Private Sector R&D: Lessons from the Success

Thailand Development Research Institute Foundation

Final Report

PRIVATE SECTOR R&D: "LESSONS FROM THE SUCCESS"

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EXECUTIVE SUMMARY

Although many countries have struggled to abolish poverty and generate prosperity, in recent history, only a few of them have been successful like Japan and the Asian NICs. Apart from other factors, technology development is becoming very critical. Experiences of the Asian Pacific Rim economies clearly suggest that in order to generate and sustain economic growth, R&D and other technical activities be needed. Nevertheless, these initially require government supports for S&T infrastructure, tax and financial incentives, and legal and policy frameworks. Also, commitments to technical change generation of the firms are equally important.

These are precisely the weaknesses of Thailand's industrial development which constitutes little R&D and other technical activities. This, in turn, tends to result in low technological capability and competitive ability of the firms.

At present, the following points can be summarized:

1. Thailand's R&D expenditure stands the lowest among the Asian Pacific Rim economies, both in terms of the total amount of expenditures and percentage of GNP.

2. The private sector R&D expenditures in Thailand is also ranked the lowest, both in terms of percentage of the total country's R&D expenditures and percentage of total sales.

3. In general, R&D activity in the private sector does improve the firm's technical efficiency and to the lesser extent profitability.

4. R&D activity alone is not a guarantee of success. Many more technical and very importantly marketing activities are needed.

5. Decisions to undertake R&D activity in the private sector are affected by both market environments (market and technical conditions) and internal factors (production and technological bases). Whilst the former affected by government policy, the latter is largely conditioned by the owner/manager perception and experience and worker skills and knowledge.

6. No clear effects of public support systems for private sector R&D in Thailand. The firms largely depends upon themselves and to some extent their foreign partners.

7. Firm characteristics do not always rule strategies and performances. Firms having similar characteristics can be dissimilar with reference to business and technology strategies, and hence their efficiency and profitability.

Therefore, if Thailand is committed to her industrial development, two essential questions must be addressed. One is how to increase technological contents of industrial firms in product and process improvements in the short term. The other is how to encourage them to further undertake R&D and other technical activities to build up capability to sustain growth in the longer run.

Recommendations stemming out from the study are as follows:

1. Policy instruments should comprise:
   - Laws for promotion of private sector R&D in order to share resources among government institutions, universities, and private firms.
   - Funds for promotion of productivity improvement and product development, in particular products for export.
   - Measures to promote potential industrial sectors and/or products.

2. Market mechanisms should consist of:
   - Gradual abolishment of industrial subsidies, ranging from import bans, local contents, export requirements, and high tariffs.

- Ensuring equal information among industrial firms, in particular public information such as policies, plans, measures, targets, movements, etc.

3. Institutional reforms should be composed of:
   - Concerting joint tasks for industrial development between private firms and three main government bodies, Ministry of Commerce, Industry, and Science, Technology and Environment.
   - Synchronizing services related to S&T infrastructure in particular S&T services such as standards, testing, training, and information services.
   - Relating technology development with other industrial and technical activities, namely, manufacturing, marketing, financing, servicing, and supporting activities.

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1.1 INTRODUCTION

Although many countries have struggled to abolish poverty and generate prosperity, in recent history, only a few of them have been successful like Japan and the Asian NICs. Apart from other factors, technology is becoming increasingly critical to the success or failure of development (see Porter 1990). Experiences of the Far East economies clearly suggest that in order to generate and sustain economic growth, technical change is needed. However, this requires strong government support of R&D, tax and fiscal incentives, and supply of qualified manpower. Also, it requires a commitment to technical change generation of the firms based upon their internal production and technological bases (see Tiralap et al. 1990).

These are precisely the weaknesses of Thailand's industrial structure which lead to little R&D and other technological activities, and thereby low technological capability and competitiveness of the country. Therefore, if Thailand is committed to her industrial development, two essential questions must be addressed. One is how to increase technological contents of manufacturing activities to improve productivity and competitiveness in the short and medium term. The other is how to encourage those industrial firms to further undertake R&D and other technological activities to build up capability to sustain growth in the longer run.

1.2 THE UNDERLYING PROBLEMS

In general, although many industrialized and newly industrialized countries have increasingly recognized research and development (R&D) as a crucial factor underlying the country's competitive edge, they frequently remain reluctant to invest in R&D. Reasons are two fold: one is the uncertainty of the return on individual projects of R&D (see Freeman 1982 and Porter 1985). The second is the complex nature of the R&D process before R&D results can be commercially harvested (see Rosenberg 1982 and Dasgupta and

Stoneman (eds.) 1987). In recent history, only a few countries have managed to be successful like Japan and the Asian NICs. They are not successful because of R&D alone technology is becoming increasingly critical to the success or failure of development (see Porter 1990).

Experiences of the Far East economies clearly suggest that in order to generate and sustain economic growth, technical change is needed. However, this requires strong government support of R&D, tax and fiscal incentives, and supply of qualified manpower. Also, it requires a commitment to technical change generation of the firms based upon their internal production and technological bases (see Tiralap et al. 1990). These are precisely the weaknesses of Thailand's industrial structure which lead to little R&D and other technological activities, and thereby low technological capability and competitiveness of industrial firms.

In Thailand, it can be said that non-price competition through R&D in the industrial sector is very new and not widely encountered. The overall public sector spending on R&D was only 0.17 percent of the country's GNP in 1989, compared with 1.82 percent of Korea's and 2.89 percent of Japan's. Of this expenditure in 1989 (about US$ 100 million), government only spent US$ 6 million for industry-related research. More interestingly, R&D expenditure in the private sector was even lower (see table 1.1). The estimated figure was about 0.13 percent of total sales in 1990, compared to 2.1 percent in Korea in 1990, 3.29 percent in 1989 in Japan, and 4.8 percent in the U.S. in 1988 (see figure 1.1).

Not surprisingly, a TDRI's study on "The Development of Thailand's Technological Capability in Industry" (see TDRI 1989) concluded that, in general, industrial firms in Thailand were technologically weak. They were largely capable of production activities, but neither adaptation nor innovation. Sizes, ownership structures, and business lines did not alter much of these findings.

Table 1.1 : R&D Expenditures

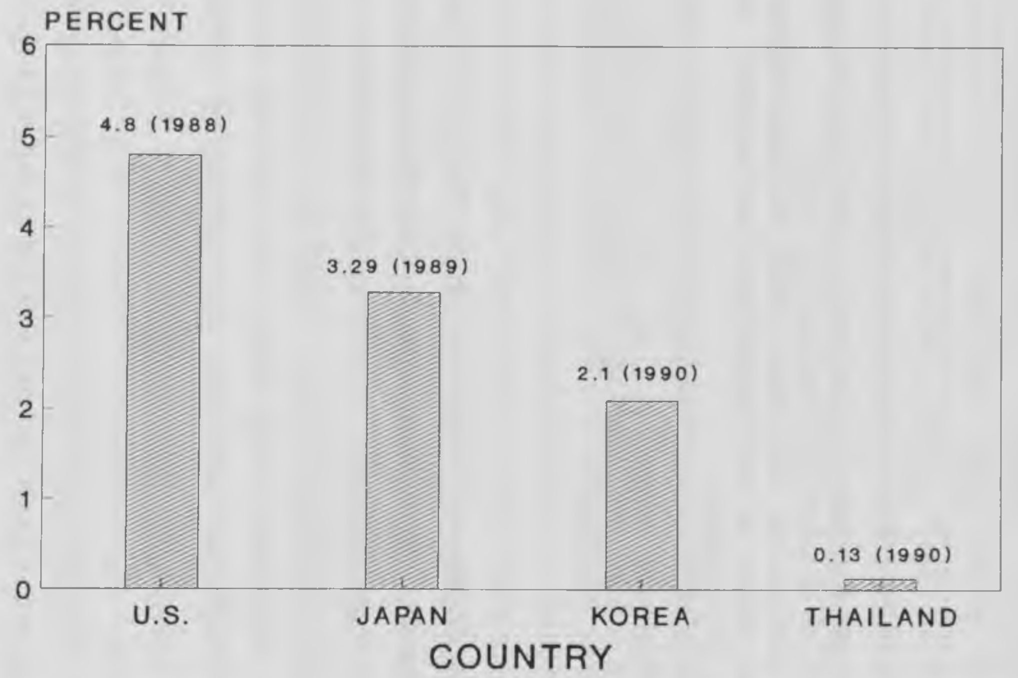
Country	R&D Expenditures (US $ million)	R&D as % of GNP	Share of Private sector
Japan (1988)	68,008	2.85	82.0
Korea (1988)	3,258	1.90	82.3
Taiwan (1988)	1,553	1.22	43.5
Singapore (1990)	366	0.90	59.0
Malaysia (1990)	293	0.80	10.0
Thailand (1989)	113	0.17	5.5

Source : 1. Science and Engineering Indicators, National Science Board, Japan
2. Ministry of Science and Technology, Korea
3. Taiwan Statistical Data Book, 1989, National Science Council
4. National Survey of R&D Expenditure and Manpower 1987/88, Science Council of Singapore
5. Pre-Consultation on S&T Strategies for Long-term Development Perspectives
6. Research Policy and Planning Division, The National Research Council of Thailand

Another TDRI's study on "Enhancing Private Sector R&D in Thailand" (see TDRI 1990) found a number of difficulties in conducting R&D in private firms. First, the national organizational infrastructure for R&D was apparently inadequate, as was the availability of information on technical activities in the public sector. There was a high demand for technical consultancy services, testing and calibration services, and supplies of technical information.

Second, there was also a clear shortage of technical manpower to satisfy present levels of demand for production engineers and technicians, who were necessary for implementing and operating imported "off-the shelf" technology. Although there is, paradoxically, no obvious shortage of R&D personnel, this is more due to the underactivity in R&D on the part of Thai companies, than to oversupply of graduates skilled in R&D.

Figure 1.1 : Private Sector R&D Expenditure of Total Sales



Source : 1. Agence France-Presse, The Nation October 21, 1991.

2. The National Research Council of Thailand

Third, despite the scarcity of R&D funds from public sector for private companies, they remained under-utilized. Reasons were that firstly, industrial firms were not aware of the various loan and grant programmes in the public sector. Secondly, the preparation of detailed R&D proposals was beyond the capability of many small firms. Thirdly, the loans were unattractive because they were fully repayable and required the same collateral as did any standard loan from a commercial bank.

Owing to these constraints caused by the weaknesses of the country's support systems for private sector R&D, for example, only a handful of electronics firms presently engaged in R&D activities. That is to say, about a half of the firms in the industry did not engage in any product/process imitation and adaptation at all. The remaining varied in the degree of adaptive activities. Only a quarter of the total firms in the industry had some sorts of R&D activities. However, it was found that although these R&D activities were largely imitative and adaptive, they yielded tremendous benefits to the firms (see Tiralap 1990).

These are, in fact, the questions of technology strategy adopted by the firms, the evolution of technical and business performance of the firms, and public policy on private sector R&D. Without good understanding on the way in which and the extent to which the availability of R&D funds, services, and researchers in the public sector affect the rate and direction of technical change and growth of the firms, public policy relating to private sector R&D cannot be effective, and hence the increases of productivity, technological capability, and international competitiveness. And importantly, this is an area which has been insufficiently investigated in Thailand and requires an in-depth analysis at the firm level.

1.3 OBJECTIVES OF THE STUDY

The ultimate goal of this study is to increase understanding of and to influence public policy relating to private sector R&D in Thailand. In this respect, learning and taking lessons from industrial firms, which are "successful" in both technical and business performance based upon their R&D activity, is very appropriate. In addition, understanding the public support systems for private sector R&D and the evolution of technical and business performance of the firms can, at least, yield valuable inputs for S&T policy planners and R&D funding agencies in order to create public instruments, market mechanisms, and institutional reforms for enhancing private sector R&D. In order to do so, detailed objectives are listed below:

a) To examine firms' constraints to R&D and technical change activities, in particular, supply-side constraints in the form of personnel shortages and inadequate technological infrastructure and services.

b) To examine the relationships between firms' R&D and technical change activities and their technical and business performance:

- Technical performance on production efficiency (e.g. production time, lead time, defect rate, and inventory time) and on product change (e.g. changes and improvements in qualities, appearances, and functions).
- Business performance on market shares, turnovers, profits, and growth.

c) To examine the impacts of current public support systems on management style and R&D and technical change activities of the firms.

- Firm behavior on management, production, marketing, finance, and human resource development.
- Firm strategy on R&D investment, and initiation and execution of the R&D projects, and utilization of R&D results.

d) To examine the spill-over effects of R&D and technical change activities on value-added, foreign currency, and employment generation.

e) To formulate policy recommendations for R&D funding agencies in order to create public instruments, market mechanisms, and institutional reforms for enhancing private sector R&D.

1.4 EXPECTED RESULTS

Results and impacts expected to be achieved by this study is to increase a better public understanding on the private sector R&D and its support system including the supply of S&T manpower and technical services in Thailand.

a) Increased understanding of the relationships between the public support systems for private sector R&D and the evolution of technical and business performance of the firms.

b) An in-depth study of firm behavior, strategy, and performance as a result of R&D and technical change activities and their complex nature.

c) First-hand data and case studies on R&D and technical change activities at the firm level.

d) Policy recommendations for enhancing private sector R&D for policy-makers, in general, and R&D funding agencies under the Ministry of Science, Technology and Energy, in particular.

1.5 ORGANIZATION OF THE STUDY

The study composes of six chapters in total.

Chapter One aims to brief the general problems regarding the private sector R&D, the study's objectives, and organization of the report for the subsequent examination.

Chapter Two provides an analytical framework comprising the study's theoretical ground, scope and terminology, and methodology for detailed examination.

Chapter Three sketches out a country-comparison private sector R&D in the Asian Pacific Rim economies. Four dimensions are highlighted: policy and legal frameworks, tax and financial incentives, technical and R&D services, and S&T manpower supply.

Chapter Four, Five and Six deal with case studies of three different technology-based industries; biotechnology, material technology, and micro-electronic technology. In each technology-based industry, three pairs of similar firms are examined to discover implications of R&D activity within firms to their own technical and business performances.

Chapter Seven is a synthesis chapter. Four main questions are delineated as follows: first, whether R&D activity gives rise to better firm performance; second, what makes firms carrying out R&D; third, whether government's support is crucial to private sector R&D, if any; and fourth, what are the constraints of private sector R&D.

Chapter Eight is a conclusion and recommendation chapter. It attempts to highlight the main findings and propose practical policy recommendations to policy planners and funding agencies dealing with private sector R&D.

CHAPTER 2: THE FRAMEWORK OF ANALYSIS

2.1 INTRODUCTION

Embarking upon an empirical study of the electronic industry in Thailand (Tiralap, 1990), firms in the industry can technologically be classified into four groups: progressive, progressing, stagnant, and declining firms. The main differences are largely confined to their technical and hence business performances. Firms which are active in carrying out technical change activity (including R&D) tend to achieve higher technical efficiency and better business results.

a) Progressive firms are largely those very active in carrying out technical change activity. Although the progressive firms do not try to be the first in the world, they cannot afford to be left behind in production technology by adopting a defensive R&D strategy. They have strengths and skills in production technology and try by every means to improve through in-house R&D and engineering activity. These are the main factors in technical progress and hence business growth.

b) Progressing firms are those inactive in undertaking technical change activity at the beginning. They are the followers of the leaders in established technology by adopting imitative R&D strategy. Technical strengths and inputs mainly stem from in-house R&D activity and partly from external sources such as local universities. They generally have ability in design and production technologies. This largely underpins their technical progress and business performance.

c) Stagnant firms are those rather passive in generating technical change activity. Most technology comes from outside. They do not attempt to initiate and carry out technical change activity. Requests from customers and parent companies are, instead, the cause of changes. Typically, they have little ability in product design and no R&D activity. Assembly capability is the main strength sustaining them in the market. They tend to be unsuccessful with regard to technical change and business growth.

d) Declining firms are those very passive in technical change generation. Since they see no reason to change their product designs, they are only able to operate at the low-end and/or in the protected market. Technical inputs are minimal and R&D activity is nonexistent. As a result of being incapable to initiate and respond to technical change introduced by the others, they are gradually driven out.

These four stereotypes of electronic firms in Thailand point to one conclusion that technical change generation, among the others, is very essential to the growth of the firm. However, a crucial question remains whether this conclusion can be generalized, and there are other supporting theories and evidence in other sector.

2.2 THEORETICAL GROUND

The evidence found above, in fact, goes along with the neo-Shumpeterian line of argument. The argument is, above all, concerned with the process of economic change, as opposed to the analysis of equilibrium states. Central to the process of economic change is technical change, initiated by the entrepreneur in the earlier Schumpeterian view, or by the R&D departments of larger firms in the later view. Firms use technical change, improving products and processes, as a major weapon in the competitive struggle, either taking the offensive and introducing innovations, or defending their successful rivals. The result is a continual series of disequilibria as change and adjustment to change occur. In the neo-Schumpeterian approach, uncertainty is also central. The outcome of investment in technical change is uncertain; different firms have differing views as to the best prospects; some firms succeed and grow, others decline and sink. The process of economic growth is the total sum of all these events (Fransman 1986 p.64).

Along the line with the neo-Schumpeterian argument, Penrose contends that innovation lies at the heart of the growth of the firm, although other factors such as diversification, acquisition, and merger are included. According to Penrose, the firm by its nature is like a biological entity which can be born, grow, and die. The growth of the firm is a process of change, growth, and development through time. There is no fixed or optimum size of the firm since it is deemed to be a living organism changing all the time (Penrose 1952). It is an interacting series of internal changes which lead to increases in size accompanied by changes in the characteristics of the firm.

Penrose contends that growth is endogenous to the firm. It takes place as a result of both internal and external changes in cumulative, interactive, and disequilibrating manners.

In the first place, she points out that growth in traditional analysis is often interpreted merely as an adjustment to the size appropriate to given conditions, rather than a cumulative process of internal resources within the firm, whereby the firm may expand with or without external changes (with or without merger) (Penrose 1959 pp.1-3).

Secondly, growth is also an interactive process, both between the internal productive resources themselves and the changing external environment. This truly dynamic interacting process occurs not only a result of changes created by the firm's activities but also because of external changes beyond the firm's control (Penrose 1959 p.4).

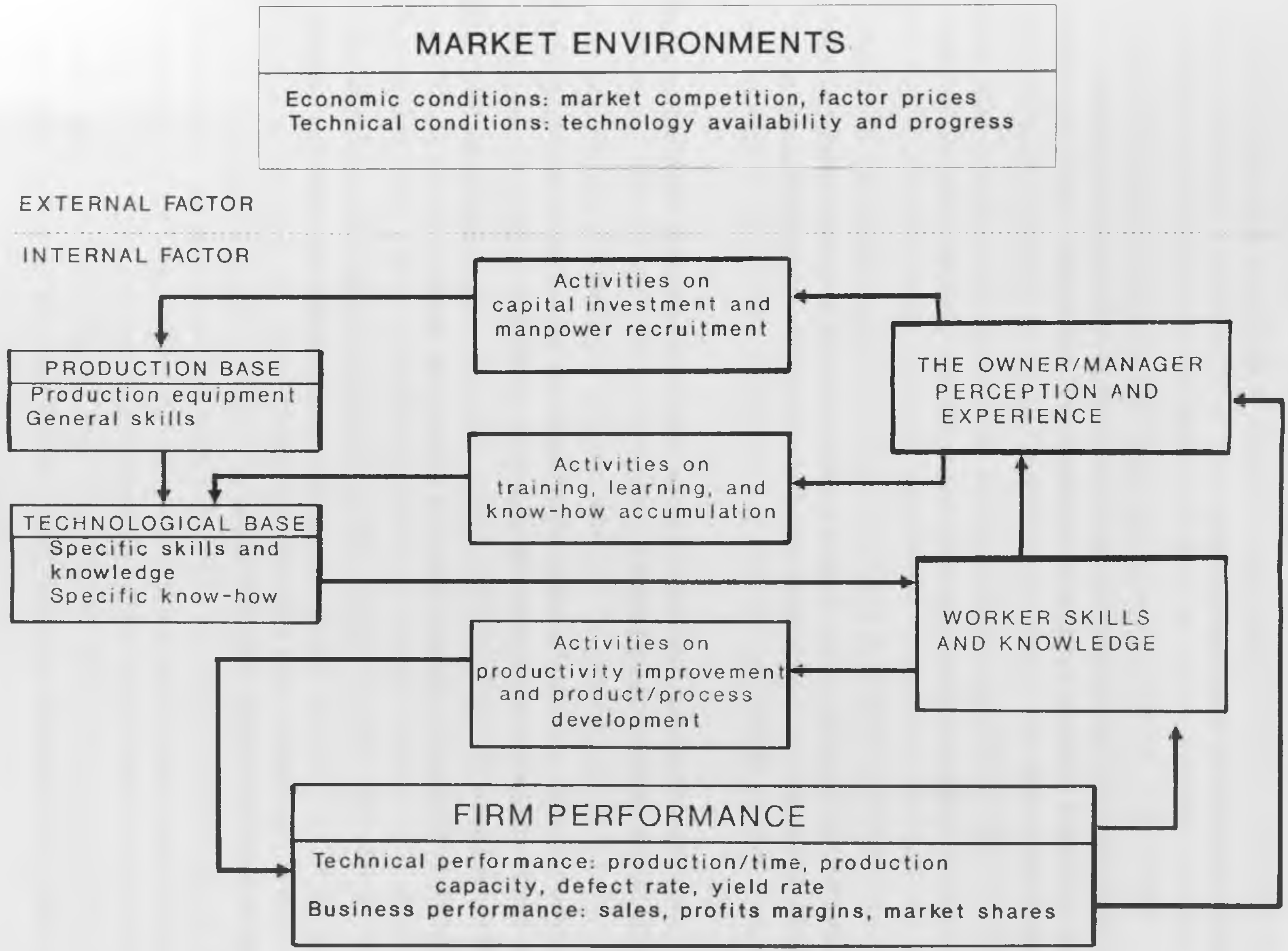
Thirdly, growth will never be in equilibrium due to the effects of cumulative and interactive changes taking place over time. Such changes inherent in the nature of the firm will create both the possibility for and set the limit to the expansion of the firm at any given period of time.

She clearly states that the growth of the firm is conditioned by its competitive ability necessitated by both the internal development of the firm's technological base and the external possibility of innovation (Penrose 1959 p.106). In other words, the growth of the firm is brought about by Schumpeterian competition. The Schumpeterian process of "creative destruction" of innovation brings about new profitable opportunities to the firm on the one hand, and forces the firm to innovate or otherwise be destroyed on the other (Penrose 1959 p.115). Technical progress becomes a major long-run strategy to gain the advantage and guard against the threat of both direct and indirect competition from new products, new processes, and new ways of marketing (Penrose 1959 pp.112-113). The rate and direction of the growth of the firm is dependent on new technical and market opportunities derived from the internal factors of each firm.

As demonstrated by the "learning" literature, technical change does not happen by chance. It is clearly not a passive, automatic, or costless improvement in routine production of the firm. But, on the contrary, depends on deliberate effort by management in manpower development and technological accumulation. The literature asserts that one cannot assume that technical change and firm performance will be gained and upgraded automatically through time. In fact, in order to achieve this, firms must deliberately undertake a wide range of activities to raise technological capability. Some of the deliberate learning activities are learning by training, searching, using, and undertaking R&D. Learning by training is the most systematic and fundamental activity of augmenting skill and knowledge. Learning by searching is a process acguiring information and knowledge from various sources. Learning by using is a way to practice and accumulate skill and knowledge by interacting with production equipment and its producers. Undertaking R&D activity is a direct process to generate technical change.

To conclude, there is evidence to say that the growth of the firm is conditioned by the owner/management and workers within the firm which generates technical change activity ranging from productivity improvement to new product/process research and development. Further, it is true to say that the growth of the firm is also affected by outside economic and technical conditions derived from differences in market and ownership structures, and other firm effort in marketing, finance, and management. Figure 2.1 depicts a simplified scheme of the process of technical change generation of and its effects to the firm (see more discussion in Tiralap 1990).

Figure 2.1 :The Process of Technical Change of the Firm



In the first place, given a certain market environment including economic and technical conditions, the owner/management will adopt technology and react to technical and market opportunities based upon his perception and past experience (and the embodiment of worker's skill and knowledge and the past performance of the firm, if any).

Next, this, in turn, directs his functions towards the acquisition of and improvement in the production base (production equipment and general skills) through capital investment and manpower recruitment activities, and, on the other hand, the acquisition and development of the technological base (specific skill and knowledge embodied in workers and know-how embodied within the firm) through training, learning, and know-how internalizing activities.

Then, worker skill and knowledge acquired, accumulated, and developed alongside improvements in the firm's production base and development of the technological base will determine the firm's productivity improvement and technical change generation.

Finally, this, in turn, contributes positively towards firm performance: technical and business performances.

Iteratedly, firm performance conditioned by worker skill and knowledge will further affect the owner/management perception and experience when new market and technical opportunities arise. This will then condition activities carried out by the owner/management and workers on and on.

By this way, we can explain the association between the evolution and the process of technical change generation of the firm. We can also explain the interaction between the firm and the market along the process of technical change generation at the industry level.

2.3 SCOPE AND TERMINOLOGY

Given the differences between a developed and developing country in terms of technical and R&D activity, Fransman suggests that the neo-Schumpeterian paradigm is theoretically more applicable to a developing country since it takes into account all incremental as well as major technical changes.

As Fransman (1986) has pointed out, technical change in a developing country is rather different from its developed counterpart. Technical change in a developing country largely involves only some of the stages of technical development such as the search for new products and processes for the firm, the industry, or the country, the adaptation of imported products and processes to local environments, and the improvement of existing products and processes. In general, it does not involve the development of new products and processes for the world and basic research. For this reason, technical change in a developing country tends to be incremental rather than radical, and generated from abroad rather than by indigenous effort.

According to Freeman (1982), classifies R&D strategy into various categories such as offensive, defensive, imitative, dependent, traditional, and opportunist strategies. He contends that in general, firms in developing country tend to adopt the imitative, dependent, and traditional strategies owing to the lack of necessary resources for technological advancement. Although these strategies are very useful and important for those developing country firms as an entry point into the global race, they are not sustainable in the long run. This is because although it lessens risks in the short run, the advantage derived is largely for scale intensive based upon cheap labor and/or national resources.

Although Thailand's industrial sector changed rapidly during the last five years, her manufacturing characteristics are still very similar to other developing countries. R&D activities in Thailand are largely confined to the level of utilizing the existing technology which is available in the international market, and developing from its original form. There is a dearth of the higher levels of R&D activities. They are, for instances, the level of conducting applied research to develop and adapt new products and processes to meet market demands and competition, and the level of conducting research to develop scientific principles for the generation of new technologies (TDRI 1990). Therefore, it seems appropriated to adopt Freeman's conceptual framework, and then adapt to the purpose of this study.

Reasons for doing so are twofold. First, it may not be useful to apply standard R&D classification such as the OECD one since all R&D activities in Thailand are likely to fall into one category: experimental development. This is surely not informative and interesting since we know only one broad category without details. Second, it seems more useful to extent and modify R&D definition and category to cover the developing country's economic and industrial structures. Thus, the scope of R&D activity adopted in this study are defined to cover other technical change activity as follows:

a) Trouble Shooting R&D

This type of R&D activity means a systematic and continuous activity to examine and solve the production problems of the existing products and/or production processes. This is only to maintain the acceptable level of the product quality and/or production efficiency. This needs not to improve or create anything new.

b) Improvement R&D

This improvement R&D refers to a systematic and continuous activity to improve and increase product quality and/or production efficiency of the existing products and/or production processes. This is aimed to enrich and enhance the existing level of product quality and/or production efficiency. Thus, the new quality and/or efficiency must be better than the existing ones, despite nothing new.

c) Development R&D

Development R&D covers all systematic and continuous activities to create a new product and/or production process differently from the existing one. This can be a minor or major change in core technologies, materials, and/or ways of using and producing. The crux of the matter is to generate something new to the production unit which may not be necessary new to the other (firm, industry, country).

d) Absorption R&D

This is defined as a systematic and continuous activity to understand and digest a technology from outside (a new product and/or production process). This can range from a pure class room on text book study to an experimental activity. Also, it can take place before or after acquiring such a new product and/or production process. The former case tends to be acquisitive activity whilst the latter is imitative.

The above R&D activity differs from other trial & error and engineering activities on the way in which and the extent to which the activity is carried out (see table 2.1 and table 2.2).

Table 2.1 : Typical Characteristics of Technical Activity

	Technical activity		
	Trial & error activity	Engineering activity	R&D activity
Problem orientation	Problem removing	Problem solving	Problem finding
Answer Availability	Answer does not know	Answer almost known	Answer not yet known
Nature of activity	Adhoc & non-systematic activity	Adhoc & systematic activity	Continuous & systematic activity
Technical treatment included	Trouble-shooting Improvement	Trouble-shooting Improvement Development	Trouble-shooting Improvement Development Absorption

Table 2.2 : Ways of Examining R&D Implications

Item	Single firm	Paired firms
Before and after undertaking R&D	*	
Doing and not doing R&D		*
Scope and extent of carrying out R&D		*

- R&D activity places main emphasis upon problem-finding. It is carried out to find out and understand the causes and effects of the problems/questions facing. The answers have not yet known. And very importantly, the activity is carried out continuously and systematically. R&D can be applied to all levels of technical treatment, ranging from trouble-shooting, improvement, development, and absorption activity.

- Engineering activity aims largely to solve the problems/questions facing. The answers are almost known. However, this activity does not intend to understand the underlying causes and effects of the questions, but is to achieve practical solutions of those questions on the permanent basis. The activity may or may not carry out continuously, but systematically. This can apply to trouble-shooting, improvement, and development activity.

- Trial and error activity is primarily to get rid of the problems facing by removing them without attention to understand the underlying causes and effects. It tends to be adhoc by nature and no systematic study is applied. Trial and error activity largely applies to trouble-shooting and, to some extent, improvement activity. It cannot cover development and absorption activity.

Apart from the aforementioned technical activities which largely concern with technical changes in products, production processes, and materials. There are other technical activities worth mentioning as follows:

a) Production base improvement

This includes production-equipment replacement activity such as investments and improvements in production, testing, and R&D equipment; and general-skill upgrading activity such as increments in basic education, skill intensity, and pre-production training.

b) Technological base development

This includes training activity such as in-house and overseas post-production training; and learning activity such as learning by operating, using, searching, hiring outside experts, and undertaking R&D.

2.4 METHODOLOGY

Traditionally, economic theory tends to assume that technology is exogenous to the production system and that technical change is a by-product of time. Thereby, the study aims to challenge the assumption of the orthodox economics that under the same market structure, firms tend to behave in the same way, pursue the same business strategy, undertake the same technical effort, and possess the same capability. It argues that with differences in technical change activity carried out by the owner/management and workers evolving over time, firms can be dissimilar in behavior, strategy, and capability, thus resulting in different performance, technical progress and business growth.

a) Theoretical Ground

Theories developed by the neo-Schumpeterian school including Penrose clearly confirm on this point. They reveal that technical change is a process of interactive and institutional accumulation evolving over time. Firms can differ in behavior, strategy, and thereby technical change generation, depending upon differences and changes in technical and R&D activities generated by the owner/management and workers within the firm.

Following Penrose's argument, the growth of the firm is brought about by the Schumpeterian competition. The Schumpeterian process of "creative destruction" of innovation brings new profitable opportunities to the firm and forces the firm to innovate or otherwise be destroyed. In the long run, technical progress becomes a major strategy to gain the advantage and guard against the threat of both direct and indirect competition from new products, new processes, and new ways of marketing. The rate and direction of the growth of the firm is dependent on external technical and market opportunities derived from the internal technological base of each firm.

b) Empirical Ground

This study's framework follows a study carried out by the Science Policy Research Unit, University of Sussex (SPRU) concerning the factors contributing to the success and failure of the firm's innovation, namely the SAPPHO project (see Rothwell et al 1974). The project was designed to discover differences between successful and unsuccessful innovations. The technique employed was a pair comparison approach where a successful innovation was compared with an unsuccessful innovation. The success of an innovation was judged by a worthwhile market share and profit in the same market as the failure innovation.

Nevertheless, to be theoretically able to link technical progress with business growth, a substantial, systematic, comparable, and long-term set of data on technical productivity and efficiency and business sales and profits, and so on is needed for analysis. In practice, it is extremely difficult since firms are generally not keen on disclosing them, particularly firms having poor performance. It should be noted that this study is also seriously constrained by the paucity of information and data, particularly long-term data on technical and business performance. As a result, it is difficult to demonstrate the analysis statistically and rigorously.

c) Ways of Examining R&D Implications

In order to investigate the repercussions of R&D firm performances in detail, the analysis will be made against various cases (see table 2.3). For example, the analysis will discuss the relationships between R&D activities and firm performances within one single firm before and after the period of undertaking R&D, or while undertaking and not undertaking R&D. Also, the relationships between R&D activities and firm performances of similar firms will be examined against the case which one carrying out R&D and the other does not, and which both carrying out R&D. this eventually aims to illustrate the effects of R&D activity on firm performance, and the complex nature of R&D process from laboratories to the markets.

d) Ways of Measurement

The measurement of technical change is distinguished only qualitatively in terms of whether or not firms have generated changes in products and production processes. If so, what are those changes and how significant they are. This is supported by data and statistics on technical efficiency and productivity improvement of the firm. Growth is proxied by changes in business performance. Average profit (profits/sales) is employed as a main indicator of comparative business performance the firm studies.

As the study is seriously constrained by inadequacy of information and data concerning sales and profits in a long-term and time series manner. This makes the comparative growth rate rather inappropriate in this study for two reasons. One is that the rate of growth seems rather arbitrary when the data of firms starting at different periods is compared at a particular time, especially over a short period. The growth process of the firm tends to be distorted by the short-term growth rate since business performance embodies some fluctuations. The other is that the rate of growth seems rather unrepresentive when the data of firms having different sizes is compared. The reason is that large firms, in which the volume of production is already large, tend to have a lower growth rate than small firms growing from a smaller base.

In the light of these shortcomings, average profit (profits/sales) is employed as a main indicator of business performance rather than the growth rate of sales and profits. More importantly, it seems to be a better indicator for relating technical change with growth for three reasons. Firstly, average profit seems to reflect the technological rent of the firm (extra profits gained from technical change and productivity improvement). In general, firms, which are productive or innovative, tend to have higher average profit than those which are not. Secondly, average profit seems to reveal a firm's ability to survive and grow in the long run since firms cannot grow without profits, and firms are difficult to gain larger profits without expansion. Firms having good business performance tend to maintain more stable and high average profit than those which do not. Thirdly, average profit seems to overcome the problem of differences in firm size. Since average profit is the outcome of profits over sales, it does not directly correlate with the volume of production. Nevertheless, where data available, the growth rate of sales and profits will be discussed.

e) Methods Employed

Based upon the SAPPHO's technique (a pair comparison technique), the firms under study are controlled for similar firm characteristics and then are compared on a pair basis to examine the effect of the public support systems for private sector R&D on the process of technical change and growth of the firms. However, only three pairs of each technology-based firms (electronics, biotechnology, and material technology) will be selected in order to examine the firms in more detail as in the case study fashion. Nine pairs of firms are controlled for similar characteristics such as operating in the same market, having the same type of ownership, starting with the similar size, and manufacturing the similar products. Then, the research will examine whether these firms having similar characteristics could be different in technical and business performance as a result of differences in R&D activities. If so, whether there are relationships with the public support systems. In order to make the examination feasible, the study will adopt the following methods:

1) The firms under study are controlled for similar firm characteristics such as product type, market orientation, promotion privilege, ownership structure, and size in order to eliminate other factors affecting the evolution of technology and business performance the firms.

2) The controlled firms are compared on a pair basis in order to differentiate the effects of R&D and technical activities on technical and business performance of the similar firms.

3) Only three pairs of each technology-based firms (electronics, biotechnology, and material technology) will be selected in order to examine the firms in more detail as in the case study fashion.

4) Apart from qualitative data, two qualitative indicators of firm performance will be examined as follows:

- Technical performance: production time, lead time, defect rates, and inventory time.
- Business performance: market shares, turnovers, profits, and average profits.

2.5 DATA COLLECTION

The analysis of the study has relied heavily on information obtained from a non-structured questionnaire. The set of open-ended questions is prepared for interviewing managers at the factory level (see Appendix I). Production managers (or chief engineers) were interviewed with regard to technological acquisition, R&D activity, and other technical change activity. Managing directors or general managers were interviewed with regard to firm strategy including R&D and other management activity. Based upon their collaboration, nearly 70 percent of the sample firms were interviewed twice. In addition, after each interview, factory visits followed to complement the information and data obtained for interview.

CHAPTER 3: GOVERNMENT PROMOTION FOR PRIVATE SECTOR R&D IN THE ASIAN PACIFIC RIM ECONOMIES

It is widely accepted that the Asian Pacific Rim economies at present have been playing a proactive part of world economic growth. Less than a half of century, these economies transformed themselves from the poor agricultural economies to be the advanced and newly industrial countries. Despite poor national resources, countries such as Japan, Korea, Taiwan, Hong Kong, and Singapore have achieved a remarkable economic and technological progress. With no secret, technology mastery stands out as a common factor underlying the successful stories. More interestingly, the catching up process of the Asian NICs has been very fast despite starting from the stage of being poor in both capital and technology for development. Although government roles are somewhat dissimilar, they are all market-led economies which the private sector plays a large part in the process of industrialization. Thereby, as the percentage of government expenditures decline, research and development in the private sector are becoming more critical to sustain industrial growth and economic prosperity. This, of course, depends upon the stage of development in each economy.

With no doubt, Japan has undertaken more basic research. Japanese government has made itself clear that its expenditures are earmarked only for research projects expected to yield results in the next 10 years or more. The rest should be covered by the private sector, which in fact many Japanese firms have been pursuing. To the lesser extent, Korean government has also set development target in the same way as Japan. It only sponsors for research projects which results can be exploited in the next 5 years or longer since many Korean firms have become giantic. However, Taiwan and Singaporian governments are more willing to invest in close-to-the-market projects as private firms are not strong enough to bear the risks. Within the region of 1 to 3 years, they are ready to render their money for research. With reference to Thailand, she clearly lags behind her counterparts in the region. Whilst R&D spending in the private sector is negligible, government expenditures are the lowest among the aforementioned countries. This is because Malaysia

Japanese government, the majority did not. This is also true in the case of Korea. However, situations in the presently less industrialized countries are rather different. Industrial firms tend to be small and trading-oriented. R&D activities are deemed as too costly and risky. Nevertheless, these activities in the private sector do increase when government provides the needed assistances. Taiwan and Singapore are good specimens. With reference to the late-coming industrialized countries such as Malaysia and Thailand, the majority of industrial firms is not only foreign-owned but also assembly-oriented in nature. Also, local firms are not only small and trading-oriented but also inward-looking. Therefore, R&D activities are seen as luxurious and unnecessary for the offshore manufacturing base, in particular in the case of low-end or matured products. Local production is largely based upon abundant national resources and cheap labor. Government supports on S&T activities in general and private sector R&D in particular are very inadequate. However, Malaysian government seems to take numerous steps ahead of Thailand to alter this situation (for legal and policy frameworks see more details in table 3.1 and table 3.2).

Table 3.1 : Legal Framework

Country	Important Laws	Year
Japan	Science and Technology Act	1947
Korea	Technology Promotion Law	1967
Taiwan	Statute for Science and Technology Development	1980
Singapore	Statute for Technology Development Promotion	1984
Malaysia	Science and Technology Act	1983
Thailand	The Science and Technology Development Promotion Act	1991

Source: 1. Science and Technology Agency Japanese Government
2. Ministry of Science and Technology, Public of Korea
3. Institute of Information Technology, Taiwan
4. National Science & Technology Board, Republic of Singapore
5. Ministry of Science, Technology and the Environment, Malaysia
6. Ministry of Science, Technology and Environment, Thailand

Table 3.2 : Policy Framework

Country	Important Policy	Year
Japan	Large-scale Research and Development Plan	1966
Korea	National Technology Development Plan	1968
Taiwan	Science and Technology Development Plan	1986
Singapore	National Technology Plan	1991
Malaysia	A National Industrial Technology Development Plan	1990
Thailand	-	-

Source: 1. Science and Technology Agency Japanese Government
2. Ministry of Science and Technology, Public of Korea
3. Institute of Information Technology, Taiwan
4. National Science & Technology Board, Republic of Singapore
5. Ministry of Science, Technology and the Environment, Malaysia

3.1.1 Japan: the Tiger Mother Remaining Fit

The Science and Technology Promotion Act, (see table 3.1) one of the most important legal frameworks to promote S&T activity in Japan, was passed in 1947. The act aimed to create adequate S&T infrastructure for country development. The government realized that in order to regain economic prosperity after being defeated, S&T was one of the key weapons. However, before gaining momentum in production and R&D, on the top of tax and financial incentives, supports for S&T infrastructure are necessary. That is to say, S&T services (such as standards, testing, training, information and consultancy services), S&T supports (such as productivity improvement and research and development), and S&T education and manpower must be adequate. This was mainly to facilitate and induce private firms to carry out their own S&T activities, either production or including R&D.

As a result, the Science and Technology Committee was formed in 1949 to be in charge of S&T policy formulation. The committee is made up of the prime minister (as the chairman), the minister of the Science and Technology Agency (STA), Ministry or International Trade and Industry (MITI), Ministry of Education (MOE), other related ministers, and many knowledgeable persons from industry and university. However, as far as promotion and implementation are concerned, basic research is chiefly organized by the STA and MOE while applied research directly related to industry is largely carried out under the MITI responsible for various industrial research institutions.

Under the MITI, the Agency for Industrial Science and Technology (AIST) is responsible for a special program called "Large-scale Research and Development Projects for Industrial Technology". This program, commencing in 1966 for promoting the development of particular industries in consonance with the country's S&T policy. For instance, the AIST is believed to be one of the most active advocators to the success of the electronic and information industries in Japan.

After the 1947 Act was promulgated, other acts specific to particular industries followed. For instance, the Temporary Act for Promoting Electronics Industries was passed in 1957. Although there were a number of S&T policies were set up in the 1950s to catch up other advanced countries, the first national policy was launched in 1960 to set a long-term (10 years) target for industrial and technology development. It included targeted industries and products, tax and financial incentives, building of S&T infrastructure. Since then, there have been a series of long-term plans giving guidelines for private firms to master imported technologies and achieve technological independence. Besides general plans, there are also various specific plans for strategic S&T fields and coordination among government, industry, and university in R&D activities. Currently, Japanese government has set up a plan for the establishment of information industry base for the 21st century by promoting R&D through close cooperation among research institutions under government, industry, and university. Two policies to enhance and enrich the high-technology industrial base in Japan are firstly carrying out more basic research and secondly marketing and sourcing globally.

With reference to the total R&D expenditure in 1988, government's shared only 18 percent, the rest was belonged to the private sector. In this context, it is true that Japanese R&D system is presently private-led.

Government's policy is now playing only a supportive role. However, it should be noted that Japanese private sector R&D has mainly focused on applied and development research. Basic research remains in the hands of government. As the flow of foreign technologies, particularly from the U.S., are limited, the government tries utmost to promote private firms to undertake more R&D including basic research in order to maintain the steady growth. Japan as a whole invested about 84,227 million dollars in R&D in 1988. This is approximately equal to 2.85 percent of Japan's GNP. Of these R&D expenditures, government shared about 18 percent. Private sector R&D was as high as 82 percent. However, the ratio of basic research expenditures in the total amount of research expenditures was about 12 percent: of which private sector shared only 7 percent (see table 3.3).

Table 3.3 : Japan's R&D Expenditures

Year	R&D Expenditures (US $ Million)	R&D as % of GNP	Share of Private Sector[1]
1965	1,413.03	1.52	n.a.
1970	3,790.03	1.85	75.0
1975	9,747.90	2.01	70.0
1980	25,843.58	2.19	71.0
1985	44,340.64	2.77	81.2
1986	57,780.64	2.74	80.3
1987	79,648.58	2.81	80.5
1988	84,227.00	2.85	81.6

Note : [1] 1970, 1975 calculated from Figure 3.8 in White Paper on Science and Technology 1990. And 1980, 1985 calculated from Figure 3.6 in White Paper on Science and Technology 1991 (Summary).

Source : 1. Science and Engineering Indicators, National Science Board
2. White Paper on Science and Technology 1990, Science and Technology Agency Japanese Government
3. White Paper on Science and Technology 1991 (Summary), Science and Technology Agency Japanese Government

Nevertheless, at present, Japanese firms are more aggressive in basic research activities in order to gain technology bases which are fundamental to original product development. Not only carrying out by themselves, they also promote basic research in universities and public institutions and make various joint research between industry, government, and the university.

3.1.2 Asian NICs: the Adult Tigers on the Run

There is no doubt that economic development of the Asian NICs has so far been extremely remarkable. However, no country in the group does believes that it can stand still by resting on labor-intensive and capital-intensive industries. All of them are moving upwards to technology-intensive industries, no exception of Hong Kong. Among the four Asian NICs, Korea seems to be the most aggressive advocator of S&T development. Government provides a strong support on both the public and private sector R&D. Taiwanese government sees itself as a supporter of private sector R&D which the activity is not yet strong. Despite resting on foreign direct investment, Singaporian government has continued to upgrade her production structure and the nature of industry. The recent shift has been on technology-intensive industry and promotion of private sector R&D.

As mentioned, among the four Asian NICs, Korea seems to be the most aggressive S&T advocator. Following Japan, Korean government launched the Technology Promotion Law in 1967. Other specific law was, for instance, the promulgation of the Electronics Industry Development and Promotion Law. The 1967 act aims to increase the level of technology development in the country ranging from technology transfer, S&T infrastructure, and R&D activity. Although national S&T policy formulation is in the hands of the Ministry of Science and Technology (MOST), a number of government organizations are actively involved in policy formulation.

R&D expenditures have increased rapidly. In the early 1960s, when Korea started industrialization, total R&D expenditures were less than 1 percent of the figure in the late 1980s. For instance, R&D expenditures were only amounted to US$ 7.70 million or 0.3 percent of the country's GNP in 1965.

Two decades later, R&D expenditures grew up to US$ 1,879.70 million or 1.82 percent of the country's GNP in 1986. On average, it grew up 50 percent annually during this period. In addition, to meet the increasing demand for indigenous technological capability, government is planning to increase R&D investment to 3 and 5 percent of the country's GNP in 1991 and 2001 respectively (see table 3.4).

Table 3.4 : Korea's R&D Expenditures

Year	R&D Expenditure (US $ Million)	R&D as % of GNP	Share of Private Sector
1965	7.70	0.30	10.00
1970	33.20	0.40	12.00
1975	88.20	0.42	33.30
1980	348.10	0.57	48.40
1985	1,327.50	1.60	81.00
1986	1,879.70	1.82	81.00
1988	3,258.00	1.90	82.30
1991		3.00*	
2001		5.00*	

Note : * = Planned target
Source : Ministry of Science and Technology, Republic of Korea

Another interesting trend is that the ratio of private R&D expenditures in the total R&D expenditures in Korea changed dramatically. In 1965, the contribution from the private sector was only 10 percent, compared to 81 percent in 1986. It jumped from US$ 0.76 million in 1965 to US$ 1522.5 million in 1986. In 1986, private institutions spent US$ 1,025.2 million, while public and universities institutions spent around US$ 333.6 and 164.5 million. These were tantamount to 67.3, 21.9, and 10.8 percent of the total R&D expenditure respectively.

Relatedly, the number of institutions engaged in R&D activities has also increased steadily. In 1986, there were 175 public institutions and 338 university-affiliated R&D institutions. With regard to private R&D institutions, they have expanded sharply in the recent year. There were 1,321 private laboratories carrying out R&D activities; of which, 335 institutions had separately organized, the rest had divisional units assigned for R&D work. Along with increases in R&D expenditures and institutions, manpower engaged in R&D grew up massively. The total number of scientists and engineers in 1986 accounted for 1.13 persons per 1,000 of population. Of which 87,430 R&D personal, 16.4 percent worked for public R&D institutions, 34.1 percent worked for university-affiliated institutions, and 48.8 percent worked for private institutions.

Taiwan laid the first policy framework for S&T development with the promulgation of the "Guidelines for the Long Range Development of Science" in 1959. The S&T development became firmly institutionalized with the establishment of National Science Council (NSC) in 1967. In order to promote S&T development, the Council for Economic Planning and Development of the Executive Yuan (Cabinet) decided in 1970 to build up indigenous capabilities. However, effective promotion of R&D activity both public and private sectors began after the Industrial Technology Research Institute (ITRI) was set up in 1983. Since then a number of strategic industries were selected. Authorities concerned have put forth many important programmes and measures to help develop the industries. Policy frameworks are set to direct the development of S&T services, R&D support and manpower development of the country.

They are, for instance, three important policies related to the development of S&T activity in general and the electronic industry in particular. The Science and Technology Development Plan (1986-1995) has formulated in order to accelerate S&T development and promoting the nation's economic development. Some important strategies included program to expand the country's R&D infrastructure, program to upgrade the efficiency of R&D, program to encourage the private sector to engage in R&D activities. Other specific policies were, for example, the Development Plan for the Electronic

Industry of Taiwan (1980-1989) and Development Plan for the Information Industry of Taiwan (1980-1989).

R&D Expenditure in Taiwan rose from US$ 293.72 million or 0.71 percent of the country's GNP in 1980 to US$ 809.65 million, 1,290.53 million and 1,559 million in 1986, 1987 and 1988 respectively. In 1988 R&D expenditure soared up to 1.22 percent of GNP; of which the private sector R&D constituted approximately 43 percent. Share of R&D expenditure also rose from 0.71 to 1.01 and 1.12 percent in 1980, 1985 and 1987 respectively. (see table 3.5)

Table 3.5 : Taiwan's R&D Expenditures

Year	R&D Expenditures (US$ Million)	R&D as % of GNP	Share of Private Sector
1980	293.72	0.71	39.5
1985	638.12	1.01	38.7
1986	809.65	0.98	39.4
1987	1,290.53	1.12	48.6
1988	1,559.00	1.22	43.2

Source : Taiwan Statistical Data Book, 1989.

3.1.3 ASEAN: the Tiger Cubs Growing Up

Although economic development and industrial capability of the ASEAN countries have expanded rapidly, the current production and S&T structures remain weak. Most of technologies are imported and local technological capabilities to absorb, digest, improve, and adapt are very low. A number of deficiencies preventing the effective use and assimilation of foreign technologies while creating indigenous ones. For instance, R&D expenditures in the private sector constitute an insignificant amount of the total R&D activity. This is extremely low compared to other industrial nations. R&D activity in the small and medium sized firms is almost absent. In addition, public sector R&D institutions tend to suffer from old and outdated facilities which are often not properly maintained and hence poorly utilized. R&D budget is generally inadequate and tends to cover expenditures for buildings and staff salaries rather than research projects. Research staff are often engaged in too many areas of research with insignificant resources. There is also too much emphasis on producing something new and advanced with inadequate measures and resources to complete the research and/or commercialize the results.

Despite late-coming, a serious consideration of the strategic role of science and technology in Malaysian economic development was made in the early 1980s. The first National Science and Technology Policy was launched in 1986. Subsequently, the essence of S&T was firstly included in the context of industrial development under the national Industrial Master Plan. A National Industrial Technology Development Plan was later formulated in 1990. Further, a Cabinet Committee on Science and Technology has been created to eliminate some of the deficiencies to increase the country's technological level and R&D activity. The chairman is the Prime Minister and the five full members are the Ministers of Finance, Education, Human Resources, International Trade and Industry, and Science, Technology, and the Environment.

From a government survey in 1981, Malaysia spent about 0.6 percent of her GNP for R&D. In 1988, this figure rose to 0.8 percent of GNP; of which the private sector constituted about 12 percent. In 1995, the target for total national R&D expenditures was set for 1.5 percent of GNP. In 2000, the government is planning to boost the figure up to 2 percent of the country's GNP; of which 60 percent should be shared by the private sector. The R&D expenditure set for the next 5 years (1991-1995) is about US$ 240 million, compared to US$ 166 million during the last 5 years (1986-1990). However, in order to promote R&D activity in the private sector, the government set aside another US$ 224 million for the development of the S&T infrastructure, compared to US$ 50 million in the previous period (see table 3.6).

Table 3.6 : Malaysia's R&D Expenditures

Year	R&D Expenditure[1] (US $ Million)	R&D as % of GNP	Share of Private Sector [2]
1981	144	0.6	n.a.
1988	262	0.8	12
1990	293	0.8	10
1995		1.5*	
2000		2.0*	60

Note : [1] = Calculated from Pre-Consultation on S&T Strategies for Long-term Development Perspectives
[2] = from interviewed
* = planned target
Source : Adapted from Pre-Consultation on S&D Strategies for Long-term Development Perspectives

In Thailand, the situation is rather different. Despite aiming to achieve the status of a newly industrialized country, her S&T activity as a whole has been not so active, leaving aside R&D activity in the private sector. It is possible to say that the Thai government has not yet played an effective role in assisting and developing local technological capability. this is reflected in its industrial policy such as fiscal and tax policies, and other policies relating to technology promotion and the production of manpower. Although the government has been active in encouraging foreign investment, it has not yet adopted measures to provide adequate incentives and supporting services to encourage local manufacturers to accumulate and upgrade indigenous capability. Until recently, under the Ministry of Science, Technology, and Environment, some efforts have been made to assist local firms in R&D activities but results remain to be seen.

With regard to the legal framework, Thailand has just promulgated the Science and Technology Development Promotion Act at the end of 1991. However, this is mainly to institutionalize the country's main S&T organization. Other acts aiming particularly to promote private sector R&D have not yet passed. Therefore, policy framework, at present, remains scattered and fragmented.

With reference to the total R&D budget, the amount of government budget allocated for R&D has been kept constantly in the region of US$ 80 to 100 million in the 1980s. Therefore, as the country's GNP grew continuously, its share in the national GNP has declined steadily since 1982 when it reached the peak of 0.41 percent. The share in 1985, 1987, and 1989 significantly showed a declining trend from 0.24 to 0.19 and 0.17 percent respectively. There is no official record for R&D expenditure in the private sector (see table 3.7). However, from a survey in 1983, it reported that private firms spent only 0.11 percent of their total sales for R&D. In 1990, another survey revealed that the share of R&D expenditures in the total sales only increased to 0.13 percent. This was still very insignificant, compared to 2.1 percent in Korea in 1990, 3.29 percent in 1989 in Japan, and 4.8 percent in the U.S. in 1988 (see figure 1.1).

Table 3.7 : Thailand's R&D Expenditures

Year	R&D Expenditures (US $ Million)	R&D as % of GNP	Share of Private Sector
1983	93.43	0.39	1.60
1984	121.36	0.23	0.67
1985	130.32	0.24	9.30
1986	120.37	0.19	2.04
1987	106.28	0.22	6.82
1989	113.23	0.17	5.53

Source : The National Research Council of Thailand

3.2 TAX AND FINANCIAL INCENTIVES

Tax and financial incentives are the measures designed directly to induce private firms to undertake R&D activity by sharing the cost of activity. The arguments for government subsidy are manifold. First, private firms are largely not able to secure adequate gains of all the research results, in particular large-scale projects which their effects spill-over across the whole economy. Second, because of the risky nature and long gestation periods, there is a shortage of venture capital for S&T development resulting from the imperfection of the capital market. Third, failures of market mechanisms exist in S&T information dissemination, interest coordination, and strategic international trade. Therefore, government should play a supportive role by employing selective measures where appropriate to promote private sector R&D and shift upwards its own S&T development activity.

It is true to say that most of the governments in the Asian Pacific Rim economies take tax and financial incentives as one of the important measures to promote private sector R&D. Japan stand as a classic case effectively using these incentives to create dynamic and innovative competition among Japanese firms. At present incentives are greatly beneficial to new technology and new business developments. Korean government, trying utmost to catch up Japan, provides various schemes to induce and increase private sector R&D activity ranging from the development to commercialization stages. Singapore and Taiwan are also quite successful in applying tax and financial incentives to raise up private participation in R&D. Compared with Thailand, Malaysia seems more positive to adopt the measures for building private sector capability in R&D.

3.2.1 Japan: Incentives Only for Technological Advancement

In Japan, at present, there are three supporting programmes directly aiming to promote S&T activity. One of which is the Research and Development Subsidiary Program which provides a subsidy on taxation and low interest loans from government financial institutions to encourage private sector R&D. Tax incentives include the Tax Deduction on Experimental and

Research Expense Increments, instituted in 1967. This allows corporations to deduct 20 percent of the incremental increase over their previous highest expenditure for research from their tax assessment. This programme has been a major factor in encouraging the expansion of private sector R&D based upon independent and innovative efforts.

Another tax measure, adopted in 1985 is the Tax Program for Promoting R&D of Basic Technologies. This exempts private firms from 7 percent of the acquisition cost of assets such as equipment and facilities purchased for the purpose of conducting R&D in basic technologies. In the same year, the Tax Deduction for Strengthening the Technological Foundation of Small and Medium Scale Enterprises was promulgated. This program allows small and medium sized enterprises to deduct a maximum of 6 percent of their overall R&D expenditures from assessment.

There are also a number of financial incentives designed to raise the country's technology level through the provision of low-interest loans. These include the Japan Development Bank managing the Domestic Technology Promotion Funding System. In 1989, the fund provided loans totalling about US$ 1.25 billion. This not only increased R&D activity but also S&T infrastructure. Further, the Medium and Small Scale Enterprise Finance Corporation has established the New Business, New Technology Promotion Funding System to stimulate new technology development of the small and medium firms.

3.2.2 Asian NICs: Incentives for All Technical Activities

Again, among the four Asian NICs, Korea seems to be the most aggressive in terms of providing tax and financial incentives to private firms regarding S&T development and R&D activity. Singapore's system of provisions of tax and financial incentives is designed to be very dynamic and comprehensive covering the introduction of new business and technology and the development of human resource and technology. However, Hong Kong seems to be the mere country which does not provide tax and financial incentives to stimulate R&D in the private sector.

Korean government not only provides incentives for R&D but also productivity improvement activities. Overall, the Korean government plays the role of generator and supporter of advanced technology through the Ministry of Science and Technology (MOST) and the Ministry of Trade and Industry (MTI). Apart from tax incentives, financial incentives are provided through other public organizations such as the Korea Development Bank, the EX-IM Bank, the National Investment Fund, the Electronics Industry Promotion Fund, and the Technology Development Corporation. Some of the major incentives to encourage private sector R&D are listed below:

a) Laboratory Stage:

1. Inclusion of technology development reserve fund in loss (reserving up to 1.5 percent of total turnover or 30 percent of total income in loss).

2. Tax deduction of technology and manpower development cost (10 percent deduction of the cost from individual or corporate income tax).

3. Tax deduction of investment in R&D equipment and accelerated depreciation (either deduction 8 percent (or 10 percent in the case of local products) of the investment cost for R&D equipment from taxable income, or depreciation 90 percent of the acquisition cost in the first year).

4. Custom tax deduction of R&D equipment (65-70 percent deduction of custom taxes for R&D equipment imported by research laboratories).

5. Tax exemption of premises (exemption of local tax on premises belonging to research laboratories with more than 30 researchers.

6. Tax exemption of special consumption tax for samples for R&D purposes.

7. Tax exemption of technology inducement and direct foreign investment (exemption of income or corporate tax for 5 years after establishment).

8. Income tax exemption for foreign experts (income tax exemption for foreign experts working in local private research laboratories or public institutions for 5 years).

b) Development Stage:

9. Tax deduction or accelerated depreciation of investment cost for commercialization (either deduction 6 percent, 10 percent in the case of local equipment, or depreciation 50 percent of the cost in the first year).

10. Tax deduction of technology income (deduction 50 percent of income earned from patents, technology know-how, and engineering services.

c) Commercial Stage:

11. Tax deduction of special consumption tax for new high tech products (low rate taxation for high-tech products for 5 years).

The tax and financial incentives in Singapore is designed to top up the incentives already given to industrial firms. This is particularly to upgrade the technological level of the private sector. In Singapore, the Research and Development Assistance Scheme is the main source of grants for private sector R&D. This is especially useful for the small and medium firms which have limited financial resources. It is designed not only to fund R&D activity but also other expenses relating to R&D, feasibility study, prototype development, and patent application. For large firms and MNCs, tax incentives are more appropriate since the government's promotion budget is rather small compared to their operation. Tax incentives for R&D activity on the top general industrial incentives are, for instance, as follows:

- extend the exemption of tax on profits up to another 2 years of pioneer status and another 2 years at the concessionaire tax rate of not less than 10 percent for post-pioneer and head-quarter status.
- double reduction for R&D expenditures.
- a 3 years writing down one-third of expenditures incurred in acquiring approved know-how or patent rights.
- allowing 50 percent investment allowance for all capital expenditures incurred for R&D.
- extending Enterprise Incentive Scheme to R&D activity with a minimum amount of 1 million Singapore dollars to capital expenditures for R&D.
- a 20 percent tax exemption for company R&D reserve fund.

3.2.3 ASEAN: Incentives Similar to the NICs Just Granted

Thailand and Malaysia are two countries seem more active than the others in the ASEAN. The profiles of tax and financial incentives are largely been in the same line as other countries in the NICs, particularly Taiwan and Korea. However, Malaysian government has recently provided a more integrated and inductive incentives compared to Thailand.

In Malaysia, a comprehensive scheme of tax and financial incentives has just granted in 1990. For financial incentives, it is made available through the Industrial Technical Assistance Fund having initial budget of US$ 20 million. This is designed to support small and medium firms in terms of 50 percent matching grants. Eligible technical and R&D activities are feasibility study, product development and design, quality and productivity improvement, and market study. Again, large firms and MNCs seem to benefit more from tax incentives as follows:

- Double reduction on expenditures spent on equipment and infrastructure and/or approved training and in-house R&D activity.
- Tax exemption for 5 years for firms established for R&D purposes. Dividends are also tax exempted.
- Accumulated losses incurred are allowed to be carried forwards after the tax-exempt period.
- Double deduction to persons contributing cash to approved R&D institutions.
- Double deduction for companies using facilities and services form the approved R&D institutions.
- Tax exemption of 5 years to new technology-based firms.
- New incentive packages are being considered by the Ministry of International Trade and Industry.

In Thailand, there has been no direct measure to promote private sector R&D, although a few incentives scattered. For instance, firms established for R&D purposes are eligible to receive promotion incentives from the Board of Investment as other investment promotion firms. Incentives include tax exemption for corporate incomes and import tariffs. However, these incentives have become less attractive at present. Another directly related tax incentives for private sector R&D is 40 percent tax depreciation for R&D equipment and facilities in the first year, then using the common practice.

Other relating financial incentives are the Revolving Fund for Technology Development under the Ministry of Science, Technology, and Environment. The budget for the fund is about US$ 1.6 million a year. The interest rate charged for the approved projects is fixed at 4 and 6 percent and the repayment period is 7 and 10 years for R&D and productivity improvement loans respectively. The Company Directed Research Development and Engineering scheme of the Science and Technology Development Board seem rather ineffective.

3.3 S&T INFRASTRUCTURE

Building up S&T infrastructure is another component which governments in the Asian Pacific Rim countries have been pursuing. Government intervention is basically justified by the positive externality of S&T infrastructure and its high privately proprietary costs. Accordingly, without support or public investment, total investment in basic S&T infrastructure tends to be low. This apparently leads to high transaction costs incurred to local firms when S&T services are located outside the country, and hence competitive ability. Thereby, government's support and/or direct involvement in providing good S&T infrastructure (ranging from standards, testing and calibration, manpower training, information network and dissemination, and technical consultancy services) is deemed necessary to support private sector R&D and other technical activity. This also holds true for S&T eduction and manpower development.

Besides incentives for R&D activity, Japanese government build up a very strong S&T infrastructure since she recognizes that solid S&T infrastructure is an advantage for industrial competition. Thus, the government not only provides a full range of basic infrastructure covering S&T services, S&T support and S&T manpower, it goes beyond to strengthen other aspects such as research exchanges, regional science and technology centers, etc. Korea has also followed the same path despite a certain gap. S&T services in Korea comprise standards, testing, training, information, and consultancy services. S&T support is largely geared to applied research, leaving production improvement and product/process development activities for private firms. S&T manpower receiving critical attention includes technical education and manpower training. Also, S&T infrastructure in Singapore and Taiwan are constantly improved to match with Japan and Korea. Among the aforementioned countries including Malaysia, Thailand is perhaps the sole country having weak S&T infrastructure (see Table 3.8).

Table 3.8 : S&T Infrastructure in the Asian Pacific Rim Economies

	Japan	Korea	Taiwan	Singapore	Malaysia	Thailand
Standard	***	***	**	**	**	*
Testing	***	***	***	***	**	*
Training	***	***	**	**	*	*
Information Service	***	***	***	**	*	*
Improvement R&D	Basic Research	Applied Research	***	**	**	*
Development R&D			***	***	**	*
Technical Education/ Manpower	***	***	***	***	**	*

Note : *** very strong
** strong
* fair

3.3.1 Japan: Excellent S&T Infrastructure

Japan has been building her S&T infrastructure for decades. Her infrastructure on standard, testing and calibration, manpower training, information network and dissemination, and technical consultancy service have been placed at the top rank of the world. Not only providing basic S&T infrastructure as mentioned above, Japanese government is also addressing the following more advanced S&T infrastructure issues:

- increasing R&D budget to build up the pool of intellectual resources required to develop the nations's science and technology base for the 21st century such as conducting basic research, encouraging large-scale research projects, and improving R&D systems and networks.

- increasing research personnel and the quality of work, in particular young researchers to be self-initiative and independent.

- management of equipment, materials and resources to ensure the establishment of a more complete system of supply for materials and genetic resources used in research, the replacement of obsolete and outdated public equipment and facilities, development of the world's most advanced equipment and consolidation of core research functions, and creation of favorable work environments for conducting joint research projects with outside researchers.

- promotion of research and researcher exchanges to promote creativity in science and technology and dissemination of research findings so as to make the most possible use of researcher and research findings.

- developing regional science and technology not only in terms of establishing the Tsukuba and Kansai Science cities but also the efficiency and effectiveness of research carried out by industrial, academic, and government institutions in those regions.

- increasing R&D activity in the private sector through cooperative development of industrial technology and coordination for licensing.

3.3.2 Asian NICs: Solid S&T Infrastructure

It is clear that governments in the Asian NICs have gradually created solid S&T infrastructure to support industrial firms right from the beginning stage of industrialization. However, at present, the level and scope of infrastructure have been created to serve various industrial activities ranging from productivity improvement and research and development activities. The latter has also shifted upwards from development research to applied research. Along with these progresses, attention was also paid to technical education and manpower development to support industrial firms.

It is true to say that Korea government has provided a very good S&T infrastructure to support private sector R&D. There is no doubt that infrastructure dealing with standards, testing, training, information, and consultancy services is certainly strong. S&T education and manpower development are also given equal weight. Under the Ministry of Science and Technology (MOST), there are a number of research institutions directly assist and lead the private sector in enabling and commercial technologies. Not only providing S&T services and R&D support, the MOST has also significantly contributed to S&T education and manpower development. It through the Korean Advanced Institute for Science and Technology (KAIST) has produced a large number of required technical manpower.

Apart from being the research arm of government, the KAIST also conducts its own graduate programmes. Under the special law to educate leading scientists and engineers, its goal is to produce high caliber S&T manpower with creativity and originality to serve the advancement of sciences and creation of innovative technologies for Korea. Students are offered full financial support, on-campus housing, and exemption from military service. However, after graduation, funded students are expected to continue to work for the sponsoring organizations. Largely, students are those funded by government and private firms in exchange for a service for a pacified period. Students mainly are those employed in government laboratories and industrial research organization. As of 1990, the KAIST has produced about 600 Ph.D. and 6,000 M.Sc. graduates.

With regard to organization responsible development of specific technology, the SERI had been very active in the field of software development. Like the KAIST, in addition to research and development of software and engineering. It provides training and education for computer manpower in both private and government sectors. Teaching areas comprise various field such as automation systems, computer-based education, MIS and data management, package programmes, measurement research, operation research, statistics, graphics, pattern recognition, artificial intelligence, CAE and CAD/CAM. The SERI trains personnel in computer hardware and software more than 1,000 persons each year.

In addition, these institutions also upgrade quality of R&D manpower in the private sector through joint research projects such as the development of thin film for video cassettes by the KAIST, the development of PBXs (TDX-1 and TDX-10) by the ETRI, and the development of the UNIX operation system by the SERI.

In Taiwan, there are three major government agencies have specific missions for providing S&T services to the industrial sector. First is the Industrial Technology Research Institute (ITRI) which offers not only R&D support but also a wide range of S&T services. Second is the National Science Council, particularly its several Regional Instrument Centers which scatter across the island and Science and Technology Information Center. Third is the China Productivity Center (CPC) which provides both training and consultant services for productivity improvement to the industrial sector.

Besides calibration services through its Center for Measurement Standards, the ITRI provides its S&T services through the Electronics Division (ERSO) and the Mechanical Division (MIRL). At the ERSO, a broad range of services are offered. They include a one-stop IC products service which help firms or designers with tools for design and fabrication of micro-electronic devices. Besides, masking services for IC manufacturers, automation engineering services, reliability and environmental testings are also available. At the Mechanical Industry Research Laboratories (MIRL), in order to speed the process of transferring automation technology, which most firms need but can't afford, the MIRL last year began planning its first spin-off, an automation corporation. In February 1989, Mirle Automation Corp. was set up, with capital of NT$550 million and having Houng Sun former MIRL's vice president as its chief executive officer. Its three main thrusts are industrial robots, automation equipment and computer-integrated and control systems.

In order to make a better use of relatively expensive instruments, the NSC has set up Regional Instrument Centers scattering across the nation. They are available to serve industrial purposes as well as research activities. Besides, the Science and Technology Information Center (STIC) was set up within the NSC to provide scientific and technological information services to the R&D workers of industrial, academic, and governmental organizations.

China Productivity Center (CPC) was founded in 1955 in order to speed up the improvement of the ROC enterprise management, industrial technology and structures. In 1984, the Factory Automation Task Force of the Ministry of Economic Affairs was merged with CPC. The CPC is now emphasizing rationalization of production through the introduction of modern computer-based production technologies. They include Computer-Aided-Design (CAD) and Computer-Aided-Manufacturing (CAM).

Education and training not only reflect the economic development and the social and political progress of the last three decades, but also must be recognized as a potent force laying a firm foundation for the continuation of Taiwan's growth and its advance from developing country to threshold of an industrialized and modernized society. The number of vocational training institutes in Taiwan increased from 300 in 1971 to 450 institutions in 1990. Of this number, about 60 percent was operated by the private sector, 25 percent by the public sector, and the rest by university and technical college and vocational school. Most curricula were in the form of supplementary courses for workers.

3.3.3 ASEAN: S&T Infrastructure Being Constructed

Among all ASEAN countries, Malaysia seems to make a good progress on S&T infrastructure. However, at present, it is mainly directed to serve productivity improvement and product/process development activities, not yet for applied research as in Korea and basic research as in Japan. On the top of technical education and manpower development, basic services include standards, testing, training, information, and consultancy. Although these services are not so extensive, it is clearly better than Thailand's. Thailand's infrastructure can be best perceived as at the initial stage of investment. Thai government has, so far, invested in only standards and testing facilities which their services are limited to and applicable for only some products and technical fields. Manpower training activity is largely belonged to universities and educational institutions. Projects and schemes which are directly sponsored or supported by the government are limited. Information and technical consultancy services provided by the government are also negligible.

On the top of technical education and manpower development, Malaysian government assists private firms by providing S&T infrastructure for R&D, QA/QC, and other productivity improvement activities. This infrastructure includes standards, testing, and consultancy services. The main responsible institution is the Standards and Industrial Research Institution of Malaysia (SIRIM). The SIRIM's objectives are to develop processes, products, and technologies for the industry; promote standardization and quality; and provide technical services, assistance, and consultancy to industry. Its services include technology development, quality improvement, technical services, and technology diffusion as follows:

- Technology development: industrial research and development in Manufacturing technology, materials, processes, and design.
- Quality improvement: standardization, schemes on quality, and metrology.
- Technical services: testing, technical information, patent examination services, and engineering services.
- Technology diffusion: incubator program, industrial extension, dissemination of technology, and branch offices.

Apart from these in-house services, the SIRIM (with Bank Pembangunan Malaysia and Malaysian Export Trade Center) is also in charge of the Industrial Technical Assistance Fund aiming to giving grants to small and medium industrial firms. The scope of assistances covers feasibility study, product development, quality and productivity improvement, and market development.

In terms of technical education and manpower development, although the Malaysian government has continuously invested in technical education and increased the number S&T graduates for a number of years, it has just started in technical manpower training. Since only 3-5 percent of the industrial workforce received institutional training, the government tries to raise up skill-intensity in the industry by introducing the Skills Development Fund similar to Singapore's. In addition, systems of technical education are revised. Examples are certifications of technical personnel and skills, training for specific skills, industrial participation in training and education provided by the public sector, and increments of post-graduate S&T education.

In Thailand, government has not yet had a clear and integrated technology policy. Technology promotion has hither to been peripheral and rather disjointed. Over 25 years of protection, industrial policy has been used to protect the assembly industry rather than building local capability. Instead of assisting private firms by creating good S&T infrastructure and providing R&D support, protectionism for assembly of foreign-brand products was chosen. Nevertheless, there has been little effort to take the necessary steps to make use of foreign technology and create infrastructure to support industrial firms as other Asian Pacific Rim economies.

The Thailand Institute of Science and Technology, Research Thailand's oldest and biggest government-owned research institution, clearly cannot comparable to other Asian NICs' and Malaysia's in terms of S&T services and R&D support to private firms. Activities of the three national technology centers and the Science and Technology Development Board (recently merged as the National Science and Technology Development Agency attached with the Ministry of Science, Technology, and Environment) seem more effective and relevant to private needs. However, their chief concern is with funding and promoting R&D activity in university which is partly to assist private firms.

Their missions, and hence objectives, are not particularly geared up to create S&T infrastructure to nurture industrial strengths and support private sector R&D.

In terms of technical education and manpower development, government has no direct measures towards the production of S&T manpower. It largely functions through the Ministry of Education (MOE) and the Ministry of University Affairs (MUA). Apart from the problem of matching demand and supply of manpower, production and ratio of S&T manpower to total population, labor force, and university graduates has been very low. This has recently become a real bottleneck to the country's industrial development.

3.4 CONCLUSION

Although all of the Asian Pacific Rim economies (i.e. Japan, Korea, Taiwan, Hong Kong, Singapore, and Malaysia) are market-led economies, governments play a large part in creating dynamic comparative advantages. By setting up national industrial policy to prioritize and develop some strategic industrial sectors, governments with consent from private firms target to a few industries and products to create the countries dynamic competition. Governments have manipulated the industry in one way or another, in particular S&T infrastructure including technical manpower and R&D supporting systems. Even in the case of Hong Kong, the so-called "free government-intervention state", it is in the process of reconsideration. Resources are pooled together to best serve private sector R&D. This is to nurture the industries to grow up and be strong to face dynamic competition both in the domestic and international markets.

It is a matter of fact that Japanese government has long been playing a critical role in providing legal and policy frameworks, tax and financial incentives, and S&T infrastructure to support private sector R&D. Therefore, not only are research and development carried out by government, private firms invest millions of dollars both in Japan and many advanced countries. Japanese firms have been actively investing in new product development and process modernization. All of these are to ensure an access to new technology and to serve better customers' needs. As a result, more and more technologies and markets in the West are being challenged and captured by Japanese firms.

In other Asian Pacific Rim economies, similar strategies stand. Governments have continuously been creating strategic and nurturing industrial firms by providing them with S&T services, S&T support, and S&T manpower. For instance, governments play a large part in building up strategic and supporting industries, no exception of Hong Kong. They all provide an environment to create competitive firms and dynamic market competition. Except Hong Kong, they strongly foster and support the industry with various S&T infrastructure: S&T manpower, S&T services, grants and loans and technical supports including R&D activities. Only one difference is the creation of demand and manipulation of demand conditions by the governments. Some certainly do such as Japan, Korea, and to some extent Taiwan. Of course, although these incur certain risks, experiences reveal that returns tend to be higher.

CHAPTER 4: CASE STUDIES OF BIOTECHNOLOGY-BASED INDUSTRY IN THAILAND

4.1 INTRODUCTION

The objective of the three consecutive chapters (Chapter Four, Five and Six) is to present some evidence, through case studies, concerning the relationship between the private sector R&D and the firms' success stories. As mentioned in Chapter 2, the firms' success is gauged here through their technical and business performances. However, given the different levels of R&D activities as well as differences in nature of R&D activities, R&D activities are, to a certain extent, correlated to the firms' performances in an attempt to relate the two.

Based upon the SAPPHO technique described in Chapter 2, three pairs of firms in each respective technology namely electronics, biotechnology and materials technology are investigated. Within each technology, each pair surveyed belongs to an industry whose product is different from the other pairs for diversity purpose (see table 4.1). The selection criterion of both firms in a pair itself is based on the fact that the firms in the same market both carry out R&D activities, although the level of intensity in its R&D activities can vary. It is recognized here that another approach could possibly be performed whereby a pair of firms consisting of one that performs R&D within the firm and the other that does not. However, it is generally felt that to study a pair of firms both of which carry out R&D activities in their firms may yield a more interesting and insightful results. In fact, with this selection criterion, we encounter some cross-section examples among the subjects surveyed that demonstrate the effects of having and not having R&D. Specifically, such cases apply to the firm that used to have no R&D activities in the past but conduct R&D at present.

Table 4.1 List of Industries Surveyed in this Study

Biotechnology	Materials	Electronics
Seeds Tissue Culture Fermentation	Plastic resin Diesel engine Synthetic fibre	PABX IC Computer card

Each pair of firms studied are matched if they possess similar characteristics including:

- year when company started
- product type
- market orientation e.g. domestic or export-oriented
- promotion privilege e.g. granted investment privileges
- ownership structure e.g. Thai-owned or joint-venture
- companv size e.g. similar in size of total sales or capital assets

Note that the above requirements have to be met only during the early year when the pair of companies first started. By controlling for similar firm characteristics at the outset allows elimination of factors affecting the firm's performances. The rest, where R&D could be a part of, can then be considered as contributions to any growth or decline of the firms.

The case studies will be presented, in narrative form, in the following order. An overview of the industry within each specific technology would be presented first followed by the history and evolution of each firm in the industry. Afterwards, each firm's strategies including its R&D and business activities will be discussed. Next, both the firm's technical and business performances used as indicators of its success or failure will be presented followed by the pairwise comparisons. Finally, comments from the firms including the public support they wish to have will be stated and conclusion will be drawn from the case study.

Agriculture has been the lifeline of the Thai economy and will continue to be so in the foreseeable future. Domestic consumption as well as exports of agricultural products have generally increased in both the agriculture and agro-industry. Many utilizes biotechnology as its core technology. The development of the industry is thus vital to the linkages between the agriculture and the industrial sector. R&D activities in biotechnology-based industry will, in effect, contribute to both agricultural and industrial sectors.

Firms that belong to three industries in biotechnology are investigated including seeds, tissue culture, and fermentation. Specifically, these three pairs of firms are the producers of corn seeds, orchid, and monosodium glutamate respectively. In order to preserve the firms' anonymity, the names of the firms will be taken as C1 and C2 for the seed industry; T1 and T2 for the tissue culture industry; and R1 and R2 for the fermentation industry respectively.

4.1.1 Seeds

a) Industry Overview

The major crop of the seed industry visited in this study is corn hybrid. Corn breeding in Thailand involves the following technological processes:[1]

- Identification of germplasm
- Inbred development
- Line testing
- Hybrid formation
- Hybrid identification

Neither tissue culture nor genetic engineering in corn breeding are performed by the private sector in Thailand. Such activities are normally

[1] Pulam, T., "How Do They Develop Corn Hybrid?," Seed Newsletter, year 1, No. 6, Aug.-Sept. 1986.

carried out overseas where the MNC headquarters are located. However, some firms in Thailand do send local seeds they are interested in to be identified overseas e.g. via genetic fingerprinting technique.

Given the open international accessibility to the seed industry which is responsible for the fast pace of development in the private sector in recent years, the recent R&D race of the firms has been stimulated by the investments of foreign firms. However, whether these foreign firms who are mostly MNCs transfer their technologies to their subsidiaries or not is not important. The important point is the fact that all of the subsidiaries in Thailand are now engaging in the technological development.[2]

Corn growers in Thailand have always been acquainted with the use of open-pollinated (OP) seeds and resisted hybrid technology especially prior to 1985 when technology adoption was minimal. Since then, such picture has changed somewhat partly due to the collective efforts of the hybrid seed industry to persuade growers to switch through demonstration plantation and marketing strategies and partly due to the apparent higher productivity of the hybrids.

The unique characteristic of this industry is that such technology e.g. new batch of seeds from overseas cannot be adopted directly but still has to go through the process described earlier in order to adapt to the local environment. Decent quality of OP or hybrid is characterized by its yield or productivity normally described in output per unit area (e.g. kg/rai)[3]. Other features that are important to growers include the corn's resistance to disease and insects; stalk body strength consistency, weight, color and regular seed pattern. A rule of thumb in breeding is that good hybrids normally come from germplasms that are most different. Corn breeders in Thailand work around SUWAN 1 (SW1), a non-hybrid, downy mildew resisting

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[2] Setboonsarng, S., et al., Seed Industry in Thailand: Structure, Conduct and Performance, IVO, 1988.

[3] 1 rai equals 0.1599 hectare = 0.3952 Acres.

Kasetsart University, to develop new hybrids. One of the techniques widely used in the industry which become the individual firm's trade secret is the results gathered from inoculating various known diseases to search for germplasm that contains resistance to such diseases.

b) History of the Firms

C1

C1 is a subsidiary of a leading foreign company which is one of the world's largest seed producers. C1 can be regarded as one of the pioneers who attempted to introduce corn hybrids, which was virtually unknown then, to the traditional corn growers in Thailand over a decade ago. It is wholly owned by its mother company, thus a recipient of an investment privilege from the Thai government. C1's function is purely research and development. There is, however, a sister company in Bangkok whose main function is in handling sales and marketing. Thus, C1's resources, both manpower and budget, are directly dedicated to the R&D activities involving seed development. The company's major crop is corn which mainly serves the domestic market. The starting registered capital was 1 million baht in 1980 and has been increased to 40 million baht in recent years.

The personnel started off with a Ph.D. in Plant Building, an agronomist, and an accountant and only a few workers in 1980. Prior to that, the company was in Thailand to test hybrid from the Philippines.

C2

C2 is a subsidiary of another foreign multinational company which has several branches all around the world. The headquarter overseas carries out R&D activities to improve various types of crops including corn, sorghum, sunflower, and forage crop etc.

Before the takeover of the company by the current owner in 1989, C2 was more of a trading firm which concentrated on marketing strategies. It brought seeds over from Australia since 1976, first for experimental purpose then for sales. Although the company did have some R&D activities in corn breeding along with diversifying into other types of crops e.g. sunflower and a forage crop, it appeared to have stopped short of growth after a decade of existence in the business. It was said that the crux of the problem lies in its lack of a systematic R&D activities in breeding. The situation seems to have changed to a certain extent after the company was taken over by a giant MNC. One of the major improvements since then has been a systematic, on-going R&D activities via a formal R&D division within the company and a fresh injection of capital to absorb previous losses.

C2

One of the reflections of the company success is a reported 800 kg/rai yield on average of C2's corn growing.

c) Firm's Strategies

C1

The pioneering work in hybrid R&D was introduced by a Ph.D. who joined C1 since the beginning. Hybrid, however, was not very well received by the growers then because of the traditional OP seeds they were acquainted with. The situation has changed since then when growth in hybrid usage increases by a hundred percent annually from 1986 onward. The company now claims a 1,000 kg/rai yield for its hybrid corn compared with a 500 kg/rai yield for OP corn. The type of R&D work that C1 does is based on the belief that there is insufficient resources or opportunities for break-through in genetic engineering in this field if C1 attempts to direct its research effort the western way. Thus C1's philosophy rests on its own preference to let its headquarter in the west carry out such high technology activities while C1 conducts its own conventional breeding R&D.

The company marketed its first hybrid resulting from its R&D activities in 1981. Later, the second hybrid was introduced which claimed 10% higher in yields than the non-hybrid SW1. However, due to the time lag between flowering production of the two parent germplasms,

C2

Prior to 1989 C2 was under the control of another trading company that paid more attention to marketing strategies than the technology itself. The company had stopped growing after a number of years. The MNC that took over in 1989 is another foreign company whose business activities cover the manufacturing of drugs, paint and biotechnology. C2 itself does not do any of the biotechnology or genetic engineering R&D work but cooperates closely with its parent company overseas. The MNC provides information requested by C2 e.g. information on RFLP (Restriction Fragment Length Polymorphism) or Genetic Fingerprint. Tropical climate seeding is operated in the U.K. while temporal climate seeding is done in the U.S.. The MNC has branches in Brazil, Australia and Thailand. The headquarter pays high priority to both conventional breeding and plant biotechnology in contrast to other major companies in the world. This is based on the philosophy that biotechnology will be the key factor in order to become the leader in the field in the future.

C1

this hybrid confronted an unexpected difficulty. In 1985 a newly improved hybrid was out in the market which yielded 27% higher than SW1 in productivity. The new breed is also an improvement, through its R&D, by adding another germplasm that subsequently corrects for the time lag problem. Further more, the new hybrid is simpler to breed and can withstand dry season.

The new hybrid itself is not without problem. It appears to be susceptible to downy mildew (DMS). To overcome the problem C1 initially bought a chemical mix from one of its competitors which proved to work well but at an additional cost. Back to the drawing board to improve the situation, the company introduced another hybrid in 1990 that contains downy mildew resistance and also costs less.

Apart from the local know-how, the company's technological capability involves its mother company in the west who supplies its subsidiary in Thailand with the information needed e.g. information on diseases etc. Moreover, research information is also shared globally among the subsidiaries in various parts of the world.

C1 considers data collection vital to its competitiveness in the market. Mini-computer and microcomputers are utilized to create an accumulative database system. Currently C1 has two Ph.D.s and one with a Master's running the company's R&D activities. Another

C2

The R&D department of C2 is divided into three sections: crop breeding, farm service and foundation seed production. The level of functional significance is given at 70, 20 and 10 percent respectively. A new production development department is now set up to handle the commercialization aspect of crop breeding. The objective is to increase productivity. Its R&D goal (in cooperation with the headquarter) is to acquire the cheapest technology. In the short run, the firm's strategy regards RFLP as the most efficient technology. In the long run, they think tissue culture, genetic and herbicide are the ways to go about. Although Isozyme can be performed in Thailand, it is limited in the numbers of loci that can be found compared with RFLP technique.

The research responsibility consists of crop (corn and sorghum) breeding, crop (forage crop and sunflower) testing, breeder seeds increase, and parent seeds production. External R&D interactions include sources in Argentina, Brazil, Australia, U.S., and Belgium. Domestically, C2 interacts with Kasetsart University, Department of Agriculture, and Khonkaen University. Out of 1,500 corn hybrids tested in the beginning, normally only 3 come out to be commercializable and takes about 4 years to conclude the overall test.

Current personnel includes 1 R&D manager (Master's), 2 plant breeder (also Master's), 2 research officers (Bachelor's) and 1 farm officer (technical college).

C1

company was set up to handle specifically the marketing and sales. Its manpower consistently rises from 3 in 1980, to a Ph.Ds, 4 Bachelor's, and the rest are from technical college. The number of workers increases from 2 in 1979 to 50 in 1991, 30 of which are on a permanent basis.

R&D budget increases at the inflationary rate of 5 to 10 percent annually. The R&D budget was 2 million baht in 1980 and has been increasing to 8 million in 1990. As a matter of fact the company did not start doing R&D until 1980. Prior to that it imported products from the Philippines for testing purpose starting from 1976. All in all, the company seems to have a product champion who has been guiding the R&D direction since 1980.

C2

Quality control involves production control e.g. male spores control, humidity control, drug mixture etc. R&D activities include:

- ongoing project to breed corn seeds that can resist DMS
- aiming to improve yield level to 1,000 kg/rai
- aiming to decrease hybrid development time from 4-5 years to 2 years
- in performing quality control of the purity of the germplasm which requires inspection that could take as long as 3 months, RFLP method will save time to 1 month as well as saving in land use.
- aiming at protecting the patent by using RFLP to check the DNA structure.
- use RFLP to inspect if resistance has entered the inbred

Its R&D budget increases around 20% annually to reach 5 million baht in 1991. C2 also utilizes computer system to do data storage as well as keeping records of customer complaints. Its export amounts to only 2-3 percent of total products but the potential is there. Of the 8,000 tons of corn seeds produced in the whole industry the C2's contribution is about 900 tons.

Unlike C1, C2 carries out both R&D and marketing activities within the same company. Its marketing department acts as a medium consisting of sales and promotion section which include distributing information, product demonstration, radio advertisement, open-air movies, keeping growers' records etc. It also has an Operation Department that handles QC, inventory, as well as set up a

C2

contract system with growers whereby the company provides the seeds to the growers who will be responsible for all the other crop growing expenses and the final product sold to C2 at guaranteed prices. An MNC managing director in Australia looks after the policy while the Country Manager handles business management in Thailand. The subsidiary in Bangkok gets the support from the headquarter to the extent that a previous 120 million baht loss in capital is taken care of.

d) Firm's Performances

C1

The technical improvement of C1 can be illustrated through several kinds of performances. First and the most visible of all is the yield level. The conventional OP has a productivity level of 500 to 600 kg/rai whereas C1's R&D product is claimed to offer a 1,000 kg/rai yield to corn growers. The yield figure is even higher in C1's controlled plantation where it is said that the yield level can go up as high as 1,500 kg/rai. On average, the maximum yield of OP corn is 40 percent less than C1's hybrids.

Second, out of 1,500 hybrids formed there might have been less than 10 hybrids that might yield 1,500 kg/rai five years ago. Now, thanks to a more systematic R&D, it becomes a certainty that these 10 hybrids will yield 1,500 kg/rai. This, of course, is a marked achievement compared with a yield of 1,200 kg/rai ten years ago.

C2

The technical performance of C2 is reflected in its productivity of 600 to 800 kg/rai with the 1,000 kg/rai goal in the near future. Its cost reduction scheme also reflects its technological capability as well as improved technical performance. Instead of using chemical to control the DMS in their hybrids, a search through R&D for a breeding that contain DMR can save the company 10 baht/kg. Such project is now moving ahead.

The distinct characteristic of C2 is in its use of RFLP in its breeding business. With this technique which C2 does not perform by itself (the headquarter does the laboratory work) the benefits are several folds. First, the time taken to develop a hybrid can be drastically reduced from 4-5 years to 2 years. Second, the process of inspecting the inbred's purity can consume 3 months but RFLP reduces it to 1

C1

Third, the accumulated know-how enables C1 to better identify germplasms that contain resistance to disease. Consequently, a hybrid that is susceptible to disease can be altered and improved within 2 years. This is a drastic improvement compared to similar treatment for an OP which is extremely difficult.

Fourth, with the existing know-how C1 can perform quality control on a hybrid with ease. On the contrary, an OP does not clearly distinguish its characteristics and varies according to the environmental condition making it difficult to perform quality control.

The business performance on the part of C1 is a reflection in part of its marketing strategy. Specifically, the latter concerns the issue of timing. The general trend in C1's sales figure has been that of growth. The total sales started to take off in 1985 when the market began to buy the idea of hybrids.

The sales as well as the profits consistently increase with the exception of the figures in 1987 when the company encountered an inventory problem. Miscalculation on the part of C1 and the seed industry to a large extent is responsible for the glut in 1987 when drought hit the country around 1984-1986. Because of a limited supply of OPs together with the fact that the growers attempted more than a single crop in a year, an artificial growth misled the hybrid breeders to oversupply the market.

C2

month in addition to saving experimental land area. Finally, the technique is also useful in issuing patent; in examining whether the resistance to disease is inhibited within the breeding and in identifying distinctions among different germplasms.

The business performance of C2 is one that reflects the contribution of R&D directly. The picture before the takeover in 1989 is that of a company whose marketing strategy dominates R&D objective. For this particular industry, the outcome appears to be disastrous. Prior to 1989, the company's revenue hardly covers its expenses. The interest payment was simply the losses to the company. The reason is that the market does not accept C2's product since its uneventful R&D activities was not creative enough to produce better products to the market. On the other hand, it is quite apparent that a strategy whereby R&D leads marketing after the takeover yields improving business performances as reflected by the sales, profit and even the market share.

C1

The market share of C1 stays between 20 to 30 percent. Since the market as well as the supplies expand, the share figure does not always reflect the company's growth.

e) Comments from the Industry

There are numerous comments from the firms interviewed. The first concerns the government agency who should do the research and convey information on good germplasm to the industry. One of a constructive viewpoints concerns a weak point in corn growing industry whose majority belong to MNC. There are wishes out there to see major Thai companies to enter the race. It is quite clear that there are demand within the industry for the government to set up experimental center with equipment to do RFLP analysis, reduce tax on R&D equipment, and possibly set up some kind of an information center that private firms can make good use in developing hybrids. These firms are more than willing to pay for the service.

4.1.2 Fermentation

a) Industry Overview

Monosodium Glutamate (MSG) production technology came from abroad in both of the firms interviewed. The production is a two-step process namely,

- Fermentation,
- Isolation & Refinery.

The goal is to ferment Glutamic Acid (liquid) through evaporation and crystallization procedures. Specifically, glutamic acid is evaporated from 3 to 1 in volume at the isolation stage, crystallized at the refinery where it forms MSG syrup which is then removed of any impurities and color before stirring the syrup to the final product of MSG. Raw materials used in the production process can either be cassava or mollasse or a combination of both depending on the strategy of the firm.

b) History of the Firms

R1

Company R1 started in 1967 dominated by foreigners with Thai personnel working only as assistants. Its only product is MSG which serves domestic Thai market. The ownership has been a joint venture with 51% Thai share. The manpower then was approximately 300. Currently, all department heads are Thais with only two foreigners in the Board of Directors. Company R1's production started with 3 batches at 45,000 litre of production capacity each per day. Currently the firm has 5 batches at 120,000 litre capacity each and 15 batches at 60,000 litre each although not all batches are active at the same time.

R2

Company R2 operated in 1964 as a joint-venture. The technology was wholly transferred from abroad accompanied by foreign technicians. Pilot plant was also set then with an emphasis on the fermentation process. R&D was a part of the laboratory. The plant employed 100 people at that time to operate the equipment. Lately, it is wholly operated by Thais.

c) Firm's Strategies

R1

The technology was first delivered directly from abroad with a yield level or DG (Direct Glutamic Acid: the direct yield from fermenting Glutamic Acid) of 60-70 milligram per cubic centimeter (mg/cc) compared with 115 mg/cc at present time. This improvement mainly occurs through the use of bacteria in the production process. In search of a bacteria is thus one of the major R&D activities in this

R2

Company R2's technology was transferred from abroad through foreign technicians and machines were also imported then. Now all technicians are Thais and manpower is increased from 100 to 400. R2 now chooses to use only molasses for its raw material although cassava was used in the old days.

Similar to R1, R2 also encountered bacteriophage problem. R&D person-

R1

industry. Once in the past, there was a certain kind of virus that killed bacteria causing the production process to fail. Through R1's technical department who tried to get rid of the virus, they accidently found a bacteria that lives in the presence of the virus (Bacteriophage). By using this bacteria in the production increases the yield level because the DNA from the virus that penetrates into the bacteria causes the bacteria to better accumulate genes, resulting in more mutation and can even resist the virus. At the same period of time, its lab abroad also developed another bacteria of similar effectiveness level but more consistent in the reaction process. R1 then decided to use the foreign version to keep consistency level in the production but kept its bacteria in the bio-freezer as well as sent the bacteria to the Applied Science Research Institute for backup storage.

Although the use of cassava as raw material offers higher yield in the end product than do molasses, it also costs more. One of R1's competitors in the market avoids product's appearance (color of MSG) problem by using only cassava as raw material that requires biotin additives in the process to help bacteria to grow (while molasses are sufficiently nutritious to feed the bacteria) which is an additional cost. Different company employs different strategies. As for R1, the company decides to mix cassava and molasses.

In another instance, the technical department (which is the unit responsible for the firm's R&D) found that the anti-foam agent used

R2

nel spent one month to find out later that the problematic bacteria came out with the exhaust air and since there are viruses in the atmosphere, the good bacteria were attacked by these viruses. The solution was then to install a new exhaust system away from the fermentation area and kept the area cleaner.

Process development normally involves equipment and techniques with the cost reduction and increasing productivity as the ultimate objectives. Once, it heard of a chemical that helps in the fermentation process in Japan. R&D section carried out a literature survey and found a closely-related article. Finally, a chemical was found and from a controlled experiment it helps to increase productivity by several percentage points.

Process improvement examples are: a new automatic piping which can improve the accuracy and a smaller pipe where cooling water runs through that works as well as a larger pipe and yet saves on cost.

R2 allocates 10 percent for advertisement. Most of its products are sold domestically and only 5 percent are sold abroad although more profits are made domestically. Its marketing strategy includes door-to-door sales and sales representatives. R2 has contacts with the Japanese who would come occasionally in the capacity of advisors. Its general manager looks after marketing and sales while the factory manager looks after the production which includes R&D section.

in the fermentation process reduces the yield. The department set up a 30 and a 600-liter pilot plants and found another anti-foam agent that does not cut into the yield level but is not as effective in getting rid of the foam. The final solution is a mixture of the two anti-foam using the cost factor to adjust the proportion. The technical department also handles QC by checking the color (white is desirable), crystal size and purity. Refinery department then corrects accordingly. Currently, R1 has 600 employees compared with 300 two decades ago. The technical department has 20 employees with 3 Bachelor's, 7 high-school graduates and the rest are 4th graders. Its department head is a Kasetsart University graduate.

R1 sells its product both through dealers and through its own sales force to both domestic and overseas market. Marketing tactics include prizes for send-in advertising slips from customers. The site where the company is located was chosen due to the fact that some of the shareholders own sugar factory there. Warehouse is located at another location but occasionally the product is delivered directly to dealers. Business is usually good in the North and the Northeast. The management is quite receptive to R&D activities. However, lack of personnel and its slow pace make R&D activities rather inactive.

d) Firm's Performances

R1

The most obvious technical improvement is in the DG which is the factor attributable to the firm's competitiveness in the market. R1 improves through its own R&D as well as technology transfer from abroad from 60 to 115 mg/cc. In addition, the production time also improves from 35 hours with a DG of 60-70 mg/cc down to 31 hours with 115 mg/cc yield. R1 also gets involved in a waste recovery activities i.e. using MSG residues in making artificial fish sauce. Moreover, the isolation and refinery processes are also improved to reduce waste from 28-30 mg/cc in the past to 20 mg/cc at present.

The business performance of R1 has been that of a steady growth in general. The market share has been around 20 percent. Five years ago the total sales amount to 7-8,000 tons while the amount has been increased to 10,000 tons recently. It is clear that higher productivity is one of the major contributions to the firm's success.

R2

R2's technical performance is vaguely reported. A rough guesstimate gives a 10 percent improvement in yield level over the years. The production time, however, has been constant all along. Waste has been reduced by 2-3 percent via recovery and equipment improvement.

Its business performance reflects a somewhat differing picture with a less steady sales and profit in the red. The losses are caused by two main reasons. The first is due to the level of yield that is not up to par i.e. for the raw material used the productivity is not high enough.

Second, the problem is due to the management and as a result there was a change in management in 1985. Overall, it is R&D that helps smooth up the process.

e) Comments from the Industry

Two comments from the industry include the following. First, the company would like to have connections with the public sector for R&D activities. The company is willing to pay for the expenses. Second, the government should reduce tax for analytical equipment used in the laboratory.

4.1.3 Tissue Culture

a) Industry Overview

Tissue culture is a technique brought into the process to expand the plant's quantity. After sterilizing the tissue of healthy plant, the cells multiply themselves after receiving special blend of food e.g. a mixture of coconut juice, bananas and potatoes in addition to chemical such as ammonium phosphate, hormone and gel. The advantage of tissue culture is in increasing the quantity of plants in a limited amount of time. There are about ten firms in Thailand that use tissue culture to produce orchid.

b) History of the Firms

T1

Company T1 started in 1979 as a small company producing orchid about 1 million in production a year with 30 people. The product champion, a Ph.D., resigned in 1985 to work overseas. By 1988 the company moved to another location and the firm expanded at which time the Ph.D counterpart came back and bought the whole company. In 1990, the firm started to diversify its product line to cover other plants such as banana, strawberry, decorating plants, asparagus, bamboo, eucalyptus, and teak etc. The owner graduated and taught courses in tissue culture as well as processes working experience from the industry abroad.

T2

T2 first started in 1969 as a conglomerate of villagers to sell orchid. T2 has been exporting orchid for more than 3 decades by selecting wild orchid. Having seen merchants from neighboring Malaysia and Singapore selling orchids for high returns, T2 started develop its own product and set up a laboratoryplant in 1981 with the goal to serve member-growers. Currently membership amounts to 400.

Both T1 and T2 are wholly owned by Thais.

c) Firm's Strategies

T1

The head of the company, a Ph.D. who now owns the company used to teach courses in tissue culture before leaving the company in 1985 to work overseas. In addition, the company's technology is derived from university's students research work, colleagues of the owner in and out of the country, and his own experience from abroad. There have also been cooperation between company T1 and Chiengmai University as well as the Department of Forestry. Some of the plants' technology such as Tong bamboo, papaya and banana already exists, thus the only concern is in commercialization.

T1 believes that R&D is essential to the industry's survival. The industry should look 10 years ahead into gene transfer and basic genetic engineering as well as buying breeding plants from abroad. Thailand has no basic research except some at Chulalongkorn. Both the Science and Technology Development Board (STDB) and the Center for Technology Transfer of the Ministry of Science, Technology and Environment (MOSTE) support T1.

In troubleshooting R&D, it occurred that the nutrient for Tong bamboo was not good enough for the root to grow. T1 tried using nutrient from Sang & Ruak bamboo to feed instead and finally solved the problem. As for improvement R&D, T1 adjusted the 20-liter food preparation container to 100 liter to accommodate the increasing operation; separate the duties of QC personnel and supervisor. As for development R&D, T1

T2

The company's R&D section has 7 people with 2 Master's. The lab has 50 people in total. In the beginning R&D has 5 cabinets in the lab compared with 30 now. R&D activities began seven years ago with one head of the lab who was responsible for the production. The lab was restructured to concentrate on research and improvement for higher productivity and lower cost. Some sample of activities include:

- cost reduction activity by changing nutrient from pineapple to coconut juice and banana and thus reducing it from 3,000 baht/kg to 600 baht/kg.
- change from special bottle in tissue growing to whisky bottle, reducing cost from 60 to 1 baht/bottle.
- utilize both natural and fluorescent light source to keep temperature at between 25^{0}C and 28^{0}C.
- use rubber corking and cotton as well as chemically treated cotton.

Technology absorption involves the feasibility study of artificial seed e.g. of asparagus via protoplast fusion. It is not yet commercialized.

Troubleshooting R&D amounts to 50% of R&D activities e.g. trial and error of nutrients, environment, original tissue, etc.

Improvement R&D includes improving nutrient quality while keeping the price of the product constant.

Development R&D aims at searching for new products and markets e.g.

T1

changes the 100 ml. bottle used to nurture orchids to a larger bottle to save time from 2-week feed time to 3-month feed time. Adaptive technology was performed with researcher in Chiengmai University and the Department of Forestry without having to pay for the research upfront but use profit sharing scheme after sales instead. Since there are risks in some of the plant e.g. unproven results in large scale production, T1 uses half experiment-half commercial method to carry out the project. Labor is becoming more expensive and rare. Turnover rate of workers is higher. T1 is looking into bioreactor as a way to increase tissue culture in a larger quantity. Computer is in the process of controlling the inventory. Waste management is significant since workers deal with delicate work. Carelessness and irresponsibility are two main headaches for the company.

For T1, since profit margin is small, cost minimizing is the only way. Products are sold domestically 90%. Export goes to the South Pacific and South America. T1 uses direct sales without dealers.

T2

cream coconut, Navua which can take as long as 7 years and high investment costs.

R&D budget is not limited but obtained according to the needs. T2 also has plant clinic which offers consultancy in fertilizer, plant improvement, demonstration field without charging any fees.

T2 exports orchid to Europe and the U.S. and tissue to Japan, U.S., Australia, Singapore, etc.

Cost of tissue culture is 8 baht per bottle. T2 has 60 permanent workers and a number of daily-hires. The qualifications range from 20 Bachelor's (mostly in Agriculture) to 30 from technical school. Training is important to develop expertise in the workplace. The rest are unskilled labor.

d) Firm's Performances

T1

The diversity of the base plants is the direct result of R&D activities for T1 especially in the case of teak and bamboo. This results in a drastic increase in the company's overall sales.

T2

T2's technical performances can be identified as follow. First, the percentage of success in expanding the plant's quantity has improved over the years. Two decades ago the success rate was less than 50

T1

Although the total sales and the market share in orchid of T1 has been reduced due to the company's strategy to focus less on orchid and more on other plants, the overall sales will increase from 2.5 million in 1987 to a projected 10 million plants in 1992. Given the nature of the industry whereby R&D always accompanies troubleshooting, the improved product quality is due to the nutrient formulation and the process handling. It is estimated that waste has been cut down by 30 to 50 percent. In the near future, it is expected that the bioreactor technique will reduce the production cycle from one year to about 8 months.

The business performance of T1 can be traced from 4-5 million baht annually during 1987 which has been increased to 6-7 million baht in 1991 with a projected sales of 15 to 20 million baht in 1992. The market share of T1's orchid, however, decreases due to the change in focus of T1 to diversify its products. The profit figures can be approximated roughly at the same ratio of the total sales.

T2

percent, about 70 percent ten years ago and greater than 80 percent nowadays. It can be claimed that a 100 percent success rate is achievable provided that no product improvement is required during the process. Second, R&D activity enhances the quality of the plant e.g. better looking, disease-free, rapid growth. Third, the rate of multiplication is also increased. Depending on the light, temperature, and the physics of the plant, R&D activity enhance the production from 1,000 to 5,000 tissues in 6 months. It is expected that within 2 and 3 years the multiplying effect will jump exponentially to 100,000 and 1 million plants respectively an impossibility if conventional approach is utilized. Finally, other than the ability to select good plants, R&D activity also offers savings on land areas and the environment can be better controlled.

The business performance also reflects a steady growth in sales and profit with the exception of a loss in 1984 when additional investment was put in an agricultural project at Thong-Pa-Poom. The market share was move than 20 percent in 1987 and 30 percent in 1990. The sales volume can get to 40 percent higher a peak period. The profit margin is claimed to be under ten percent of the total sales.

T1's market share rose from 2% (1 million plants) to 6-7% (2.5 million plants). Other than orchid, other products are not yet as competitive. T1 is now ranked third or fourth after the other major competitors in

T2

the market. Next year T1 expects to increase its export to 20% mainly to Europe. Manpower ranges from 8 in 1979, 15 in 1985, 30 in 1988 to 90 this year. Personnel include 1 Ph.D., 10 Master's and Bachelor's, 12 from technical school. The sales figure has been increasing from 6 million baht in 1987 to 9 million in 1991 and a projected 15 million by the end of 1992.

T2's total market for orchid is 80 million baht a year and tissue for 10 million baht a year. The sales figures climb up from 35 million baht in 1977, 73 million in 1980, to over 100 million in 1988 with some fluctuations in between. The profits, however,fluctuates below a couple of million baht. The company limits its production even though more orders come in.

e) Comments from the Industry

A number of comments from the firms include the topics ranging from the public support to waste management. One commented that STDB provides good program to support industry but firm that has no asset will face difficulty since it will have to present collateral to the bank like any other customers. Another said that waste study should be carried out which will effectively reduce costs. Finally, there remains some confusion over the law regarding import for the purpose of export.

4.2 CONCLUSION

In order to perform the pairwise comparisons of the firms surveyed, the following criteria are the basis of comparison:

1. Technical Performance
    - new product
    - yield/productivity
    - production capacity/quality/time
    - waste reduction

2. Business Performance
    - cost-down
    - sales
    - profit/profit margin
    - market share
    - new business opportunities

In addition, an attempt is also made to compare the R&D level of intensity in each firm so that R&D can be linked to the outcome of the performance. It should be emphasized here, however, that it is an impossible task to obtain a complete picture as well as complete information of any firm through the survey. Consequently, the following comparison table is an estimation exercise at best. The foregone conclusions are derived from all sources available to the researchers ranging from hard figures e.g. sales records from the Ministry of Commerce to the sense we get from the interviews or factory visits. However, given the fact that the case-study and our interview is designed to cover each particular firm in depth, as far as firm culture goes for instance, we believe that the result offers a realistic and reliable picture of the pair's relative performance. This is backed up by a large number of data we obtained from the company itself as well as from public access.

Before we present the firm comparison, the scale of R&D activities for each type of R&D is identified (see table 4.2). As mentioned earlier, the type of R&D classified in this study include:

- Trouble shooting R&D (TBS)
- Improvement R&D (IMP)
- Development R&D (DEV)
- Technology Absorption R&D (ABS)

Table 4.2 : Type and Degree of R&D Activities of the Biotechnology-base Firms Surveyed in this Study

Industry	Product	Type of R&D			
		TBS	IMP	DEV	ABS
Seeds	Corn	***	***	**	
Tissue Culture	Orchid	***	***	**	
Fermentation	MSG	**	*		

Note : The number of asterisks represent the amount of R&D work done.

For biotechnology, our observation indicates that there are a number of R&D activities going on in both the seed and tissue culture industries. On the contrary, not much is going on in the production of MSG. The two R&D-active industries perform a lot of trouble-shooting and improvement R&D to reduce cost as well as improve productivity. Some development work is also happening as both industries cannot survive or be competitive in the long run without the introduction of new products.

As for firm comparisons, three areas of comparisons are concluded i.e. R&D intensity, technical performance and business performance as shown in table 4.3.

Table 4.3 : Pairwise Comparisons in R&D Intensity, Technical and Business Performance of Biotechnology-based Firms

Industry	R&D Intensity	Technical Performance	Business Performance
Seeds	C2>C1	C1=C2	C2>C1
Tissue Culture	T1=T2	T1=T2	T1=T2
Fermentation	R1>R2	R1>R2	R1>R2

In R&D intensity, C2 has an edge over C1 because of its application of fingerprinting technique while R1 has benefitted from its effort to experiment and connect with expertise outside the company. While C1 and C2 accomplish equally well in their technical performance, C2's drastic improvement in business elevates its status to equal and only recently surpass that of C1. This is the case partly because of its business expansion in the sorghum and sun-flower. Tissue culture firms are both competitive and variance in their R&D intensity cannot be detected.

CHAPTER 5: CASE STUDIES OF MATERIALS TECHNOLOGY-BASED INDUSTRY IN THAILAND

5.1 INTRODUCTION

In the past, Thailand relied heavily on imports of metal and non-metal materials from abroad resulting in the nation's trade deficit. As the country's economic activities accelerate at a rapid pace during the recent decade, so does the demand for basic and fabricated materials as indicated by the value-added of the metal and non-metal industries.[4] Currently, many related products have been developed and manufactured within the country for both domestic use and export purpose. Given the bright potential of the industry, it is inevitable that R&D becomes one of the important contributions to the success of the industry.

Firms that belong to three industries in materials are investigated including Petrochemical, Machinery, and Textile. Specifically, these three pairs of firms are the producers of plastic resin, diesel engine and synthetic fiber respectively. In order to preserve the firms' anonymity, the names of the firms will be taken as P1 and P2 for the plastic resin industry; Y1 and Y2 for the diesel engine industry; and N1 and N2 for the synthetic fibers industry respectively.

5.1.1 Plastic Resin

a) Industry Overview

In 1991, it is expected that the plastic trade situation will be dormant because the world's economy as a whole is slowly returning to normal after the Persian Gulf Crisis. Demands for plastic are low while the stock kept during the war still remains, thus the trend of plastic price is expected to be on its way down. For Thailand, the past 3 to 4 years of economic expansion has decreased. The expansion rate of plastic, however, still increases due to the demand for construction materials.

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[4] TDRI (1989), The Development of Thailand's Technological Capability in Industry, Bangkok.

There are four types of plastic resins namely Polyethylene (PE), Polyvinyl Chloride (PVC), Polypropylene (PP) and Polystyrene (PS).

The two firms that we surveyed consist of a producer of PE, PP and PS and the other whose main product is PVC.

b) History of the Firms

P1

P1 was established in 1978 to venture into the petrochemical industry. The first plant producing LDPE (Low-density polyethylene) was brought on stream in 1982 and the second plant producing LDPE/HDPE in 1986. This took place several years ahead of the completion of Thailand's first petrochemical complex known as NPC I.

P1 was given an opportunity by BOI to undertake three more projects i.e. PP, ABS (Acrylonitrile Butadiene Styrene) and PS in Thailand's second petrochemical complex known as NPC II. P1's major shareholders (90%) are Thais. Its products mainly serve domestic use and its initial registered capital was 300 million baht. The initial production capacity was 65,000 tons per annum.

P2

P2 is the sole producer of PVC plastic in Thailand. In 1966, P2 was incorporated with a 10 million baht registered capital. In 1971 the first PVC resin/compound production started, the first of its kind in Thailand. In 1972, the company entered into a joint-venture, holding equal shares, between a foreign group (20%) and a Thai counterpart (80%) with another foreign chemical company as one of its shareholder who provides technical assistance. P2 celebrated its 20th anniversary in the manufacturing business in 1991. Its Managing Director is a foreigner and its Chairman of the Board is a Thai with a 50:50 Thai-Japanese board composition. P2 carries out its own marketing as well as through a foreign medium who exports its product to South East Asia and Japan. 75-80% of PVC resin and 70% of PVC compound are sold domestically.

c) Firm's Strategies

P1

The company's first project was to produce Low Density Polyethylene (LDPE) in 1981 without R&D since the production technology of LDPE was already established. In 1986, the company started R&D activities to produce High Density Polyethylene (HDPE). HDPE production requires catalyst(s) which continuously evolves in the development of new products. During that time the company's know-how was highly dependent on the licensor of the raw materials abroad. Since self-reliance has been the company's objective, the R&D department was set up to search for new catalysts. The R&D group is, however, separated into the one responsible for the confidential part of the research and another responsible for the commercial products. In general, catalyst is imitated prior to development.

Troubleshooting R&D includes the problem solving of catalysts via a pilot unit that performs polymerization, the impurity analysis of solvent in the system, and the correction of problems with raw materials. Specifically, by checking the swell ratio, the abnormality in the product can be detected. Problematic solvent causes the product's melt index to the uncontrollable. Raw materials are checked by both the standard testing system (STS) and company's own testing.

Product improvement in the final product is carried out by the two sections i.e. the product control and the technical services.

P2

For company P2, R&D activities cover trouble-shooting, improving products to satisfy customers and to be competitive and develop new products. In 1991 there are 46 people in R&D. PVC is the company's principle product with a production capacity of 8,000 tons of PVC resin in 1971 and 100,000 tons in 1986.

Raw material for the production of PVC resin is Vinyl Chloride Monomer (VCM) from oil refinery process imported from abroad. By adding oil, chemical, color, filler, PVC compound can be produced. Production control is computerized. The application of PVC ranges from cable, pipe, shoes, to bottle.

R&D activities began in 1989 with 18 people. The R&D personnel rose to 39 in 1990 and 46 this year with 2 Ph.Ds, 5 MScs, 16 BSc-BEs and 23 technicians. Technical advisor in resin is from a foreign company. Technical service is divided into QC, application (now becomes R&D), and customer service.

Troubleshooting R&D concerns cases such as PVC resin used in medical compound i.e. IV tube which has a strict medical specification. After six months of study, the company found an anti-oxidant that caused excessively emission of UV. The company then used a new substance to correct the problem.

Product development R&D includes the development of resin similar to that from abroad that offers high polymerization for the production of high strength cable resulting in a

P1

Although a product passes the QC procedure, some customers might still be unsatisfied. Such problem will be handled by a team who would analyze the problem e.g. how stable is Hexane's quality, how good is the product's color. The team considers customer service important. R&D analyzes products from competitors and products from abroad. For example, at times the company wishes to produce product with appearance like those from overseas, R&D would cooperate with production section to search for parameters necessary to improve the product.

Sometimes a threshold is reached between product improvement and new product development. The company is proud of introducing a new grade of thin-film plastic used for shopping bags and a new grade of container which can withstand large volume of chemicals without developing corrosion. Water pipe grade plastic is another example which can withstand high pressure and withstand attack from sunlight. R&D section also studies by-product e.g. wax, waste. There is an on-going attempt to recover waste e.g. burn waste from the boiler to make use of the heat generated, recover Titanium dioxide which is normally neutralized and thrown away.

Currently, there is also a new project coming out of the R&D lab. The purpose is for scaling up a product to commercial level that will not have to acquire know-how from abroad but simply emulate from existing literature. The product from R&D will be sent to the product control to obtain process engineering and later scale up from pilot scale production to a commercial production.

P2

cheaper product. The company also plans to develop PVC compound for drinking bottle in a more transparent appearance. There is very little process development.

R&D spending is in building, equipment, polymerization pilot plant, compounding pilot plant. The company spent 39 million baht in 1989, 43 million baht in 1991 for R&D activities.

P1

The company's cycle of product development involve R&D, production, QC and marketing. Budgeting for R&D follows needs without specific budget allocation. The expenditure includes equipment (usually high cost), operating cost (little cost), and personnel. R&D personnel include a Ph.D., Master's, Bachelor's, and technicians. For example, in 1986 there was only one Ph.D. in the R&D section; there were 1 Ph.D., 6 Bachelor's, and 4 technicians in 1989 whereas there are 1 Ph.D., 14 Bachelor's and 17 technicians in 1991. The increase in R&D personnel stems from the expansion of the company's products to cover Poly-propelene (PP), Acrylonitrile Butadiene Styrene (ABS) and Polystyrene (PS). The R&D section will recruit inexperienced graduates for training. The R&D section also emphasizes pleasant working environment. It directly reports to the managing director.

It should also be noted that there is no need for R&D if there is no competition. LDPE has virtually no R&D and yet cannot produce enough to serve the market's needs whereas HDPE is highly competitive. Its competitors include domestic competitors in Bangkok as well as importers. The important point for R&D is that once the company pays for the license, it then develops further by itself.

R&D's operating cost was 20 million baht in 1990, an increase from 1 million baht in 1986.

d) Firm's Performances

P1

Four characteristics define the improvement in technical performance in the case of P1. The first regards the wider application in developing new products as a result of its own R&D. Examples include the production of PE for use with microwave oven that can withstand heat; the production of HDPE for water pipes which is possible through the use of a catalyst to strengthen the original molecular structure. In addition, 2 years ago R&D activities were able to generate 5 new grades of plastic compared with 10 new grades achieved through the current R&D level. Second, product is improved e.g. the reduction of odor and the elimination of the yellowish plastic color to become white for bottle grade plastic. Third, the cost reduction project which involves the study of impurity in the solvent for recycling purpose without affecting the solvent's quality. Fourth, the process improvement by process engineers who, for example, get rid of the chemicals emitted from the smokestack.

On business performance, it is apparent that the firm's sales and profit consistently increase. Inevitably, new products originated from the R&D section has been a major contributor. The sales figure started from 243 million baht in 1982, gradually increase to 1.26 billion baht in 1985 before the increase took exponential steps to 3.75, 5.21, 5.05 and 6.02 billion baht from 1987 to 1990 respectively. Likewise, P1's profit started from

P2

P2's total sales in 1990 was 4 billion baht with a production capacity of 180,000 tons. The sales figures started from 410 million in 1977, 776 million in 1980, 1.5 billion in 1985 and 3.7 billion in 1988 respectively. The profit pattern also grows accordingly with 8 million baht in 1977, 11 million in 1980, 86 million in 1985 and 717 million in 1990. The recent figures show a return on sales of 12.2 percent in 1990, an increase from 2 percent in 1988. The return on shareholders equity is even more at the rate of 33.2 and 4.7 in 1990 and 1988 respectively. P2 claims to control 75-80 percent market share in PVC and 70 percent in PVC compound.

There are 950 people working for the company including those in Rayong and Bangkok. P2 attempts to develop human resource to possess a sense of quality through QC and hope for low rejects. QC establishes a raw material lab to control raw materials from the supplier for consistent quality. R&D also reduces reject compound by helping in the search for a new raw material to replace the problematic one, help improve e.g. color addition in the compound to scatter the color consistently. R&D also selects appropriate catalyst for optimum yield (productivity). When there is inventory problem, R&D helps identify a temporary formula. The production has been increasing from 8,000 tons of PVC resin in 1971 to 180,000 tons per year in 1990. This figure excludes the production of PVC compound, VCM and caustic soda.

P1

126 million baht in 1983 to 114 in 1986 before jumping to 853, 1,721, 141, 658 million baht from 1987 to 1990 respectively.

e) Comments from the Industry

A number of problems with R&D have been identified including:

- There is little opportunity to cooperate with the outside world because of the confidential nature of the industry.
- Research work requires endurance, time, capital intensive in the beginning.
- Problems dealing with capability in equipment utilization, lack of service support for the equipment and lack of spare parts.

The following are some of the comments from the firms:

- Government should consider lowering tax for raw material import.
- Firms would like to apply for patent.
- Firms wish for the university to arrange training courses for private sector e.g. property test of PVC compound.
- It would be ideal to have a polymer training center.

5.1.2 Diesel Engine

a) Industry Overview

Agricultural machinery utilizes large quantity of metal and plastic parts, both through its own production and through domestic and foreign orders. Activity starts from the design process of a diesel engine in our case. Since firms in this industry are joint-ventures, the design is normally flown in from abroad while the Thai counterparts have to pay for the royalty and bound by the technical agreement. Demand for products in this industry is vast, both domestic and overseas.

b) History of the Firms

Y1

In 1948, Y1's diesel engine was initially imported into Thailand by a foreign corporation. In 1978, Y1 began the construction of the first diesel engine assembly plant in Thailand. In 1988, the business venture was being reorganized to become a joint Thai (60%) and foreign (40%) holding. The engine production of Y1 has enjoyed the BOI promotion with a 200 million baht registered capital. Its main product is a general purpose-horizontal water cooled small diesel engine.

Y2

Y2 was established in 1978 with a 100 million baht registered capital. It is a joint-venture between foreign (60%) and Thai (40%). Its main product is diesel engine and the company receives BOI promotion with the aim of producing 40,000 to 50,000 engines. Y2 is a subsidiary of a major Thai corporation who enjoys business diversification as well as economies of scale in its several production.

c) Firm's Strategies

Y1

For company Y1, the original company was taken over by Y1. The reason for the failure and the subsequent takeover is due to the lack of knowledge about the Thai industry which has no precision part QC (while Japan has no such problem). It is also a design problem since user behavior in Thailand is different. Problem is also due to mismanagement among the middle management who are Thais. These problems resulted in a drop in market share from 70% to 10% and a subsequent takeover.

Y2

Company Y2 is also a joint venture since 1978. There were big problem in the variance of the parts e.g. cylinder cannot be attached. There is a QA team of technical advisors from abroad, but no policy for in-house research. The company uses press work from subcontractors and metal work from a local company. The product is a horizontal, water-cooled, diesel engine. There is still problem with the aluminum diecast.

Y1

Any technical activities carried out must have the stamp of approval from its headquarter abroad. This includes the fact that any new local know-how must also be sent for approval to the headquarter. R&D activities are considered too expensive and there is insufficient domestic market to cushion the expense. Consequently, engineers are taught to handle production and not R&D. Precision work and machining are performed in-house while forging, casting are subcontracted to small shops.

Examples of R&D activities:

- Applying appropriate technology; company Y1 spent 2 years improving air cleaner in the engine to prevent dust, thus increase durability, increase efficiency at the same cost.
- Y1 corrected a problem of valve stick by redesigning the stem seal.
- Resulting from a cost-down project (Y1 has a cost-down committee), Y1 switches from cast iron to steel sheet that has virtually no reject rate and free of mould cost.
- Change from plastic to steel plate because farmers often break the plastic.
- Y1 redesigned the exhaust pipe to reduce packaging expense and save cost on spare part since the new exhaust pipe is redesigned into two smaller pieces.
- Punch three holes on the flywheel to reduce material cost and provide additional applications by farmers for chaining to prevent theft.

Y2

R&D expenditure for new product just started 3 years ago without definite direction. From the total sales of 1 billion, R&D is around 2 million or 0.02 percent. Research and product development section started 6 years ago and became a department just 2 years ago. R&D personnel rises from 2 in 1985 to 8 today of whom 3 are engineers. The R&D head studied engine design from Japan with the mother company. R&D activities cover new products, product improvement, and costdown e.g. how to reduce the flywheel's weight. A production of a 7.5 HP engine is considered a new product (originally 7 and 8 HP existed).

Y1

Y1 improves the production process by restructuring both factory and management. More in-house policy is used in the factory to reduce QC problem e.g. set up a tolerance level for the gear and lump each tolerance together. The company also changes the test line and cycle time which had been a bottle-neck. It also identifies culture problem in production e.g. a loose torque adjustment that nobody cares to tighten up. Y1 changes all this to air-tools. Y1 also upgrades its workers to a higher level of educated workers. R&D budget is about 3% of total factory expenses. Customer service is also emphasized by setting up service centers all around the country. There is a product champion in the company who have been overseeing that constructive changes are properly initiated.

Y1's reasons for joint-venture with foreign holder is that the Thais have neither technology nor brandname (for marketing purpose) though possessing capital and production personnel. Personnel include both local and expatriate (salary man). The Thais are the ones who demand joint-venture for fear that the foreign partner will leave causing the fragile company at that time to collapse. The Technical Assistance Agreement (TAA) is a licensee agreement to enable to use the brandname by paying TAA and royalty fee.

d) Firm's Performances

Y1

Y1's market share improves from 10% in 1988 to 34% in 1991 while profit consistently rises from X in 1988 to 4X in 1989 to 5X in 1990. The production capacity rises in 1988 to 3 times of that in 1986, to 6 times in 1989, to 6.5 times in 1990 before it slows down in 1991 because of the subcontracting problem.

The sales started off from 547 million baht in 1977, 875 million in 1980, 1.1 billion in 1985 before dropping to 301 million in 1988. The profits, however, were not that impressive before the takeover: 7 million in 1977, 14 million in 1980, a loss of 56 million in 1983, a profit of .45 million in 1985.

Y2

The technical performance of Y2 can be reflected through the company's new product. Recently, the firm is ready to introduce a new power tiller, an R&D product suitably designed for Thailand. This project takes one and a half year to survey the market, a year to design, and half a year to generate market through demonstrations. Without R&D, only a horizontal diesel engine from abroad can Y2 market. The ambitious project is also aimed to penetrate markets in neighboring Laos, Kampuchea, Myanmar, Vietnam and possibly Bangladesh. Second, the company's cost down activities involve R&D in action. For example spare parts supporting the fuel tank are converted from aluminum to cast iron reducing the cost by 45 baht per unit. Computing this saving for 100,000 to 130,000 units a year, the cost saving is enormous. During 1980-1988, the R&D activity per se did not exist but related activity occurred in the form of providing guidance and support for the sub-contractors to comply with the engineering specifications.

Y2's market share in 1978 was 20%. It now claims a market share of 70%. Its sales figures range from 358 million baht in 1980, 902 million in 1985 and jumped drastically to 1.8 billion in 1988. The profit grows accordingly: 11 million baht in 1980, 60 million in 1985 and 142 million in 1988.

e) Comments from the Industry

There are several viewpoints from the perspective of the firms. First, there is an opinion that BOI creates problem by demanding 80% local content that is hard to fulfill due to domestic unavailability. In addition, there are no more double credits for compulsory parts. With regard to R&D, for R&D to work in this industry, there must be cash injection from the government. University should produce graduates with R&D concept. Upon implementing the above suggestions, management thinks that matching fund for R&D development program is likely from the private sector since without local know-how a large sum of money is spent each year on royalty and technical fee. Finally, the government should provide direct assistance in both funding and developing personnel to company that has R&D in the beginning.

5.1.3 Synthetic Fiber

a) Industry Overview

Within a course of just 20 years, Thailand has made the transition from a textile consuming nation to a textile exporting country. In the early days, the fiber industry confined itself to producing a large volume of the few types of conventional fibers demanded by the local Thai market. About midway through this period, the market for conventional fibers began to reach saturation, on both global and local scales, and Thailand's textile industry found it necessary to break new ground i.e. to produce a wider range of fibers.

b) History of the Firms

N1

N1 first operated in 1967 as a joint-venture. At that time the Thai market's fishing net was only from natural fiber. N1 came in as a producer of synthetic fiber or nylon. It produced 3 tons a day of nylon for fishing nets with a BOI

N2

N2 was established in 1967 and first operated in 1970 producing staple fiber and filament yarn in 1971. It is also a Thai: foreign joint-venture 9:91 at the outset and currently at 55:45. The idea of setting up a polyester plant in

N1

promotion. Since the market was small then the stock was exported back to Japan. Two years later, the factory started producing polyester (filament only). The production kept on increasing at 200-300 tons a month. BOI then requested the joint-venture to rearrange the holdings from 10:90 Thai: foreign to 45:55 and now 55:45. There is a 50% tax reduction on machines and equipment but none on the chemicals. Its first registered capital was 60 million baht and employed 100 workers.

N2

Thailand was shared by three parties i.e. N2 from abroad, a group of Thai investors and BOI. During the course of time N2 has grown from an initial capital of 27.8 million baht to over 500 million baht in 1977. Turnover increased nearly 10 folds over 10 years time.

c) Firm's Strategies

N1

N1 is the producer of nylon multi-filament, Nylon mono-filament yarn, polyester filament yarn and pre-oriented yarn (POY). N1 is the sole producer of nylon filament yarn for industrial use i.e. mainly for fishing net. It also manufactures filament yarns for apparel use. The production process for nylon utilizes caprolactam as its raw material. The process involves polymerization, spinning, cooling, cutting, extraction of unpolymerized caprolactam, drying an draw-twisting. Polyester uses terephthalic acid and ethylene glycol as raw materials. It does through similar production process. N1 is planning to set up a caprolactam factory at Eastern Seaboard joining NPC II. There are 20 types of polyester distinguished by numbers. The number of filament range from 10 to 48. The characterization calls

N2

As N2 put it, the company is to achieve self-reliance by virtues of promoting support industries and R&D activities. The company sends its staff for training abroad and foreign technicians sent to Thailand to transfer their experience with the Thai counterparts. It claims to have helped local industries e.g. to improve metal coating and plating industries whose operations are necessary for N2's machinery maintenance; developed a sandblast technique during 1975-1976 which gives a roller or a bar a desirable surface and thus saves energy and reducing roughness that damages the fibers.

Trouble shooting R&D depends on the commitment from abroad whose trouble shooter would be readily available when needed. Had it been Thais, it would take up too much time to solve

N1

for brightness, semi-dull, cross-section, round or triangular etc. The application starts off with fishing nets, then auto canvas, conveyor belt, rope and apparel.

There are quality controls in each of the departments. The factory manager looks after the production which covers both O&M. Foremen are sent for training in Japan. Inventory for raw material is 30 days while finished products can last 10 days. Caprolactam is imported from Germany and Japan and terephthalic from England. New Products follow customers' requests e.g. the making of fiber containing uneven filament for a soft and stretch down type of material. Thus N1 sometimes checks sample material to identify type and toughness of the fiber. The process of producing new product thus originated from the sales and marketing division from where request is being sent to the technical service and the production. It takes year(s) to complete and test a product. Its slogan is to cut down on waste, improve productivity, and reduce defects.

N1 pays high priority to customer service. There is a technical service in the headquarter and personnel in the production is a part of that service. The response to customs is both passive and active i.e. accommodates customers respectively. The company is conservative with regard to change. Its manpower operates on 4 teams of workers in 3 shifts. All of the workers are from vocational school and down to 4^{th} graders. Low turnover is characterized by a 13 year working years on average. The number of workers is a bell shape

N2

the problem. Examples include the unmatched control and instrument and the production machine that causes temperature to swing off; the chemical reaction which is not changing its state properly; and the power outage, something unfamiliar in the developed country that causes filaments to break.

Improvement R&D involves production capacity increase, energy conservation and labor savings. For instance, the original machine is set for 10 ton of production. Now the same machine can produce 25 tons by de-bottleneck and speed up at each point of operation. The improvement utilizes only 1.3 times the original energy use and a change to a more powerful motor. From 1980 to 1986 48% of the energy is saved e.g. reduce unnecessary lighting and pump, better insulation and fuel switching. Finally, automation is equipped to save on labor (which is life-time employment) and increase productivity. In 1980, for example, there were 1,350 workers to produce 3,800 tons whereas in 1990 there were 1,000 workers to produce 8,200 tons. Productivity is increased by 2.6 times. The automation is through purchasing of new machine, increase production line and training.

Starting in 1977, the Technology Division took 3 years to develop a new manufacturing process that uses Terephthalic acid instead of Dimethyl Terephthalate which was expensive and in short supply.

Product development involves several techniques such as air-jet, trilobol that enable N2 to introduce various types of staple fibers and filament

N1

from 1967 up until now even though production capacity increase. This can be attributed to a more automated production.

N2

yarns to the market. Among these are Cationic Dyeable (CD) which gives different color shades in a single dyeing; BB or brilliantly bright filaments; fine denier for high-count filaments and mono-filaments for industrial uses. The product development enables N2 to penetrate the high-end market and makes it possible for local textile mills to produce fabrics which otherwise have to be imported.

d) Firm's Performances

N1

N1's technical performance is illuminated by its new products to serve market needs. It also claims a higher productivity especially when automation is brought into the line of production. Campaigns are also carried out to cut down on waste, defects, and improve productivity.

Its market share started off with 100% in the beginning. Now, given a number of competitive firms, N1 is capturing about one-third of the market. This may or may not have anything to do with its conservative policy as the directors of the company themselves admit. Its sales, however, reflect a steady growth from 444 million baht in 1976, 745 million in 1980, 881 million in 1985 and double of the 1985 figure in 1990. The profit figures are mostly consistent with the sales figures with a 6 million baht loss in 16; 18 million, 130 million and 324 million baht profit in 1980, 1985 and 1990 respectively.

N2

N2's technical performance is also reflected in its new products, its higher yields in the production lines, its energy savings and cost reduction. The company is, however, highly dependent on the know-how from abroad.

N2's sales figures tell the same story i.e. that of constant growth. Its sales started from 885 million Baht in 1976 to 1,840 million in 1980, 2,539 million in 1985 and 4,440 million in 1990. Its profit has been climbing from a loss of 106 million in 1980, 242 million and 405 million profit 1985 and 1990 respectively.

e) <u>Comments from the Industry</u>

Comments from the synthetic fibre industry include that of a tax proposal by the Thai Federation of Textile Manufacturers which asks for zero import tax on raw materials. In terms of R&D, the activity should make quick and cost effective returns in order to be granted the opportunity to R&D.

5.2 CONCLUSION

Table 5.1 summarizes the type of R&D activities for the materials technology-based industry. Both the plastic resin and textile industries show keen efforts in achieving competitiveness through product research and development.

Table 5.1 : Type and Degree of R&D Activities of the Materials-based Firms Surveyed in this Study

Industry	Product	Type of R&D			
		TBS	IMP	DEV	ABS
Petrochemical	Plastic Resin	***	***	***	**
Machinery	Diesel Engine	***	***	**	
Textile	Synthetic Fibers	***	***	***	

Note : The number of asterisks represent the amount of R&D work done.

Plastic industry is particularly interested in developing new plastic grades to the market while textile industry does the same more through its mother company abroad. Diesel engine's development work is considerably dwarfed by its technical capability as well as the binding technical agreement whereby any change in the product design locally must be revealed to and obtain approval from the mother company abroad.

The overall performance of the firms in the plastic resin industry appear to be similar both in their R&D activities and the subsequent technical and business outputs with the potential for P1 to accelerate at an aggressive pace into the future (see table 5.2). The consistency of Y2 in both its technical and business strategies make the company more stable, hence appear to hold a competitive edge over Y1 whose current market share is where Y2 was over a decade ago i.e. low. What's more interesting is the fact that Y1 itself has improved drastically after the company's restructuring in 1988. A more systematic R&D effort is at least partly responsible for the firm's improvement in both technical and business aspects. In the textile sector, the conservative policy of N1 in its business ventures into new product and new development sets the firm in a disadvantage position. A more innovative-minded N2 outperforms N1 in the amount of R&D activities and technical performance and has now passed N1 in the business performance.

Table 5.2 : Pairwise Comparisons in R&D Intensity, Technical and Business Performance of Materials-based Firms

Industry	R&D Intensity	Technical Performance	Business Performance
Petrochemical	P1=P2	P1=P2	P1=P1
Machinery	Y1<Y2	Y1<Y2	Y1<Y2
Textile	N1<N2	N1<N2	N1<N2

CHAPTER 6: CASE STUDIES OF ELECTRONICS TECHNOLOGY-BASED INDUSTRY IN THAILAND

6.1 INTRODUCTION

Thailand has experienced both import and export activities of electronic-based equipment including telecommunications, computer-related as well as consumer electronics. The former ranges from household radios and televisions to telephone switching equipment from abroad. The latter normally involves the multinational operations in the country manufacturing electronic components for exporting purpose. As the country and the world, to a large extent, move towards an information society, it is vital to position herself in keeping with the forefront, let alone becoming the forefront herself. R&D activities in electronics-based industry are definitely issues of concern in this regard.

Firms that belong to three industries in electronics are PABX, IC, and computer card respectively. In order to preserve the firms' anonymity, the names of the firms will be taken as X1 and X2 for the PABX industry; I1 and I2 for the IC industry; and V1 and V2 for the Thai card industry respectively.

6.1.1 Private Automatic Branch Exchange (PABX)

a) Industry Overview

Given the economic growth and the upgrading of infrastructure in Thailand, PABX is one of the telecommunication devices that are becoming popular in the business and government circles. The PABX industry consists of both foreign and local companies. Naturally, the imported product with its advance features take an early lead. Technology and pricing are the two criteria of concern to both local and foreign companies.

b) History of the Firms

X1

The company X1 started off by importing electronic equipment at BanMor four years ago by a team of electrical engineering graduates from King Mongkut's Institute of Technology Ladkrabang (KMITL). Within eight months, a PABX was designed imitating foreign products by carefully studying its features and using the same chip set. Through its determination to survive in this competitive market where brandname is a symbol for reliability, X1 has commited itself to improve and expand its PABXs beyond the customers' doubt. R&D activities certainly play a role in this.

X2

X2 was born out of a major oil company which is now becoming a trading representative for X2. Its members are graduates from Chulalongkorn University some of whom are getting another degree in business in order to handle both R&D and business activities. X2's product history started since college years. It took over a year to develop the product. The company's success also derives from its business diversification in 3 areas namely PABX, Air Controller, and Bedside panel respectively.

c) Firm's Strategies

X1

There is no strict budget for R&D. However, R&D expenses include wages while equipment cost amount to around 3% of total sales. Engineers' starting salary is 15,000 baht. Many of its engineers are attracted by and moved to larger companies. X1 tries to maintain its engineers by 3 factors i.e. salary, ease of mind and fringed benefits (health & life insurance, bonus). R&D work is divided into 6 hardware people and 4 software people. The goal is to increase features, improve quality in the long run even if it means lower profit. The firm is looking to being the leader in its field. R&D thus create new or

X2

There are 10 electrical engineers from Chulalongkorn, an industrial engineer to design the appearance of the product and trainees (normally third year students from Chulalongkorn University). Little benefits can be gained from the trainees because of lack of skill and too little time. However, some current engineers employed come from these trainees. The incentives the company could offer consist of challenges through R&D activities provided and a moderate level of salary (10,000 baht). Technicians cover three areas: production (test, repair), engineering support and customer service (e.g. install

X1	X2

improved products and their reliability. For reliability to prevail depends on skills, component and improved circuitry.

Data books and overseas manuals and connections with component manufacturers are essential sources of technology acquisition. Improvement R&D activities include building in a current limiting circuit in place of a fuse which although adds material in cost but reduce service cost. Troubleshooting R&D include adjusting the circuit to correct the ringing sound. R&D problems include team work, job-switching and owner's heavy involvement in other activities. X1 sent R&D personnel to Singapore for training. The company is also keen to get involve with agency such as National Electronics and Computer Technology Center (NECTEC).

X1's problems in the beginning is product accountability. The problem was solved by lending the product for trial use. Another problem is to compete with smuggled foreign products while X1 claims to have paid full taxes. Advertisement and promotion takes 8% of total sales. X1 is now applying for patent of its circuit and has obtained its trademark. The firm starts to export in 1991 to Singapore and Poland. The company does not do its own marketing but select its dealers. Customer service is viewed as important. Through dealers, complaints and repairs are done at X1. Conversation with its agents is X1's way to do marketing research. The owner of X1 appears to be a product champion as well.

bedside panel). The company's system sets responsibility through regular engineering meetings that would assign project leader and feedback. Now technicians' job such as Printed Circuit Board Design (PCB) fabrication and prototype are considered R&D activities. Schematic capture and layout PCB employ high level technicians. New technology is acquired from vendors, suppliers e.g. chipsets as well as from magazines and seminars. A Thai Ph.D. residing in the U.S. would also come to give training occasionally. R&D budget is at 10% of total sales.

Design improvement employs systematic way to improve product reliability within acceptable cost. In addition, a new mold reduces the manual work in hotel bedside panel which is another product the company goes into.

One of the keys in X2's marketing strategies is the use of MBAs or rather engineers turn MBAs. Marketing is carried out through its trading representative. X2 diversifies its products in three areas: PABX, Air controller, and bedside panel at one third each in sales. It claims a 5% market share in PABX which remains the same for the past 3 years. Prior to that the company had only 0.1% in PABX market share.

d) Firm's Performances

X1

Any improvement in technical performance for X1 relies on the following characteristics. First, the fact that new products are out in the market e.g. 8 line-in 32 line-out PABX in 1991 clearly demonstrates the positive contribution R&D has towards the company growth especially when the product is well received. Second, the production quantity is also increased from 150 PABX per month to 300-400 PABX per month. Apart from the improved quality through R&D work, after-sales service and sale and technical support for marketing are also important. Third, a reduction in defect rate is another indicator of improved technical performance. Previously, it is quite common to have a 20% defect rate before rework whereas the number is less than 1% now, adding to the fact that all of the defects can be 100% reworked. The defect is very much dependent on the defective components. Currently this defective lot of components e.g. PCBs, is reduced to 5% due to a more selective strategy of component suppliers.

QC is checked manually and performed by testing circuits but not via ATE. Burn-in period is 24 hours because of sales rush. In 1991, inventory is three times of the production rate while in 1989 it was a day to day production. Quality has also improved. Features now include locked area code, paging, interrupt line, conferencing. Product designer is hired to improve the appearance. Customers' complaint is reduced from 10% to 4%.

X2

Company X2 started to be profitable in 1987. In 1981 the registered capital was 2 million baht which now is to be increased to 10 million. The firm is granted BOI for R&D related tax exemption. Manpower of 15 in the first year including 2 in R&D, 25 (5) in 1988, 40 (8) in 1989, 50 (10) in 1990 and 50 (12) in 1991 (R&D personnel in parentheses).

Total sales increase from 1.3 million in 1986, 4 million in 1987, 6 million in 1988, 15 million in 1989, 30 million in 1990 to 60 million baht this year with a projection of 150 million in sales for 1992. Net profit before tax is around 1 million in 1989 and 3 million in 1990 as a proportion of total sales. Major expenses are in wages. X2's policy is in reducing its own in-house production and to subcontract more. In doing so it would naturally lead to more testing and QC. Rejection rate is at 5% after rework. Assembly involves visual inspection and functional test and calibration. Forty-eight hours of burn-in period and random sampling at 1% QL test. The company uses manual testing.

X1

Company X1's market share in small PABX consistently rises from 5% in 1989, 15% in 1990 to 25% in 1991. (A foreign competitor took a 60% slice off the total market share because of its famous brandname.) It is projected that 400 PABX per month will be sold in 1991. Total sales improve from 8.3 million baht in 1989, 24 million in 1990 to an anticipated 40 million in 1991. Labor increases from 15 in 1989, 18 in 1990 to 23 this year including 3 engineers and 1 technician. The rest are unskilled labor. The product range of varieties are expanded from 1 capital is 1 million baht. Profit is around 30% of total sales before tax. From domestic business, X1 now expands its sales to several countries abroad (about 300 PABX).

e) Comments from the Industry

Both companies in this case study share the following comments. First, the government should revise tax policy especially redundancy in tax collection. In addition, the importing process of electronic component should be reviewed. Finally, the firms are willing to receive technical assistance as much as its need from experienced engineers.

6.1.2 Integrated Circuits

a) Industry Overview

Foreign-owned IC firms started their off-shore operation in Thailand with production equipment for manual IC packaging which was sophisticated and up-to-date at the time. As technology advanced, they brought in a newer vintage of production equipment for automatic IC assembly. The whole production process is computerized. However, know-how still largely, if not all, comes from its parent companies overseas.

b) History of the Firms

I1

I1 is a 100% foreign-based firm. It is also the first IC manufacturer in Thailand. The parent company of the same name is situated in Silicon Valley. Its first venture 18-19 years ago was in Singapore, Malaysia and Indonesia and Thailand is almost the last country the manufacturer settled in. It is the main producer of memory IC chips.

I2

I2 is also a foreign - based company in Thailand. It is another progressive firm facing not only other IC producers in the world market but also other subsidiaries in the same field. Production efficiency is thus a vital criterion in its mass-produced assembly manufacturing which employs sophisticated production technology and a considerably educated workforce.

c) Firm's Strategies

I1

The technology that I1 is involved with is of two folds:
- wafer, wafer, DIP produced in Europe and the U.S.
- assembly, delivered to Asia Pacific.

I1 invested in Thailand some 20 years ago by producing watch module. After four years, the firm introduced semiconductors in the form of small IC chips from ceramic package (CDIP: for Ceramic Dual Inline Package) which was developed following the world trend. Currently, plastic package (PDIP) is used instead to reduce cost. I1 now produces CDIP and MODIP as their major products.

I2

I2 started in 1974 producing IC, both plastic and ceramic and both logic and linear. The company has now terminated its ceramic process and sold out its machine to another company. Current monthly production of plastic DIP is 2.2 million and 200,000 for SO. Production process includes DIP, SAW, DIG ATIC, EPOXY CURE, WIRE BOND, DEJUNK, DEFLASH, MARK, POSTCURE, TRIM/FORM and SOLDER COAT.

Improvement R&D includes:
- Gold wire production to reduce the size of wire bond from 1.3 to 1.2 and 1.0 to 0.9 reducing the cost by 10% although some losses do occur in the process.

I1

During the past 3-4 years, I1 has brought in small IC, SO (Small Outline), PLCC, SMD (Surface Mount Devices) for microprocessor, memory, and digital. I1 headquarter abroad designs the package for production in Thailand. The company transfers technology through Singapore. Thus the standard depends on the U.S. which is a leader for its linear IC.

R&D activities is the responsibility of engineers. Departments are separated into different units (production, O&M) and products are differentiated according to:
- hybrid (build, no test)
- memory
- plastic assembly (build, no test)
- C&C (Computing and Communication)

While linear IC is built in Malaka, Logic in Penang, Memory IC is built in Bangkok.

R&D started 8 years ago. While I1 Thailand expanded, other branches of its international network shrank. Research time for a new product takes two years to materialize. The restructuring of the headquarter resulted in more responsibility for I1 in Thailand. Technology transfer started to be sustained in Bangkok. Improvement and development of products can now be done in Bangkok to a certain level. Budget allocation is obtained through annual operating plan (AOP) following the headquarter objectives.

Training program includes its contract with King Mongkut's Institute of Technology Ladkrabang (KMITL) where engineers and technicians in I1 can take courses fully paid for by the company. operators can also be promoted to

I2

- Epoxy cure burn-in period improvement to 1-2 minutes instead of 10-20 hours.

- Encapsulation without passing through heat at 175 ^{0}C for 3 hours by changing compound for which the process is called Super Fast Cure.

- Cut off the dejunk process by cutting the frame that attaches to the chip at the mould.

- Change the acid and alcohol-based flux used during the solder coat to water base and halide free solution, thus reduces cost and prevent pollution.

- Change tools in the trim/form process that can cut cost by 4 to 5 folds.

Development R&D includes:
- Reduce the cost of compounds that need to be stocked e.g. powder and pellet.

- Terminate the deflash procedure since the process creates fat and reacts chemically to compound. Its vapor affects lung tissue.

- Correct the post cure process by changing the oven that can distribute heat more evenly thus reducing the baking time.

R&D concerning process has 23 personnel. The laboratory has X-ray equipment as well as a spectrometer. Sometimes the company uses Chulalongkorn University's equipment center to test the strength and compound of carbon.

technicians. Personnel is divided into three levels:
- Labor, Operator, QC at daily rates
- Technician, clerk, secretary and
- Supervisor, manager, engineer

Troubleshooting R&D examples include:
- Ceramic is fragile and easily chipped at 1%. I1 built a bumper-like structure that reduces the defect to 0.3% with the goal of 0.1% in the future. In addition, the design team also changed the shape of IC from square corner to a round corner to prevent chipping etc.

- I1 corrected the bonding problem caused by small lead-bond and device by changing to a steeper wedge or angle of bonding in limited area. This is temporary, however, so that a new DI can be developed in the U.S.

Improvement R&D examples include:
- An attempt to correct problems in certain levels of frequency in telecommunication equipment. A new design included spaces at the top and bottom of ceramic to change the capacity and thus the frequency.

- Search for new chemicals in cooperation with outside vendors to reduce acid dip time and toxicity problem. This is, however, still too expensive.

For I1 in the past, there was no freedom in the production process but only passively followed instructions from the headquarter. Thailand was attractive because of its low wages. But since the IC

I1

industry changes rapidly, I1's new products were too slow to succeed. Management in the U.S. started to change its strategy by cutting the size of its production arms in Malaysia and the Philippines and moved to Thailand making it the lead plant in producing Ceramic IC. BOI's incentive has been reduced. Business concept within the organization structure is changing to become business units which are responsible for its own stock.

d) Firm's Performances

I1

Currently I1 produces 6 million CDIP per month, 18 million MODIP per month even though the capacity can reach 32 million. This is due to the slump in world market. All its products are for export purpose only.

Defect rate improves to .1% from the previous 10%. BOI expects labor hiring to increase, but I1's labor is reduced due to automation and higher wages. At its peak 8-10 years ago, there were 3,900 workers. Currently there are 3,200 employees. Labor rate was 40 cents/hr five years ago, now it is 1 dollar/hour which is higher than that paid in Indonesia and the Philippines. Brain-drain is considered a big problem.

Lot rejection uses PPM and now PPB. Cycle time is reduced to 1 month from 2 months and is expected to

I2

I2 had 3,000 workers in 1984 and continuously reduced because of new machine and economic slump. There were 1,800 workers in 1989, 1,700 in 1990, and 1,600 this year. About 400-500 workers have since moved to another company.

Of all the workers, 700 are in production, 500 technicians, 300 administration and 50 engineers. I2 produces 2.2 million DIPs and 200,000 SOs.

Training includes funds for further education, overseas training, joint project with LadKrabang and internal training in English language. The sales for I2 have increased over the years: 52 million baht in 1976, 378 million in 1982, 779 million in 1985 and a quick jump to 3.3 billion in 1988. The profit took off from 8 million in 1976, 47 million in 1982, 154 million in 1985 and 62 million in 1988.

I1

reach 2 week goal soon. Inventory is performed by JIT. Raw material stock is reduced from 2 months to 2 weeks. Finished products that are in stock for more than a year are thrown away. The new inventory concept lets each business unit to be responsible for its own stock. Customer interface is a function of QA. Engineers are to response to questions and complaints within 25 days which now has been reduced to 9 days. The company is a heavy user of computers ranging from E-mail, to Sun workstation. I1's sales have increased over the years: 5.5 billion baht in 1983, 5.8 billion in 1985 and 8.9 billion in 1987. The profit pattern behaves similarly i.e. a loss in 1983, a profit of 401 million baht in 1985 and 354 million in 1987.

e) Comments from the Industry

A few comments were raised by the firms including the willingness on the firms' part to use University service or private laboratory for testing. In general, the firm has no time to develop software, thus outside vendor can fill up this gap.

6.1.3 Computer Card

a) Industry Overview

Although the growth of the computer component industry is largely dominated by foreign firms, there is a niche for local firms on graphic computer cards for Thai languages. In the early 1980s, a number of local firms were very active in the industry when graphic computer software had not yet developed to handle the Thai language and the ASIC chip technology had not yet penetrated the graphic computer market. Therefore, Thai computer users required a computer card to convert English characters (text mode) into

Thai, and production of the Thai card is largely based on discrete components. However, as the software and VLSI technologies progress rapidly, the niches and production structures of the graphic computer cards for Thai language change swiftly.

b) History of the Firms

V1

V1 is one of the first small Thai firms to involve in the Thai card market in 1987. Originally, its product design for Hercules card using manual wiring has evolved over the years to a mass-produced version. The Company is now focusing on color VGA since monochrome is becoming obsolete. V1 merged with a trading company in an attempt to overcome marketing fiasco. The company's R&D has been operating over the years by a product champion. However, as the story will reveal, leader in R&D activities does not always imply business success at the level it deserves.

V2

V2 is another small Thai firm producing Thai card for the domestic market. Started off with 6 people in the company, its first product is a modified Hercules card. The company's major success was when the IRC standard Thai card was introduced in 1987. This comes about because of the company's R&D in conjunction with an aggressive marketing strategies.

The company is also involved with the National Electronics and Computer Technology Centre in a joint research effort since 1990. The obsolescence of monochrome also pushes the company toward a VGA card introduced in 1991.

c) Firm's Strategies

V1

The starting point of company V1 was from a company who first developed a 25-line Thai card. Later on, another company developed the 2nd Thai card adapting from Multitech which finally failed. V1 is now a merger between the original company and a trading company. The evolution of V1's products ranges from a Hercules card to a super VGA card.

V2

V2 started in 1986 with 6 people, 3 of whom do R&D. Its first product is a modified Hercules card. Later came out V2 standard in 1987 card and later a VGA card within 5 years. Hard-lock was used in 1989 and terminated a year later. Piggy bag itself has a reliability problem for which R&D can solve. Other problem includes customers who send in their

V1

Some of the products succeed while some fail. The failure was due to its technology limitation. The successful ones have been mass-produced with imported PCBs from abroad because they are both cheaper and faster in delivery. Its factory is located in the Northern province since its partner has a knitting factory there and workers there are skillful. The original company started in 1986 with 2 persons one of whom did R&D on 30,000 baht budget. Currently, the firm has 3 persons doing QC and software R&D.

Prior to setting up his own company, the current owner worked for other major company in converting the Chinese version of computer card to the Thai language which later proved to be too cumbersome and impractical. After setting up his own company in 1986, the new company's first product launched lasted one year due to conceptual change in the design and hence limited in the needed technology. New products that followed become more and more popular due to its imported know-how and cheaper PCBs from abroad. The original manual wiring and assembly has been transformed slowly to a mass produced production.

V1's product improvement involves:
- Workers' skills which drastically affect job quality
- Basic equipment
- Job organization which shifts from a one person-does-all to production line
- Reduce number of chips
- PCB design as two-layered for ease in repair. Workers can see through the light if dust for instance is trapped inside. It is too thick to see through a four-layered.

V2

cards to be modified. Some model has no burn-in while some do have a 24 hour burn-in. Sometimes low grade ICs can cause garbage on screen which can be corrected by specifying IC brand. Problems include screen outage, loose electrical contact, stalled picture, wiring and soldering problems.

Manual is essential but has to be obtained via a third country due to the copy-right law resulting in a slow pace of technology absorption. The situation further improves when MNC subsidiaries are the sources of some information. Nowadays R&D consists of 4 hardware specialists, 4 software specialists and 4 application specialists. The R&D personnel has been consistently increased from 3 to 15. Its budget is around 5% of the total sales. The company realizes that keeping R&D personnel is a major problem.

V2 takes marketing seriously and marketing is followed by R&D and customer service. The company is active in increasing service, advertisement, and sideline trading. It invests in new equipment, donates cards to the universities and computer schools. Sales depend much on the distributors and pricing is a major issue. Other than sales in the domestic market, V2 also delivered its product overseas e.g. to Nepal, Sri Lanka and India. The company's customer service scheme provides 3 and 2 year-warranty for the monochrome and VGA card respectively. Every spare part will be free under the warranty and the customer can enjoy a spare card while waiting for the repair.

V1

In the beginning, the production is small scale, household level employing 3 handicapped workers to do the wiring. The home-made type of products proved to be cumbersome as there is a lack of work flow. The production line coupled with skilled workers from the North help to improve the product.

V1 sees commercial trend in software. New hires freshly graduated from college may be good in theory but lack skills in digital electronics. Thus, to guide them to do software is the solution. The company, however, has little contact with outside technology. This is realized while working jointly with Hong Kong in the development of XVGA. There exists knowledge-base and cost of equipment is low in Hong Kong.

V1 has another partner as mentioned earlier who takes care of sales and marketing. It is concluded that business could have been better with better marketing. No one even the trading company is available to do marketing. V1 accepts the fact that its competitor's brandname is recognized more than its own in the major issue. Other than sales in the market even though V1 came into the market first. Another problem is a communication problem that exists between the foreign technicians and the provincial workers.

The company's marketing strategy is not taken care of properly while management is disorganized. Lately R&D has less impact on the firm's success relative to marketing.

V1

Customer service is through dealers. V1 provides technical support for both hardware and software. There is a hot-line for software questions and a two-year warranty for hardware. It is claimed that the product can last between 5 and 10 years.

The firm's R&D activities follow trends in the market. New ideas exist but cannot be done due to the small market in Thailand which makes it cost ineffective. Thus, R&D is not quite systematic and rather ad hoc. If R&D activity is stopped today, they felt that the company will last for another five years. There is a product champion in the company.

d) Firm's Performances

V1

V1's technical performance is indicated by its new products. Product improvement is reflected in its range of products offered in the market from a primitive version to a more advanced one. The production quantity increase is not obvious. However, a design that reduces the number of chips, improves on reliability, lessens need for QC as well as higher productivity are contributing factors within. The number of cards produced in a month started from 10 cards in 1987, to 500 in 1988 and 1,000 in 1989. Last year it produces 800 cards. Thirdly, the production cycle is also reduced. It was 800 cards produced in 30 days with 12 workers

V2

V2's technical performance can be scrutinized via its new product development ranging from a modified Hercules card, to a VGA card. The VGA card, for instance, is developed following popular VGA chipset in the market. Secondly, the production quantity also increases e.g. from 400-500 cards in 1987 to 2,000 cards in 1989 and 3,500 cards in 1991. The ratio of mono to color cards is now 20:80 respectively. The company also subcontracts to another computer producer. Its policy is to use marketing as a lead in the company direction. The defect rate was at 20% in 1988 and down to 4-5% recently all of which can be repaired. Many technical problems

V1

in 1989 whereas it now takes 20 days to produce 1,500 cards. The defect rate was 3% previously and now less than 1.5% after rework. Part of the success is due to the skillful workers up North eliminating the need for foreign technicians. Burn-in period is actually performed for 1 hour instead of the usual 3 hour burn-in due to high demand. After which QC is repeated in Bangkok. There is almost no defects returned for the older version. As for the new version, there was almost 10% defect rate in the beginning and the number is now less than 1%.

Its business performance takes off from 2 million baht sales in 1987, 10 million baht in 1988 and 1989 and to 25 million baht in 1990. An estimated figure for 1991 is 45 million baht. Although the volume goes up, competition is more severed. The market share for monochrome has been decreasing from 60% in 1987, 33% in 1988, 25% in 1989 and 1990 respectively. V1 claims to capture 70% of the VGA market in 1991. Profit margin was 25% prior to the merger and the current standard profit margin is approximately 15%.

V2

common to this type of component has been successfully dealt with e.g. garbage or outage problem on the screen which are solved by being more selective in the ICs and PCBs used.

The business performance of V2 sees an increase in total sales i.e. from 15, 30, 50 to 60 million baht in sales for 1988 to 1991 respectively. While the profit stays at a constant proportion to the sales figure. V2 claims to capture 25%, 50% and 70% market share of Thai cards in 1988, 1989 and 1990 respectively. The registered capital steadily climbs from 1 million baht in 1986 to 5 million baht in 1991.

e) Comments from the Industry

The common comment concerning the high tax rate. Both firms wish to see the public sector set up some kind of a know-how center in this field where information can be easily retrieved.

6.2 CONCLUSION

Table 6.1 summarizes the type of R&D activities for the firms in the electronic-based industry. Both the PABX and Thai card companies carry out troubleshooting improvement, up to development R&D in order to survive and hopefully become market leader of its kind. While PABX firm has an uphill battle with powerful foreign multinationals in Thailand, Thai card firms compete among a few of them given the nature of the language. This is a contrast to the IC industry where relatively little R&D activities are being carried out because of its foreign-owned subsidiary nature.

Table 6.1 : Type and Degree of R&D Activities of the Electronics-based Firms Surveyed in this Study

Industry	Product	Type of R&D			
		TBS	IMP	DEV	ABS
Telecom Equipment	PABX	***	***	***	*
Computer	Thai Card	***	***	***	
Electronic Component	IC	***	***	*	

Note : The number of asterisks represent the amount of R&D work done.

Table 6.2 summarizes the comparison between each pair of companies. We take note that there is no major difference between the PABX makers. It is yet to be seen how a more focussed X1 will fare as X2 diversifies into other non-PABX business. V1 and V2 make an interesting case where V2 dominates V1 in its business performance. Likewise, the R&D intensity goes in the same direction although the margin is quite narrow as reflected by their comparable technical performance. The decisive factor is the lack of a good marketing strategy on the part of V1. In IC business, I2 has a generally small advantage over I1 in all aspects that are considered.

Table 6.2 : Pairwise Comparisons in R&D Intensity, Technical and Business Performance of Electronics-based Firms

Industry	R&D Intensity	Technical Performance	Business Performance
Telecom Equipment	X1=X2	X1=X2	X1=X2
Computer	V1<V2	V1=V2	V1<V2
Electronic Component	I1<I2	I1<I2	I1<I2

CHAPTER 7: SYNTHESIS OF THE FINDINGS

7.1 INTRODUCTION

The following chapter provides a synthesis of the findings reported in Chapter 4 focussing especially on the overall picture of the relationship between R&D activities and the performances of the firms surveyed. The central issue is whether R&D has a positive effect, or if any effect at all, on the well-being of the firms and whether R&D can act solely on its own to carry the firms forward. Whichever direction the effect of R&D has on the firm's success, the next question is whether there is any public support as an influencing factor along the process.

7.2 LEVEL OF R&D

Before the relationship between R&D and the firms' performance can be established, it seems proper to go over the level of R&D activities of the firms surveyed at this point. This overview of R&D levels will then lay the groundwork for further discussion and subsequent analysis.

As described in Chapter two, R&D activities are separated into 4 categories namely trouble-shooting, improvement, development and technology absorbing R&D respectively. It is clear that none of the firms being surveyed in this study carry out any traditional R&D activities whereby a new, first of its kind, breakthrough either in the product itself or the process within the production takes place. It is also not too far off to take this fact as a general trend in Thailand's industrial society as a whole.

On the other hand, all of the firms we surveyed do currently perform troubleshooting R&D for the obvious reason i.e. to be able to survive and compete in the business. This ranges from a simple change from plastic to steel plate to avoid breakage in the diesel engine to a more sophisticated technique in redesigning the spaces at the top and bottom of the ceramic in order to correct for the frequency problem in the IC business.

Most of the firms also perform improvement R&D although at various degrees of intensity and sophistication. There are some that perform this level of R&D on an ad hoc basis (as against systematic R&D) due to different circumstances in their companies e.g. too busy with the day-to-day production work etc. The objective of most, if not all, of the improvement R&D is to reduce cost, for example, redesigning of the exhaust pipe in the diesel engine industry; the impurity study for the solvent in the plastic industry in order to recycle the solvent without affecting its original quality; and the redesign of a PABX module to accommodate multiple models. Cost reduction is thus one of the most effective incentives in encouraging the firm to take up R&D. Consequently, the implication to this is that it is not a question of how R&D can be done but why would a company want to do R&D. Other justifications for a firm to do R&D include competition, preference of upper management, encouragement from parent company, all of which may again be related at various degrees to the desire to increase cost and technical productivity.

About half of the companies we surveyed can be considered doing development R&D. Again, their development R&D activities are of differing intensity and sophistication. This ranges from trying to search for a new grade plastic to serve the market demand to identifying a new corn hybrid that can resist Downy Mildew as well as yield impressive productivity level. In addition, many of the cases we have discussed so far are within the overlapping region between two types of R&D. For example, the plastic resin example lies between development R&D and technology absorbing R&D since most of its development work originates from acquiring and imitating technology. The seed industry example stands between improvement R&D and development R&D due to the nature of the breeding business.

Finally, only a few can be considered doing technology absorbing R&D. Apart from the plastic example, imitative activity is also performed in the electronics industry such as those of PABX. Occasionally, this level of R&D

can be a subset of development R&D depending on the initial activity and its sequence.

7.3 R&D AND THE SUCCESSFUL BUSINESS

The core question in this study is whether R&D is "the factor" that causes the firm to succeed in its business endeavor. The answer is yes but not always. But before we get into the detailed discussion of the above statement, let us consider the question from a reverse angle and ask what effect there is if no R&D activity is undertaken within the firm. The answer to this question can be derived from several examples in the case study. That is, any business venture that deals with technology, that business takes risk in competing for market share or profit margin. Without R&D, it is just a matter of time before survival is no longer possible. This conclusion can be strengthened by what happened to the seed, machinery and fermentation industry. One of the seed companies was taken over after running into heavy losses when its strategy is to focus on marketing only and neglecting R&D work. In order to regain its competitive position, the management team of one of the diesel engine companies is drastically overhauled when the previous management neglected a systematic QC and R&D work. Since then an improved business performance is apparent when a new management reorganized the firm's R&D activities. The length of the survival period for the firms that do not take R&D seriously in this study depends on several factors including the nature of the industry and technology, the level of competitiveness, the financial back-up or the "deep pocket", the business diversification of the firm and the dynamism of the competitive industry.

We can conclude that R&D is a necessary but may or may not be a sufficient condition for a firm to succeed. This is because all of the cases we study demonstrate the fact that R&D is directly linked to how a company performs. However, we also found other factors that also contribute to a firm's success. The latter will be dealt with in the next section.

The linkage between R&D and a firm's success is evidenced through the firm's technical and business performances and their correlation to R&D. The following points summarize the key relationships between R&D and both technical and business performances of the firms.

On technical performance:

1. R&D creates new products. To put it otherwise, without R&D there would be no new products. This is obvious when one considers a number of new grade plastic as a result of R&D work each year, or a new PABX module which is more powerful and offer more variety of new features, or new development of tissue culture in commercial plants and fruits, etc.

2. R&D, especially improvement R&D, serves to increase productivity. An obvious example is the improvement of corn hybrid that offers corn growers a higher yield of corn per unit area.

3. R&D activities help in reducing production time which is another dimension of productivity gained. For example, the elimination of the dejunk process in the IC industry enables the company to cut down on production time and as a result reduces labor, maintenance and operating costs.

4. R&D creates innovation which can arise out of a self-reliance policy from foreign technology. A good example is the effort taken by the plastic industry, whose products can be highly dependent on transfer technology, to rely more on its own R&D effort in their search for new catalysts.

5. R&D helps to eliminate waste through recycling or simply better management. This is obvious in many industries including plastic, tissue culture and electronics.

6. R&D helps to increase the rate of success in producing the desirable product and quantity e.g. the success rate in multiplying a batch of specimens (orchids) at a desirable level of multiplication in a given period of time.

7. R&D helps improve product's quality, appearance and environment e.g. in the design of the diesel engine, the appearance of the final product of MSG and plastic applications, and the use of new cleaning agents in the IC industry.

On business performance:

1. R&D increases sales volume and profit e.g. plastic, textile and many other industries.

2. R&D is responsible for the success in the firms' cost-down policy e.g. in diesel engine design and development.

3. R&D may increase profit margin and market share depending on each firm's strategy and the market size respectively.

4. R&D leads the way for the firm to save on royalty and technical fees e.g. in petrochemical and machinery industries.

5. R&D opens up new business opportunities by creating new products and services. This is obvious in many of the industries we have already mentioned e.g. plastic, PABX etc.

7.4 R&D ALONE MAY NOT BE THE ANSWER

Several evidence in the case studies led us to believe that R&D alone may not be the answer to the firm's success. There are several instances where a company's business performance clearly declines even though the company is heavy into R&D activities. This illustrates the insufficiency aspect of R&D toward a firm's success. On the other hand, there are other factors that are responsible for, sometimes in conjunction with R&D , the firm's success. The following list summarizes the additional factors that contribute to the firm's success:

1. Marketing - the factor frequently found to be the key to the firm's success or failure. A combination of R&D and marketing forms a Siamese twins whose health can be equaled to the well-being of the firm. One cannot exist without the presence of the other. When a firm in biotechnology decided to follow the policy of marketing first, it faded away and was later taken over. When a firm attempted to be a technological pioneer in electronics and neglects marketing, it is not doing as well as it is capable of.

A marriage of convenience in this kind of relationship is reflected as evidenced from what we observe during our visits i.e.

- more engineers are turning into MBAs,
- R&D firm is cushioned by its sister trading firm,
- merger between an R&D firm or entity and a trading firm.

2. Manpower - or rather educated manpower who can carry out direct or indirect R&D activities. These people range from electronic engineers who design new PABX to a skilled worker who has been trained to do tissue culture's dissection well.

3. Upper management - specifically cooperation, consent as well as support from upper management have to be there, otherwise R&D activities can be stagnated. This also includes the case where parent companies dictate the technology and transfer it from abroad. Dependency may not be harmful to the business but in the mean time local expertise will never gain ground and local improvement or adjustment will not occur.

4. Quality suppliers - a major obstacle to many industries. We found from our survey that one of the fundamental problems that obstructs the firm's path and pace of growth and prosperity is the quality of parts and components from its suppliers. There are some difficulties in performing quality control on these suppliers and to use these spare parts and components without screening yields a less-than-perfect final product if not a defective one. In the electronics industry, each lot of PCBs or ICs contains a number of defective parts. In the machinery industry, precision metal working from sub-contractors can turn into a nightmare of imprecisions.

5. Taxation and counterfeits - even with a strong R&D activity, some products developed may have to be frozen since they cannot compete in price to cheaper imports and counterfeits in the market. PABX is one good example.

6. Customer service - which could be considered a part of marketing strategy but deserves a special emphasis here due to its importance. Faith, standard, respect, reputation and service are all interrelated and responsible

for the acceptability level of the product in the market no matter how good the R&D division is. Examples of efforts range from providing a spare electronic product for customers to use while defective product is being repaired to setting up a hot line to answer questions and receive complaints.

7. Educating user - this is yet another issue of concern. A newly designed computer card which is supposed to be more efficient and takes up less space is not well accepted once out in the market because it is smaller, hence perceived to have inferior circuitry.

8. Market demand - obviously if a newly developed plastic resin grade finds no application in the market, then the effort and investment is in vain.

7.5 PUBLIC SUPPORT FOR PRIVATE SECTOR R&D

On average, very little public support or government involvement toward the private sector R&D activities exist. Only a few activities are taking place, for instance, a project funding from the Office of the Science and Technology Development Board (STDB) to a biotechnology company to do research on tissue culture for three cash-crops; the National Electronics and Computer Technology Center (NECTEC) who sponsors several projects with private sector involvement for commercial purpose including the development of IC design and a PABX prototype. Other than that there are some connections between universities and private sector e.g. Kasetsart University and corn breeder, Chiengmai University and tissue culture company, Chulalongkorn University and electronics companies.

Private firms interviewed generally perceive the government as not doing enough to be a catalyst toward the industry's technological progress. Many common provisions they would like to see include:

- tax reduction for R&D related equipment.
- a testing facility for each industry where they can perform necessary experimentation and testing of their products for a nominal fee.

- a training center for each industry will be most valuable and efficient to their human resource development.
- an information center for each individual industry where they can learn first-hand knowledge and information to keep up with or imitate the relevant technology.
- a redirection of the nation's tertiary education whereby students are taught to take part in R&D and not just taking notes. There are talks about possible matching funds from the industry since the industry is already paying a hugh amount of money for royalty and technical fees each year.
- tax reduction on imported components e.g. electronic components, chemicals etc. Companies often cite high tariffs on imported components as obstacle to their competitiveness.
- public support is needed to help link the industry and the appropriate R&D organization or personnel. There appears to be a missing link where the two interested parties can be identified and matched.
- private sector is now quite concerned with laws on patent and copyright which may play a major role in the company's decision to initiate or go on with their new product design or project development.

CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

Although many countries have increasingly recognized technology as a crucial factor underlying the country's competitive edge, they frequently remain reluctant to make a substantial investment in R&D. Reasons are manifold. One of them is the uncertainty of the return on individual projects of R&D although the overall investment tends to yield positive returns. Second, it is because of the complex nature of the R&D process before R&D results can be commercially harvested. Third, it is caused by the long lead time of gestation and accumulation of manpower expertise and adequate facility. Nevertheless, performance of many industrialized and newly industrialized countries, in particular the Asian Pacific Rim economies, reveals that a continuous investment in R&D coupled with other S&T activity is a fundamental factor underlying their success stories. As such, private sector R&D stands as a major source of sustaining and generating industrial and economic development.

8.1 EXPERIENCES OF THE ASIAN PACIFIC RIM ECONOMIES

It is widely accepted that the Asian Pacific Rim economies at present have been playing a proactive part of world economic growth. Less than a half of century, these economies transformed themselves from the poor agricultural economies to be the advanced and newly industrialized countries. Despite poor national resources, countries such as Japan, Korea, Taiwan, Singapore, and Hong Kong have achieved a remarkable economic and technological progress. With no secret, technology mastery stands out as a common factor underlying the successful stories. Although government roles are somewhat dissimilar, they play a large part in setting up national industrial policy to prioritize and develop some strategic industrial sectors with consent from private firms. This is to nurture the industry to grow up and be strong to face dynamic competition both in the domestic and international markets.

Nevertheless, this initially requires government support for S&T activity ranging from legal and policy framework, tax and financial incentives, and S&T infrastructure. Commitments to technical change generation of industrial firms are also equally important. Thereby, as the percentage of government expenditures decline, private sector R&D is becoming more critical to sustain industrial growth and economic prosperity.

8.2 RATIONALE FOR GOVERNMENT SUPPORT

Leaving aside the market-failure, externality, and public goods arguments, the rationale for government intervention in S&T activity lies mainly on the reduction of transaction costs. One way to encounter this is to set up institutional framework in the forms of laws and policies. Laws make legal institutional settings such as authorities to provide incentives, budgets to operate policies, and organizations to carry out the planned tasks. This is to empower the government to encourage and/or perhaps enforce both government and private institutions to achieve the agreed industrial structures, conducts, and performances. Thereby, policies are required to provide general guildlines for the institutional settings thereof. The clearer the policies are, the more effective the private sector activities. This is particular true for private sector R&D whereby risk and uncertainty are great, initial investment costs are high, and returns on investment tend to take a certain period of time.

Tax and financial incentives are the measures designed directly to induce private firms to undertake R&D activity by sharing the cost of activity. The arguments for government subsidy are manifold. First, private firms are largely not able to secure adequate gains of all the research results, in particular large-scale projects which their effects spill-over across the whole economy. Second, because of the risky nature and long gestation periods, there is a shortage of capital for S&T development resulting from the imperfection of the capital market. Third, failures of market mechanisms exist in S&T information dissemination, interest coordination, and strategic international trade. Therefore, government should play a supportive role by employing selective measures where appropriate to promote private sector R&D and shift upwards its own S&T development activity.

Building up S&T infrastructure is another component which governments in the Asian Pacific Rim countries have been pursuing. Government intervention is basically justified by the positive externality of S&T infrastructure and its high privately proprietary costs. Accordingly, without support or public investment, total investment in basic S&T infrastructure tends to be low. This apparently leads to high transaction costs incurred to local firms when S&T services are located outside the country, and hence competitive ability. Thereby, government's support and/or direct involvement in providing good S&T infrastructure (ranging from standards, testing and calibration, manpower training, information network and dissemination, and technical consultancy services) is deemed necessary to support private sector R&D and other technical activity. This also holds true for S&T education and manpower development.

8.3 THE PROFILE OF PRIVATE SECTOR R&D IN THAILAND

In Thailand, it can be said that impediments in promoting and supporting private sector R&D are, firstly, the inadequate S&T infrastructure. This includes the inadequate flow of information on technical activities in the public sector, which remains the sector consumes and conducts a large portion of R&D expenditures and projects, despite a high demand for technical consultancy, testing and calibration, and supplies of technical information.

Second, there was also a clear shortage of technical manpower to satisfy present levels of demand for production engineers and technicians, who were necessary for implementing and operating imported "off-the shelf" technology. Despite the underactivity of the Thai companies, it is clear that there is a huge shortage of R&D personnel to carry out industry-related R&D projects sponsored by public funding agencies.

Third, apart from the scarce R&D funds, they remained under-utilized. Reasons were that firstly, industrial firms were not aware of the various loan and grant programmes in the public sector. Secondly, the preparation of detailed R&D proposals was beyond the capability of many small firms. Thirdly, the loans were unattractive because they were fully repayable and required collateral as did any standard loan from a commercial bank.

Owing to these constraints caused by the weaknesses of the country's support systems for private sector R&D, only a handful industrial firms presently engaged in R&D activities.

8.3.1 The Country's Profile of R&D Expenditures

Compared to the Asian Pacific Rim economies (ranging from Japan, Korea, Taiwan, Singapore, Hong Kong, and Taiwan), Thailand's R&D expenditure stands the lowest among the Asian Pacific Rim economies, both in terms of the total amount of expenditures and percentage of GNP. The private sector R&D expenditures in Thailand is also ranked the lowest, both in terms of percentage of the total country's R&D expenditures and percentage of total sales. In terms of amount of R&D expenditures, Thailand spent less than 0.2 percent of Japanese expenditures in 1988. This was less than 4 and 10 percent of Korea and Taiwan respectively. With regard to private sector R&D, while industrial firms in Japan and Korea shared more than 80 percent of the total country's R&D expenditures, Thai firms shared only 5.5 percent (see Table 1.1). Moreover, while American, Japanese, and Korean firms spent about 4.8, 3.3 and 2.1 of their total sales for R&D, Thai firms spent only 0.1 percent (see figure 1.1).

These are precisely the weaknesses of Thailand's industrial development which constitutes little R&D and other technical activities. Both government and industrial are apparently not so active in building up and mastering S&T capability. In Thailand, legal and policy frameworks to support national S&T and private sector R&D are not firmly established. Subsequently, tax and financial incentives are very inadequate, as are S&T infrastructure.

This, in turn, tends to result in low technological capability and competitive ability of the country and industrial firms.

8.3.2 The Relationships Between R&D and Firm Performance

In general, there is some evidence to say that R&D activity in the private sector does improve the firm's technical efficiency and to the lesser extent profitability. However, R&D activity alone is not a guarantee of success. Many more technical and very importantly marketing activities are needed.

Case studies show that successful R&D activities clearly give rise to better technical performance, either in terms of productivity or quality. However, This may not result in better business performance because of many reasons. For instance, firstly, the cost of bringing R&D results to the market or production line is too high or not economic-wise. This is largely caused by unexpected costs during the research owing to the inadequate technical support systems within the firms. Secondly, the market is not ready to accept or the production line cannot accommodate the products/processes resulted from R&D. In other way round, the products/processes are obsolete when they are completed or introduced. Thirdly, there are better or competitive products/processes introduced. More importantly, only a few research projects are technically successful from a number of projects launched, and hence their financial and business implications.

8.3.3 The Effects of Public Support Systems

No clear effects of the public support system for private sector R&D in Thailand are found. R&D in industrial firms largely depends upon themselves and their foreign partners.

Case studies reveal that the existing public support system for private sector R&D is not widely known and recognized as a major supportive source. For large local firms, they largely establish their own R&D facility with their own personnel. Other S&T services necessary to R&D activity tend to rely on services of foreign institutions such as standards, testing and calibration, training, marketing information, and technical consultancy. What they acquire is mainly well-trained technical manpower from the public sector. This brain-drain effect is, perhaps, the most concrete effect found from the study. However, there are some evidence to say that owing to the public support system, a few small local firms are more active in and conduct more R&D activity. This is largely because their R&D projects are more simple and require less technical expertise, facility, and services. Nevertheless, there has been no clear evidence to say that because of the public support system, their business performance does improve. With regard to foreign firms or joint ventures, they do very little R&D activity, and largely depend on their parent companies overseas. The public support system more or less does not affect their activity and performance.

8.3.4 The Constraints to Private Sector R&D

With regard to supply-side constraints, manpower shortages and inadequate S&T infrastructure are clearly the major constraints to private sector R&D. Effective R&D requires high calibre staff as well as adequate supporting facility. However, both are scarced in Thailand.

Case studies point out that many R&D projects/activities are delayed, failed or abolished because of the unavailability of technical manpower and facility. Although foreign firms stand in a better position because of support from parent companies, they do little R&D. Inadequate S&T manpower and infrastructure apparently discourage a number of firms intending to increase their R&D activities in Thailand. This also holds true for joint-venture firms. Many of them fail to establish in-house R&D or conducting some small R&D projects within the firms because they cannot find manpower to fulfil the jobs. Some of them, having in-house research team, also fail because of lacking experienced staff and supporting equipment and information. The situation of local firms is even worse. Except for those of which the owners are scientists or engineers, small local firms largely have insufficient resources to acquire and/or retain good researchers. This is, too, applicable to R&D and testing equipment and information which are very costly.

8.3.5 The Spill-over Effects of R&D Activity

There is no clear spill-over effect of R&D activity among the case studies. Although value-added generation and employment creation can be claimed as a spill-over effect in many firms, these sometimes take place in firms undertaking little R&D or firms having no R&D activity. Reasons may simply be the repercussions of other investment and marketing activities within firms. More importantly, since there is no clear evidence to say that R&D activity always lead to better business performance, these R&D spill-over effects can not be generalized. Nevertheless, case studies suggest that skills, know-how, and knowledge gained from R&D activity do spill over other activities within firms ranging from manufacturing to purchasing, maintenance, marketing and customer services. These seem more useful to the firms, particularly, when the market is very competitive.

8.3.6 The Belief of Traditional Economics

Firm characteristics do not always reflect firm strategies and performances. Firms having similar characteristics can be dissimilar in their business and technology strategies, and hence efficiency and profitability. Decisions to undertake R&D activity in the private sector are affected by both market environments (market and technical conditions) and internal factors (production and technological bases). Whilst the former affected by government policy, the latter is largely conditioned by the owner/management perception and experience and worker skills and knowledge.

Case studies, using the SAPPHO technique, illustrate that firms, which are controlled for similar characteristics such as types of ownership, sizes, product lines, and market segments, can be very different in the ways of doing business. Although it is true to say that government policy and market conditions are the macro settings conditioning the path of business development, the way in which and the extent to which industrial firms see and can exploit such business opportunities are dissimilar. This depends upon whether the owner/management has a good or bad experience in the past and hence the present perception towards the business issues. Along with the skills and knowledge of employees within the firms, this is the embarking point of the firms to invest and build up their production machinery and equipment, general skills, and very importantly specific skills and knowledge. This process tends to be accumulative, making two similar firms at one point of time differing at another point of time. This holds particular true for the private sector R&D found in the case studies when one firm sees the opportunities and invest in R&D along with other technical capabilities, the other does not. This eventually gives rise to a different profile of business development: technical efficiency, firm profitability and business opportunity.

8.4 RECOMMENDATIONS

Based upon the above findings, two essential questions must be addressed, if Thailand is committed to her industrial development. One is how to increase technological contents of industrial firms in product and process improvements in the short term; and the other is how to encourage those firms to further undertake R&D and other technical activities to build up capability to sustain growth in the longer run.

8.4.1 Policy Instruments

Policy dealing with public instruments are mainly designed to strengthen public support systems, which are very inadequate and have no clear effects on the private sector R&D at present.

- Laws for promotion of private sector R&D in order to reduce costs and risks of individual R&D projects.

This, in fact, could share resources and reduce risks of industrial research projects in government institutions and universities when the private sector play an active role.

- Funds for promotion of productivity improvement and product development, in particular products for export.

It aims to allocate resources back to those contributors in the export sector which must be more and more competitive and is willing to do so.

- Measures to promote potential industrial sectors and/or products.

This is to adopt experiences from the Asian Pacific Rim economies in giving guildances and using scarce resources in some potential sectors. It is, by no means, aims to abandon other less potential sectors, but giving weights to the better ones.

8.4.2 Market Mechanisms

Not only policy for public instruments, market mechanisms are an very effective mean to promote private sector R&D, which does not work properly in Thailand.

- Gradual abolishment of industrial subsidies, ranging from import bans, local contents, export requirements, and high tariffs.

Despite a good intention, industrial protection provided by the government has, hitherto, had a tendency to penalize private firms in the long run. However, it must be gradual and have definite time.

- Ensuring equal information among industrial firms, in particular public information such as policies, plans, measures, targets, movements, etc.

In order to strengthen market forces to work effectively, information flows among the parties concerned are extremely crucial. In particular, information from public owned and collected sources should be freely available.

8.4.3 Institutional Reforms

Without institutional reforms, the suggested policies relating to public instruments and market mechanisms could be abortive from the outset.

- Concerting joint tasks for industrial development between private firms and three main government bodies, Ministry of Commerce, Industry, and Science, Technology and Environment.

This is one of the institutional weaknesses which government bodies, and hence their policies and implementations, are rather disjointed, despite complementary and common in nature.

- Synchronizing while upgrading and building S&T infrastructure, in particular S&T services such as standards, testing, training, information, and consultancy services.

Before private sector R&D can perform effectively, S&T infrastructure must be well laid down in a synergetic manner. A services are complementary and interdependent.

- Relating R&D organizations with other technical and industrial institutions, namely, manufacturing, marketing, financing, servicing, and supporting activities.

As R&D alone means very little to business and economic considerations if it does not generate profitability or value-added. Therefore, R&D organizations must be an integrated bodies of other industrial institutions.

ABBREVIATION

ABS	Absorption R&D
ABS	Acrylo-Nitrile Butadiene Styrene
AIST	Agency for Industrial Science and Technology
AOP	Annual Operating Plan
ASEAN	Association of South East Asian Nations
ASIC	Application Specific Integrated Circuit
BB	Brilliantly Bright
BOI	Board of Investment
CAD	Computer-Aided-Design
CAE	Computer-Aided Engineering
CAM	Computer-Aided Manufacturing
C&C	Computing and Communication
CD	Cationic Dyeable
CDIP	Ceramic Dual Inline Package
CPC	China Productivity Center
DEV	Development R&D
DIP	Dual Inline Package
DMR	Downy Mildew Resistance
DMS	Downy Mildew Susceptible
ERSO	Electronics Research & Service Organization
ETRI	Electronics and Telecommunication Research Institute
EX-IM	Export-Import
GNP	Gross National Products
HDPE	High-Density Polyethylene
HP	Horse Power
IC	Integrated Circuit

ABBREVIATION

IMP	Improvement R&D
ITRI	Industrial Technology Research Institute
JIT	Just-In-Time
KAIST	Korean Advanced Institute for Science and Technology
KMITL	King Mongkut's Institute of Technology Ladkrabang
LDPE	Low-Density Polyethylene
MBA	Master of Business Administration
MIRL	Mechanical Industry Research Laboratories
MIS	Management of Information System
MITI	Ministry of International Trade and Industry
MOE	Ministry of Education
MOST	Ministry of Science and Technology
MOSTE	Ministry of Science, Technology and Environment
MNC	Multi-National Company
M.Sc.	Master of Science
MSG	Monosodium Glutamate
MTI	Ministry of Trade and Industry
MUA	Ministry of University Affairs
NECTEC	National Electronics and Computer Technology Center
NIC	Newly Industrialized Country
NSC	National Science Council
NSTDA	National Science and Technology Development Agency

ABBREVIATION

OECD	Organization for Economic Cooperation and Development
O&M	Operation & Maintenance
OP	Open-Pollinate
PABX	Private Automatic Branch Exchange
PBX	Public Branch Exchange
PCB	Printed Circuit Board
PDIP	Plastic Dual Inline Package
PE	Polyethylene
Ph.D	Doctor of Philosophy
PLCC	Plastic-Leaded Carrier Chip
POY	Pre-Oriented Yarn
PPM	Parts Per Million
PS	Polystyrene
PP	Polypropylene
PVC	Polyvinyl Chloride
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RFLP	Restriction Fragment Length Polymorphism
ROC	Republic of China
SAPPHO	Scientific Activity Predictor from Patterns with Heuristic Origins
SERI	Software and Electronics Research Institute
SIRIM	Standards and Industrial Research Institution
SMD	Surface Mount Devices
SO	Small Outline
SPRU	Science Policy Research Unit

ABBREVIATION

S&T	Science and Technology
STA	Science and Technology Agency
STDB	Science and Technology Development Board
STIC	Science and Technology Information Center
STS	Standard Testing System
TAA	Technical Assistance Agreement
TBS	Trouble-Shooting R&D
TDRI	Thailand Development Research Institute
VCM	Vinyl Chloride Monomer
VLSI	Very Large Scale Integrated Circuit

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APPENDIX I

PRIVATE SECTOR R&D: LESSONS FROM THE "SUCCESS"

COMPANY INTERVIEW CHECKLIST

Control Characteristics

1. Could you please describe the history, evolution and development of your company?
2. Could you please describe your product(s) and the market(s) you are in when you first started the company?
3. Please describe the type of ownership of your company when you first started the company.
4. What promotion privileges did you received at the beginning of your company's operation?
5. What is the size of your company in terms of total revenue, assets, manpower and capacity at the start of your company?

Success Characteristics

a. Technical Performances

6. Please define and state your production performance attributes e.g. production time, lead time, defect rate and inventory time.
7. Please state your product's quality attributes e.g. quality improvement, appearance, functioning. Do you have any patent or copyright?

b. Business Performances

8. What is your company's business performances in terms of market share, profit, total sales, average profit and percentage growth of average profit?

R&D Activities

9. Do you have a formal R&D department? If not, how are your R&D activities carried out?
10. Please describe the nature of your company's R&D activities.
11. How do you acquire your technology? Do you consider your technology imitated, adapted, innovated or invented with reference to the existing technology?
12. What is your annual R&D expenditures both in actual number and in percentage of total sales? Do any of these R&D expenditures come from public/government funding?
13. Please describe your R&D team? Are there any training program for members of the team? What kind of promotion and reward system for team members? List team member's qualifications, status (parttime/fulltime) and team size at both the beginning and peak.

14. Is there continuity in your R&D work as against ad hoc R&D?
15. What problems do you encounter in your R&D work? How do you overcome them?
16. What is your assessment of the efficiency and effectiveness of your R&D?
17. Do you cooperate with other R&D departments?

Role of Government/Funding Agencies

18. Do you receive any support in your R&D activities from government agencies? If so, in what form and how regular?
19. Do you know of any government agencies that support R&D? Have you ever contact them? If so, what is your experience and problem?
20. Are there any manpower development and experts provided by the government that influence your R&D work?
21. Are there any legislation or government regulations that affect, positively or negatively, your company's R&D? How? Are there any indirect public support towards your R&D activities including incentives such as taxation?

Customer service

22. Do you identify and detect customers' problems early on?
23. How do you response to customers' request?
24. What type of customer service and customer satisfaction policy do you provide?

Marketing

25. What marketing strategies do you employ?
26. Do you carry any marketing research?
27. What market innovations do you have in adapting to changes in the market?
28. Do you publicize your company's innovation?

Management

29. Is the search for R&D a deliberate attempt of the management?
30. Do you encounter any opposition to R&D activities on both technical and commercial ground?
31. Do you make decision to do R&D more for marketing reason?
32. Are there R&D chief and product champion in your company?
33. What is the criteria for R&D budgeting in your company? Do you think you over- or under-spend on R&D?
34. How do you form an R&D team? Is the management enthusiastic about R&D? What is the status, power, responsibility of the R&D unit relative to other units in the company?

Finance

35. How is your current financial status? What major factors do you think, affect the company's finance?
36. How do you think your company's R&D activities relate to the financial health of your company?

Communications

37. Does the R&D team link/communicate/join the other R&D teams or the S&T community on specialized area?
38. Do you benefit from outside R&D and technology? Do you receive and response to feedback from customers?

Key individuals

39. Does your company have technical innovator, business innovator, CEO or product champion who are related to the R&D activities?

Entrepreneurship

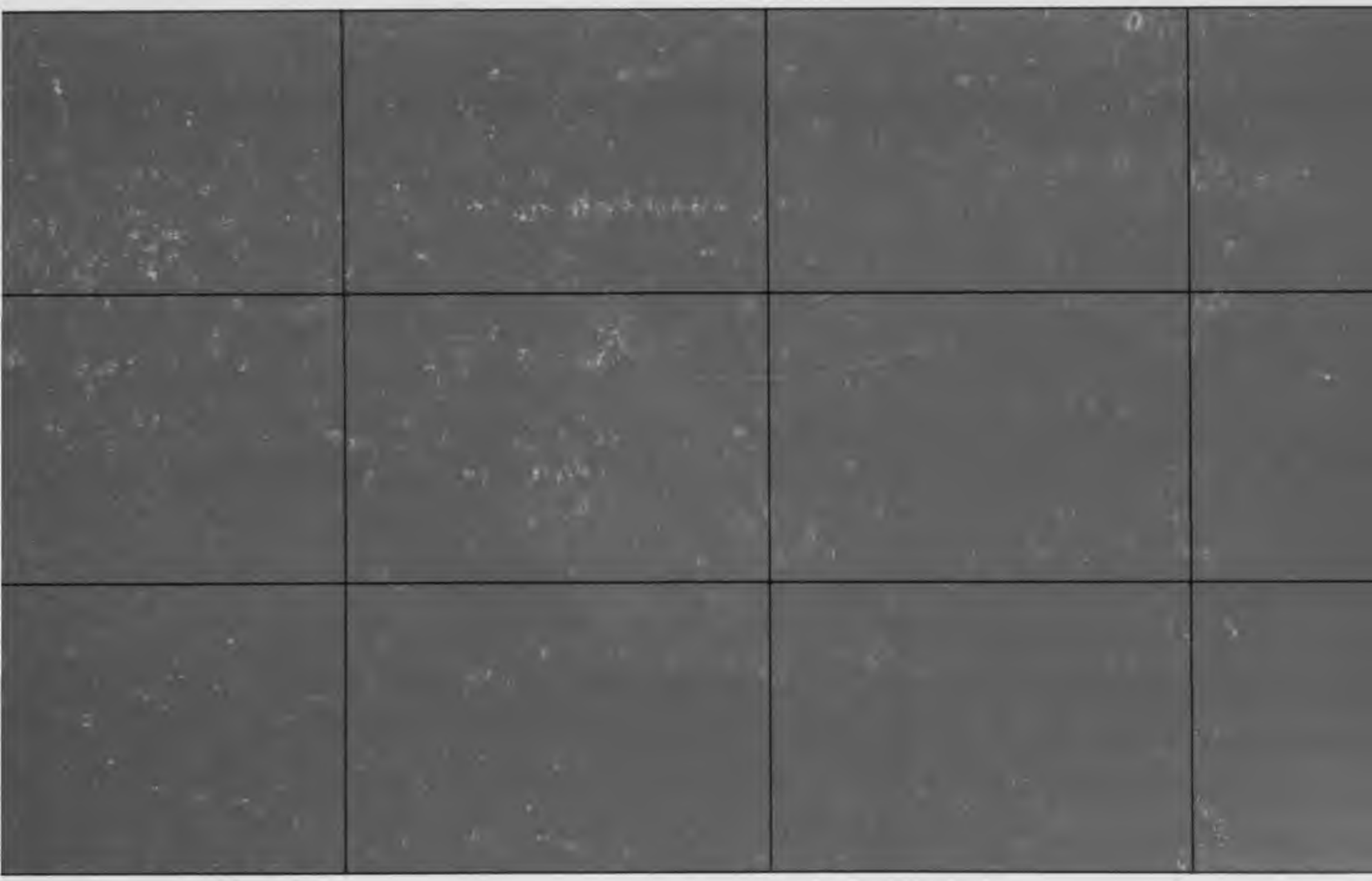
40. Please describe the history of your company's entrepreneurship, if any, and how its development relate to the success of the company?
41. How is the company's R&D activities relate to the entrepreneurship?

Human Resources

42. Please describe the nature of the company's human resource policy, on-going employment and related problems?
43. Please categorize your employees by level of education, skills, experiences, age, sex, responsibilities etc.
44. How can you improve the quality of your employees and what is the existing personnel development activities?

Others

45. What are the associated risks taken with respect to R&D?
46. How familiar is your company to the R&D product and market?
47. Are there any spillover effects from your R&D?
48. What is your perception of the technology trend in your industry?
49. Do you look forward to any institutional reform with regard to R&D activities both internally and externally?



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