25	0.84	16.9%
PERCENTAGE OF MAXIMUM SCORE		31.9%	20.0%	10.6%	5.0%	16.9%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.11

TECHNOLOGICAL CAPABILITIES BY FIRMS SIZE AND OWNERSHIP IN SUB-AREAS OF THE ELECTRONICS INDUSTRY

(A) ACQUISITIVE CAPABILITY

AREA \ SIZE & OWNERSHIP	FOREIGN FIRM	JOINT VENTURE	LARGE THAI	SMALL THAI
1. CONSUMER ELECTRONICS	30.0%	55.6%	60.0%	50.0%
(No. of Firm)	(1)	(3)	(1)	(3)
2. COMMUNICATION EQUIPMENT	63.3%	-	-	63.3%
(No. of Firm)	(1)			(2)
3. COMPUTER HARDWARE	66.7%	-	-	58.9%
(No. of Firm)	(2)			(2)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	-	46.7%	-	55.6%
(No. of Firm)		(1)		(3)
5. ELECTRONIC COMPONENTS	46.7%	60.0%	80.0%	51.7%
(No. of Firm)	(5)	(2)	(1)	(2)
6. COMPUTER SOFTWARE	-	-	76.7%	60.0%
(No. of Firm)			(1)	(2)

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

AREA \ SIZE & OWNERSHIP	FOREIGN FIRM	JOINT VENTURE	LARGE THAI	SMALL THAI
1. CONSUMER ELECTRONICS	80.0%	68.0%	40.0%	40.0%
(No. of Firm)	(1)	(3)	(1)	(3)
2. COMMUNICATION EQUIPMENT	84.0%	-	-	54.0%
(No. of Firm)	(1)			(2)
3. COMPUTER HARDWARE	76.0%	-	-	62.7%
(No. of Firm)	(2)			(2)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	-	52.0%	-	45.3%
(No. of Firm)		(1)		(3)
5. ELECTRONIC COMPONENTS	90.4%	74.0%	84.0%	55.0%
(No. of Firm)	(5)	(2)	(1)	(2)
6. COMPUTER SOFTWARE	-	-	68.0%	62.0%
(No. of Firm)			(1)	(2)

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

AREA / SIZE & OWNERSHIP	FOREIGN FIRM	JOINT VENTURE	LARGE THAI	SMALL THAI
1. CONSUMER ELECTRONICS (No. of Firm)	6.7% (1)	62.2% (3)	60.0% (1)	35.6% (3)
2. COMMUNICATION EQUIPMENT (No. of Firm)	66.7% (1)	-	-	43.3% (2)
3. COMPUTER HARDWARE (No. of Firm)	56.7% (2)	-	-	45.6% (2)
4. INDUSTRIAL ELECTRONICS EQUIPMENT (No. of Firm)	-	46.7% (1)	-	64.4% (3)
5. ELECTRONIC COMPONENTS (No. of Firm)	36.0% (5)	56.7% (2)	60.0% (1)	38.7% (2)
6. COMPUTER SOFTWARE (No. of Firm)	-	-	73.3% (1)	73.3% (2)

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

AREA / SIZE & OWNERSHIP	FOREIGN FIRM	JOINT VENTURE	LARGE THAI	SMALL THAI
1. CONSUMER ELECTRONICS (No. of Firm)	0.0% (1)	10.0% (3)	20.0% (1)	5.0% (3)
2. COMMUNICATION EQUIPMENT (No. of Firm)	0.0% (1)	-	-	25.0% (2)
3. COMPUTER HARDWARE (No. of Firm)	22.5% (2)	-	-	7.5% (2)
4. INDUSTRIAL ELECTRONICS EQUIPMENT (No. of Firm)	-	20.0% (1)	-	28.3% (3)
5. ELECTRONIC COMPONENTS (No. of Firm)	14.0% (5)	5.0% (2)	5.0% (1)	10.0% (2)
6. COMPUTER SOFTWARE (No. of Firm)	-	-	50.0% (1)	42.5% (2)

SOURCE : PRESENT SURVEY 1988

TABLE A1.12
TECHNOLOGICAL CAPABILITIES BY FIRM SIZE AND OWNERSHIP
(SHOWING SCORES OF COMPONENTS OF EACH CAPABILITY)

(A) ACQUISITIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE SCORES: SEARCH	ASSESSMENT	NEGOTIATION	PROCUREMENT	PLANT LAYOUT & DESIGN	INSTALLATION & START UP	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE SCORE
1 SMALL AND MEDIUM THAI FIRMS	14	2.79	2.93	3.07	2.93	2.14	2.43	2.71	54.3%
2 LARGE THAI FIRMS	3	3.67	3.67	3.67	3.67	3.67	3.33	3.61	72.2%
3 JOINT VENTURE FIRMS	6	2.67	3.00	2.50	2.67	2.83	3.00	2.78	55.6%
4 FOREIGN OWNED FIRMS	9	2.33	2.78	2.56	2.67	2.56	2.44	2.56	51.1%
ALL FIRMS	32	2.72	2.97	2.88	2.88	2.53	2.63	2.77	55.3%
PERCENTAGE OF MAXIMUM SCORE		54.4%	59.4%	57.5%	57.5%	50.6%	52.5%	55.3%	

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

INDUSTRY AREA	NUMBER OF FIRMS	AVERAGE RATINGS: PROCESS OPERATION	MAINTENANCE	QUALITY CONTROL	INVENTORY CONTROL	MANPOWER DEVELOPMENT	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	14	2.43	2.14	2.57	2.43	2.14	2.34	46.9%
2 LARGE THAI FIRMS	3	3.67	3.00	3.33	3.00	3.00	3.20	64.0%
3 JOINT VENTURE FIRMS	6	3.50	3.50	3.50	3.33	3.00	3.37	67.3%
4 FOREIGN OWNED FIRMS	9	4.44	4.33	4.44	4.22	3.89	4.27	85.3%
ALL FIRMS	32	3.31	3.09	3.34	3.16	2.88	3.16	63.1%
PERCENTAGE OF MAXIMUM SCORE		66.3%	61.9%	66.9%	63.1%	57.5%	63.1%	

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATINGS				PERCENTAGE OF MAXIMUM POSSIBLE RATING
		TECHNOLOGY DIGESTION/ PRODUCT IMITATION	MINOR PRODUCT MODIFICATION	MINOR PROCESS MODIFICATION	OVERALL AVERAGE	
1 SMALL AND MEDIUM THAI FIRMS	14	3.00	2.71	1.64	2.45	49.0%
2 LARGE THAI FIRMS	3	3.67	3.33	2.67	3.22	64.4%
3 JOINT VENTURE FIRMS	6	3.50	3.50	1.67	2.89	57.8%
4 FOREIGN OWNED FIRMS	9	2.89	1.44	1.78	2.04	40.7%
ALL FIRMS	32	3.13	2.56	1.78	2.49	49.8%
PERCENTAGE OF MAXIMUM SCORE		62.5%	51.3%	35.6%	49.8%	

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

INDUSTRY AREA	NUMBER OF FIRMS	AVERAGE RATINGS: RESEARCH, DEVELOPMENT & ENGINEERING	RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	RADICAL PROCESS MODIFICATION OR NEW PROCESS DESIGN	NEW INVENTION	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	14	1.71	1.43	0.64	0.36	1.04	20.7%
2 LARGE THAI FIRMS	3	2.00	1.67	0.67	0.67	1.25	25.0%
3 JOINT VENTURE FIRMS	6	1.33	0.50	0.17	0.00	0.50	10.0%
4 FOREIGN OWNED FIRMS	9	1.44	0.44	0.56	0.11	0.64	12.8%
ALL FIRMS	32	1.59	1.00	0.53	0.25	0.84	16.9%
PERCENTAGE OF MAXIMUM SCORE		31.9%	20.0%	10.6%	5.0%	16.9%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.13
TECHNOLOGICAL CAPABILITY BY FIRM SIZE AND OWNERSHIP
(OVERALL SCORES)

(A) ACQUISITIVE CAPABILITY

FIRM SIZE \ OWNERSHIP	THAI OWNER	JOINT VENTURE	FOREIGN FIRM
SMALL FIRM (No. of Firm)	47.6% (7)	46.7% (1)	-
MEDIUM FIRM (No. of Firm)	61.0% (7)	56.7% (3)	-
LARGE FIRM (No. of Firm)	72.2% (3)	58.3% (2)	51.1% (9)

NOTE. LARGE FIRM: WHEN MANPOWER > 300 OR REVENUE > 500 MB
MEDIUM FIRM: WHEN MANPOWER > 100 OR REVENUE > 50 MB
SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

FIRM SIZE \ OWNERSHIP	THAI OWNER	JOINT VENTURE	FOREIGN FIRM
SMALL FIRM (No. of Firm)	42.9% (7)	52.0% (1)	-
MEDIUM FIRM (No. of Firm)	50.9% (7)	73.3% (3)	-
LARGE FIRM (No. of Firm)	64.0% (3)	66.0% (2)	85.3% (9)

NOTE. LARGE FIRM: WHEN MANPOWER > 300 OR REVENUE > 500 MB
MEDIUM FIRM: WHEN MANPOWER > 100 OR REVENUE > 50 MB
SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

FIRM SIZE \ OWNERSHIP	THAI OWNER	JOINT VENTURE	FOREIGN FIRM
SMALL FIRM (No. of Firm)	47.6% (7)	46.7% (1)	-
MEDIUM FIRM (No. of Firm)	50.5% (7)	57.8% (3)	-
LARGE FIRM (No. of Firm)	64.4% (3)	63.3% (2)	40.7% (9)

NOTE. LARGE FIRM: WHEN MANPOWER > 300 OR REVENUE > 500 MB
MEDIUM FIRM: WHEN MANPOWER > 100 OR REVENUE > 50 MB
SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

FIRM SIZE \ OWNERSHIP	THAI OWNER	JOINT VENTURE	FOREIGN FIRM
SMALL FIRM (No. of Firm)	20.7% (7)	20.0% (1)	-
MEDIUM FIRM (No. of Firm)	20.7% (7)	5.0% (3)	-
LARGE FIRM (No. of Firm)	25.0% (3)	12.5% (2)	12.8% (9)

NOTE. LARGE FIRM: WHEN MANPOWER > 300 OR REVENUE > 500 MB
MEDIUM FIRM: WHEN MANPOWER > 100 OR REVENUE > 50 MB
SOURCE : PRESENT SURVEY 1988

TABLE A1.14

TECHNOLOGICAL CAPABILITIES BY BOI-PROMOTIONAL STATUS

(SHOWING CAPABILITIES IN DIFFERENT AREAS OF THE ELECTRONICS INDUSTRY)

(A) ACQUISITIVE CAPABILITY

AREA \ PROMOTIONAL STATUS	PROMOTED	NON-PROMOTED
1. CONSUMER ELECTRONICS	52.0%	48.9%
(No. of Firm)	(5)	(3)
2. COMMUNICATION EQUIPMENT	95.0%	53.3%
(No. of Firm)	(2)	(1)
3. COMPUTER HARDWARE	60.0%	55.6%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	50.0%	56.7%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	56.7%	26.7%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	65.6%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

AREA / PROMOTIONAL STATUS	PROMOTED	NON-PROMOTED
1. CONSUMER ELECTRONICS	58.4%	50.7%
(No. of Firm)	(5)	(3)
2. COMMUNICATION EQUIPMENT	96.0%	48.0%
(No. of Firm)	(2)	(1)
3. COMPUTER HARDWARE	80.0%	50.7%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	48.0%	46.0%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	82.2%	32.0%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	64.0%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

PROMOTIONAL STATUS / AREA	PROMOTED	NON-PROMOTED
1. CONSUMER ELECTRONICS	48.0%	40.0%
(No. of Firm)	(5)	(3)
2. COMMUNICATION EQUIPMENT	76.7%	46.7%
(No. of Firm)	(2)	(1)
3. COMPUTER HARDWARE	46.7%	48.9%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	43.3%	76.7%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	45.9%	13.3%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	73.3%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

AREA \ PROMOTIONAL STATUS	PROMOTED	NON-PROMOTED
1. CONSUMER ELECTRONICS	12.0%	1.7%
(No. of Firm)	(5)	(3)
2. COMMUNICATION EQUIPMENT	25.0%	15.0%
(No. of Firm)	(2)	(1)
3. COMPUTER HARDWARE	0.0%	26.7%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	12.5%	40.0%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	11.1%	5.0%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	45.0%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

TABLE A1.15
TECHNOLOGICAL CAPABILITIES OF BOI-PROMOTED FIRMS
(SHOWING SCORES OF COMPONENTS OF EACH CAPABILITY)

(A) AQUISITIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE SCORES							PERCENTAGE OF MAXIMUM POSSIBLE SCORE
		SEARCH	ASSESSMENT	NEGOTIATION	PROCUREMENT	PLANT LAYOUT & DESIGN	INSTALLATION & START UP	OVERALL AVERAGE	
1 SMALL AND MEDIUM THAI FIRMS	4	3.50	3.50	3.75	3.50	2.75	3.00	3.33	66.7%
2 LARGE THAI FIRMS	2	3.50	3.50	3.50	3.50	3.50	3.50	3.50	70.0%
3 JOINT VENTURE FIRMS	5	2.60	3.00	2.40	2.60	2.80	3.00	2.73	54.7%
4 FOREIGN OWNED FIRMS	8	2.13	2.63	2.38	2.50	2.50	2.38	2.42	48.3%
ALL FIRMS	19	2.68	3.00	2.79	2.84	2.74	2.79	2.81	56.1%
PERCENTAGE OF MAXIMUM SCORE		53.7%	60.0%	55.8%	56.8%	54.7%	55.8%	56.1%	

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: PROCESS OPERATION	MAINTENANCE	QUALITY CONTROL	INVENTORY CONTROL	MANPOWER DEVELOPMENT	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	4	3.00	2.00	3.00	3.00	3.00	2.80	56.0%
2 LARGE THAI FIRMS	2	3.50	3.00	3.50	3.00	2.50	3.10	62.0%
3 JOINT VENTURE FIRMS	5	3.40	3.40	3.40	3.20	2.80	3.24	64.8%
4 FOREIGN OWNED FIRMS	8	4.50	4.38	4.63	4.38	3.88	4.35	87.0%
ALL FIRMS	19	3.79	3.47	3.84	3.63	3.26	3.60	72.0%
PERCENTAGE OF MAXIMUM SCORE		75.8%	69.5%	76.8%	72.6%	65.3%	72.0%	

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING				PERCENTAGE OF MAXIMUM POSSIBLE RATING
		TECHNOLOGY DIGESTION/ PRODUCT IMITATION	MINOR PRODUCT MODIFICATION	MINOR PROCESS MODIFICATION	OVERALL AVERAGE	
1 SMALL AND MEDIUM THAI FIRMS	4	2.75	2.75	1.75	2.42	48.3%
2 LARGE THAI FIRMS	2	3.50	3.00	2.50	3.00	60.0%
3 JOINT VENTURE FIRMS	5	3.40	3.60	1.40	2.80	56.0%
4 FOREIGN OWNED FIRMS	8	2.75	1.13	1.75	1.88	37.5%
ALL FIRMS	19	3.00	2.32	1.74	2.35	47.0%
PERCENTAGE OF MAXIMUM SCORE		60.0%	46.3%	34.7%	47.0%	

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: RESEARCH, DEVELOPMENT & ENGINEERING	RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	MINOR PROCESS MODIFICATION OR NEW PROCESS DESIGN	NEW INVENTION	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	4	2.00	1.25	0.25	0.00	0.88	17.5%
2 LARGE THAI FIRMS	2	1.50	1.00	0.00	0.00	0.63	12.5%
3 JOINT VENTURE FIRMS	5	1.40	0.60	0.20	0.00	0.55	11.0%
4 FOREIGN OWNED FIRMS	8	1.13	0.00	0.63	0.00	0.44	8.8%
ALL FIRMS	19	1.42	0.53	0.37	0.00	0.58	11.6%
PERCENTAGE OF MAXIMUM SCORE		28.4%	10.5%	7.4%	0.0%	11.6%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.16
TECHNOLOGICAL CAPABILITIES OF NON-BOI-PROMOTED FIRMS
(SHOWING SCORES OF COMPONENTS OF EACH CAPABILITY)

(A) ACQUISITIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE SCORES: SEARCH	ASSESSMENT	NEGOTIATION	PROCUREMENT	PLANT LAYOUT & DESIGN	INSTALLATION & START UP	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE SCORE
1 SMALL AND MEDIUM THAI FIRMS	10	2.50	2.70	2.80	2.70	1.90	2.20	2.47	49.3%
2 LARGE THAI FIRMS	1	4.00	4.00	4.00	4.00	4.00	3.00	3.83	76.7%
3 JOINT VENTURE FIRMS	1	3.00	3.00	3.00	3.00	3.00	3.00	3.00	60.0%
4 FOREIGN OWNED FIRMS	1	4.00	4.00	4.00	4.00	3.00	3.00	3.67	73.3%
ALL FIRMS	13	2.77	2.92	3.00	2.92	2.23	2.38	2.71	54.1%
PERCENTAGE OF MAXIMUM SCORE		55.4%	58.5%	60.0%	58.5%	44.6%	47.7%	54.1%	

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: PROCESS OPERATION	MAINTENANCE	QUALITY CONTROL	INVENTORY CONTROL	MANPOWER DEVELOPMENT	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	10	2.20	2.20	2.40	2.20	2.20	2.24	44.8%
2 LARGE THAI FIRMS	1	4.00	3.00	3.00	3.00	4.00	3.40	68.0%
3 JOINT VENTURE FIRMS	1	4.00	4.00	4.00	4.00	4.00	4.00	80.0%
4 FOREIGN OWNED FIRMS	1	4.00	4.00	3.00	3.00	4.00	3.60	72.0%
ALL FIRMS	13	2.62	2.54	2.62	2.46	2.62	2.57	51.4%
PERCENTAGE OF MAXIMUM SCORE		52.3%	50.8%	52.3%	49.2%	52.3%	51.4%	

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: TECHNOLOGY DIGESTION/ PRODUCT IMITATION	AVERAGE RATING: MINOR PRODUCT MODIFICATION	AVERAGE RATING: MINOR PROCESS MODIFICATION	AVERAGE RATING: OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	10	3.10	2.70	1.60	2.47	49.3%
2 LARGE THAI FIRMS	1	4.00	4.00	3.00	3.67	73.3%
3 JOINT VENTURE FIRMS	1	4.00	3.00	3.00	3.33	66.7%
4 FOREIGN OWNED FIRMS	1	4.00	4.00	2.00	3.33	66.7%
ALL FIRMS	13	3.31	2.92	1.85	2.69	53.8%
PERCENTAGE OF MAXIMUM SCORE		66.2%	58.5%	36.9%	53.8%	

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: RESEARCH, DEVELOPMENT & ENGINEERING	AVERAGE RATING: RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	AVERAGE RATING: MINOR PROCESS MODIFICATION OR NEW PROCESS DESIGN	AVERAGE RATING: NEW INVENTION	AVERAGE RATING: OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	10	1.60	1.50	0.80	0.50	1.10	22.0%
2 LARGE THAI FIRMS	1	3.00	3.00	2.00	2.00	2.50	50.0%
3 JOINT VENTURE FIRMS	1	1.00	0.00	0.00	0.00	0.25	5.0%
4 FOREIGN OWNED FIRMS	1	4.00	4.00	0.00	1.00	2.25	45.0%
ALL FIRMS	13	1.85	1.69	0.77	0.62	1.23	24.6%
PERCENTAGE OF MAXIMUM SCORE		36.9%	33.8%	15.4%	12.3%	24.6%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.17
TECHNOLOGICAL CAPABILITIES BY BOI-PROMOTIONAL STATUS
(OVERALL SCORES)

(A) ACQUISITIVE CAPABILITY

SIZE & OWNERSHIP \ PROMOTIONAL STATUS	PROMOTED	NON-PROMOTED
1. FOREIGN OWNED FIRMS	48.3%	73.3%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	54.7%	60.0%
(No. of Firm)	(5)	(1)
3. LARGE THAI FIRMS	70.0%	76.7%
(No. of Firm)	(2)	(1)
4. SMALL & MEDIUM THAI FIRMS	66.7%	49.3%
(No. of Firm)	(4)	(10)

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

SIZE & OWNERSHIP \ PROMOTIONAL STATUS	PROMOTED	NON-PROMOTED
1. FOREIGN OWNED FIRMS	87.0%	72.0%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	64.8%	80.0%
(No. of Firm)	(5)	(1)
3. LARGE THAI FIRMS	62.0%	68.0%
(No. of Firm)	(2)	(1)
4. SMALL & MEDIUM THAI FIRMS	52.0%	44.8%
(No. of Firm)	(4)	(10)

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

SIZE & OWNERSHIP / PROMOTIONAL STATUS	PROMOTED	NON-PROMOTED
1. FOREIGN OWNED FIRMS	37.5%	66.7%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	56.0%	66.7%
(No. of Firm)	(5)	(1)
3. LARGE THAI FIRMS	60.0%	73.3%
(No. of Firm)	(2)	(1)
4. SMALL & MEDIUM THAI FIRMS	48.3%	49.3%
(No. of Firm)	(4)	(10)

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

SIZE & OWNERSHIP / PROMOTIONAL STATUS	PROMOTED	NON-PROMOTED
1. FOREIGN OWNED FIRMS	8.8%	45.0%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	11.0%	5.0%
(No. of Firm)	(5)	(1)
3. LARGE THAI FIRMS	12.5%	50.0%
(No. of Firm)	(2)	(1)
4. SMALL & MEDIUM THAI FIRMS	17.5%	22.0%
(No. of Firm)	(4)	(10)

SOURCE : PRESENT SURVEY 1988

TABLE A1.18
TECHNOLOGICAL CAPABILITIES OF EXPORT-ORIENTED FIRMS
(SHOWING SCORES OF COMPONENTS OF EACH CAPABILITY)

(A) ACQUISITIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE SCORES							PERCENTAGE OF MAXIMUM POSSIBLE SCORE
		SEARCH	ASSESSMENT	NEGOTIATION	PROCUREMENT	PLANT LAYOUT & DESIGN	INSTALLATION & START UP	OVERALL AVERAGE	
1 SMALL AND MEDIUM THAI FIRMS	2	3.50	3.50	3.50	3.50	2.50	3.00	3.25	65.0%
2 LARGE THAI FIRMS	1	4.00	4.00	4.00	4.00	4.00	4.00	4.00	80.0%
3 JOINT VENTURE FIRMS	3	2.67	3.00	2.33	2.67	3.00	3.00	2.78	55.6%
4 FOREIGN OWNED FIRMS	8	2.13	2.63	2.38	2.50	2.50	3.00	2.52	50.4%
ALL FIRMS	14	2.57	2.93	2.64	2.79	2.71	3.07	2.79	55.7%
PERCENTAGE OF MAXIMUM SCORE		51.4%	58.6%	52.9%	55.7%	54.3%	61.4%	55.7%	

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE SCORES: PROCESS OPERATION	MAINTENANCE	QUALITY CONTROL	INVENTORY CONTROL	MANPOWER DEVELOPMENT	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	2	3.00	1.50	3.50	3.00	1.50	2.50	50.0%
2 LARGE THAI FIRMS	1	5.00	4.00	5.00	4.00	3.00	4.20	84.0%
3 JOINT VENTURE FIRMS	3	3.67	3.67	3.67	3.33	2.33	3.33	66.7%
4 FOREIGN OWNED FIRMS	8	4.50	4.38	4.63	4.38	3.88	4.35	87.0%
ALL FIRMS	14	4.14	3.79	4.29	3.93	3.14	3.86	77.1%
PERCENTAGE OF MAXIMUM SCORE		82.9%	75.7%	85.7%	78.6%	62.9%	77.1%	

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: TECHNOLOGY DEGESTION/ PRODUCT IMITION	AVERAGE RATING: MINOR PRODUCT MODIFICATION	AVERAGE RATING: MINOR PROCESS MODIFICATION	AVERAGE RATING: OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	2	3.00	3.00	1.50	2.50	50.0%
2 LARGE THAI FIRMS	1	4.00	3.00	2.00	3.00	60.0%
3 JOINT VENTURE FIRMS	3	3.67	3.67	0.67	2.67	53.3%
4 FOREIGN OWNED FIRMS	8	2.75	1.13	1.75	1.88	37.5%
ALL FIRMS	14	3.07	2.07	1.50	2.21	44.3%
PERCENTAGE OF MAXIMUM SCORE		61.4%	41.4%	30.0%	44.3%	

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: RESEARCH, DEVELOPMENT & ENGINEERING	RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	MINOR PROCESS MODIFICATION OR NEW PROCESS DESIGN	NEW INVENTION	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	2	2.00	0.00	0.00	0.00	0.50	10.0%
2 LARGE THAI FIRMS	1	1.00	0.00	0.00	0.00	0.25	5.0%
3 JOINT VENTURE FIRMS	3	1.33	0.33	0.33	0.00	0.50	10.0%
4 FOREIGN OWNED FIRMS	8	1.13	0.00	0.63	0.00	0.44	8.8%
ALL FIRMS	14	1.29	0.07	0.43	0.00	0.45	8.9%
PERCENTAGE OF MAXIMUM SCORE		25.7%	1.4%	8.6%	0.0%	8.9%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.19
TECHNOLOGICAL CAPABILITY OF NON-EXPORT ORIENTED FIRMS
(SHOWING AREAS OF COMPONENTS OF EACH CAPABILITY

(A) ACQUISITIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE SCORES: SEARCH	ASSESMENT	NEGOTIATION	PROCUREMENT	PLANT LAYOUT & DESIGN	INSTALLATION & START UP	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE SCORE
1 SMALL AND MEDIUM THAI FIRMS	12	2.67	2.83	3.00	2.83	2.08	2.33	2.63	52.5%
2 LARGE THAI FIRMS	2	3.50	3.50	3.50	3.50	3.50	3.00	3.42	68.3%
3 JOINT VENTURE FIRMS	3	2.67	3.00	2.67	2.67	2.67	3.00	2.78	55.6%
4 FOREIGN OWNED FIRMS	1	4.00	4.00	4.00	4.00	3.00	3.00	3.67	73.3%
ALL FIRMS	18	2.83	3.00	3.06	2.94	2.39	2.56	2.80	55.9%
PERCENTAGE OF MAXIMUM SCORE		56.7%	60.0%	61.1%	58.9%	47.8%	51.1%	55.9%	

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE SCORES: PROCESS OPERATION	MAINTENANCE	QUALITY CONTROL	INVENTORY CONTROL	MANPOWER DEVELOPMENT	OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	12	2.33	2.25	2.42	2.33	2.25	2.32	46.3%
2 LARGE THAI FIRMS	2	3.00	2.50	2.50	2.50	3.00	2.70	54.0%
3 JOINT VENTURE FIRMS	3	3.33	3.33	3.33	3.33	3.67	3.40	68.0%
4 FOREIGN OWNED FIRMS	1	4.00	4.00	3.00	3.00	4.00	3.60	72.0%
ALL FIRMS	18	2.67	2.56	2.61	2.56	2.67	2.61	52.2%
PERCENTAGE OF MAXIMUM SCORE		53.3%	51.1%	52.2%	51.1%	53.3%	52.2%	

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: TECHNOLOGY DEGESTION/ PRODUCT IMITION	AVERAGE RATING: MINOR PRODUCT MODIFICATION	AVERAGE RATING: MINOR PROCESS MODIFICATION	AVERAGE RATING: OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	2	3.00	2.67	1.67	2.44	48.9%
2 LARGE THAI FIRMS	1	3.50	3.50	3.00	3.33	66.7%
3 JOINT VENTURE FIRMS	3	3.33	3.33	2.67	3.11	62.2%
4 FOREIGN OWNED FIRMS	8	4.00	4.00	2.00	3.33	66.7%
ALL FIRMS	14	3.17	2.94	2.00	2.70	54.1%
PERCENTAGE OF MAXIMUM SCORE		63.3%	58.9%	40.0%	54.1%	

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

TYPE OF FIRM	NUMBER OF FIRMS	AVERAGE RATING: RESEARCH, DEVELOPMENT & ENGINEERING	AVERAGE RATING: RADICAL PRODUCT MODIFICATION OR NEW MODEL DESIGN	AVERAGE RATING: MINOR PROCESS MODIFICATION OR NEW PROCESS DESIGN	AVERAGE RATING: NEW INVENTION	AVERAGE RATING: OVERALL AVERAGE	PERCENTAGE OF MAXIMUM POSSIBLE RATING
1 SMALL AND MEDIUM THAI FIRMS	2	1.67	1.67	0.75	0.42	1.13	22.5%
2 LARGE THAI FIRMS	1	2.50	2.50	1.00	1.00	1.75	35.0%
3 JOINT VENTURE FIRMS	3	1.33	0.67	0.00	0.00	0.50	10.0%
4 FOREIGN OWNED FIRMS	8	4.00	4.00	0.00	1.00	2.25	45.0%
ALL FIRMS	14	1.83	1.72	0.61	0.44	1.15	23.1%
PERCENTAGE OF MAXIMUM SCORE		36.7%	34.4%	12.2%	8.9%	23.1%	

SOURCE : PRESENT SURVEY 1988

TABLE A1.20

TECHNOLOGICAL CAPABILITIES BY EXPORT ORIENTATION

(SHOWING CAPABILITIES IN DIFFERENT AREAS OF THE ELECTRONICS INDUSTRY)

(A) ACQUISITIVE CAPABILITY

AREA / EXPORT OREINTATION	EXPORT	NON-EXPORT
1. CONSUMER ELECTRONICS	30.0%	53.8%
(No. of Firm)	(1)	(7)
2. COMMUNICATION EQUIPMENT	63.3%	63.3%
(No. of Firm)	(1)	(2)
3. COMPUTER HARDWARE	60.0%	55.6%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	50.0%	56.7%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	56.7%	26.7%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	65.6%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

AREA / EXPORT OREINTATION	EXPORT	NON-EXPORT
1. CONSUMER ELECTRONICS	80.0%	52.0%
(No. of Firm)	(1)	(7)
2. COMMUNICATION EQUIPMENT	84.0%	54.0%
(No. of Firm)	(1)	(2)
3. COMPUTER HARDWARE	80.0%	50.7%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	48.0%	46.0%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	82.2%	32.0%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	64.0%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

EXPORT OREINTATION AREA	EXPORT	NON-EXPORT
1. CONSUMER ELECTRONICS	6.7%	62.9%
(No. of Firm)	(1)	(7)
2. COMMUNICATION EQUIPMENT	66.7%	43.3%
(No. of Firm)	(1)	(2)
3. COMPUTER HARDWARE	46.7%	48.9%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	43.3%	76.7%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	45.9%	13.3%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	73.3%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

EXPORT OREINTATION AREA	EXPORT	NON-EXPORT
1. CONSUMER ELECTRONICS	0.0%	9.3%
(No. of Firm)	(1)	(7)
2. COMMUNICATION EQUIPMENT	0.0%	25.0%
(No. of Firm)	(1)	(2)
3. COMPUTER HARDWARE	0.0%	26.7%
(No. of Firm)	(1)	(3)
4. INDUSTRIAL ELECTRONICS EQUIPMENT	12.5%	40.0%
(No. of Firm)	(2)	(2)
5. ELECTRONIC COMPONENT	11.1%	5.0%
(No. of Firm)	(9)	(1)
6. COMPUTER SOFTWARE	-	45.0%
(No. of Firm)		(3)

SOURCE : PRESENT SURVEY 1988

TABLE A1.21
TECHNOLOGICAL CAPABILITIES BY EXPORT ORIENTATION
(OVERALL SCORES)

(A) ACQUISITIVE CAPABILITY

SIZE & OWNERSHIP / EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. FOREIGN OWNED FIRMS	48.3%	73.3%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	55.6%	55.6%
(No. of Firm)	(3)	(3)
3. LARGE THAI FIRMS	80.0%	68.3%
(No. of Firm)	(1)	(2)
4. SMALL & MEDIUM THAI FIRMS	65.0%	52.5%
(No. of Firm)	(2)	(12)

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

SIZE & OWNERSHIP / EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. FOREIGN OWNED FIRMS	87.0%	72.0%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	66.7%	68.0%
(No. of Firm)	(3)	(3)
3. LARGE THAI FIRMS	84.0%	54.0%
(No. of Firm)	(1)	(2)
4. SMALL & MEDIUM THAI FIRMS	50.0%	46.3%
(No. of Firm)	(2)	(12)

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

SIZE & OWNERSHIP \ EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. FOREIGN OWNED FIRMS	37.5%	66.7%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	53.3%	62.2%
(No. of Firm)	(3)	(3)
3. LARGE THAI FIRMS	60.0%	66.7%
(No. of Firm)	(1)	(2)
4. SMALL & MEDIUM THAI FIRMS	50.0%	48.9%
(No. of Firm)	(2)	(12)

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

SIZE & OWNERSHIP \ EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. FOREIGN OWNED FIRMS	8.8%	45.0%
(No. of Firm)	(8)	(1)
2. JOINT VENTURE FIRMS	10.0%	10.0%
(No. of Firm)	(3)	(3)
3. LARGE THAI FIRMS	5.0%	35.0%
(No. of Firm)	(1)	(2)
4. SMALL & MEDIUM THAI FIRMS	10.0%	22.5%
(No. of Firm)	(2)	(12)

SOURCE : PRESENT SURVEY 1988

TABLE A1.22
TECHNOLOGICAL CAPABILITIES OF PROMOTED FIRMS VERSUS EXPORT ORIENTED FIRMS

(A) ACQUISITIVE CAPABILITY

PROMOTIONAL STATUS \ EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. PROMOTED	55.0%	60.7%
(No. of Firm)	(14)	(5)
2. NON-PROMOTED	-	54.1%
(No. of Firm)		(13)

SOURCE : PRESENT SURVEY 1988

(B) OPERATIVE CAPABILITY

PROMOTIONAL STATUS \ EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. PROMOTED	76.9%	54.4%
(No. of Firm)	(14)	(5)
2. NON-PROMOTED	-	51.4%
(No. of Firm)		(13)

SOURCE : PRESENT SURVEY 1988

(C) ADAPTIVE CAPABILITY

PROMOTIONAL STATUS \ EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. PROMOTED	44.3%	54.7%
(No. of Firm)	(14)	(5)
2. NON-PROMOTED	-	53.8%
(No. of Firm)		(13)

SOURCE : PRESENT SURVEY 1988

(D) INNOVATIVE CAPABILITY

PROMOTIONAL STATUS \ EXPORT ORIENTATION	EXPORT	NON-EXPORT
1. PROMOTED	8.9%	19.0%
(No. of Firm)	(14)	(5)
2. NON-PROMOTED	-	24.6%
(No. of Firm)		(13)

SOURCE : PRESENT SURVEY 1988