TECHNOLOGY AND ECONOMIC DEVELOPMENT: A CASE STUDY OF TECHNOLOGICAL CAPABILITY BUILDING IN SELECTED FOOD MANUFACTURING SECTORS IN THAILAND

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ABSTRACT

The study analyses the role of various internal and external factors (of firms) in technological capability building (TCB) in the food industry of Thailand, by viewing two main aspects of TCB: first, four main elements of technological capabilities (i.e. acquisitive, operative, adaptive and innovative); and secondly, the capability of developing new products. A review of the relevant literature demonstrates that various internal and external factors can influence the success or failure of technological capability building of the firm. The internal factors include size of firm, role of the entrepreneur, firm's policy and strategy, management and administration, accumulation of firm's own experience, manpower flow and internal links, firm's own effort in R&D, and human resource development. The external factors include competitive environment, role of government and related institutions, customers, competitors, foreign direct investment, and cooperation with external agencies.

Data collected from a sample of 62 firms have been closely studied. To start with regression analyses have been undertaken. At a second stage, a perception analysis was used to identify the relative importance of the various factors, as perceived by the firms, influencing the enhancement of the four elements of technological capability. However, for viewing firm-level capability building for developing new products, we have also used a qualitative analysis in the form of a 'pair comparison' review. Although for operative and adaptive capabilities the regression analyses carried out do not show that any of the factors identified have statistically significant relationship, for acquisitive and innovative capability building statistically significant relationships are observed against ownership and promotion status (and in the case of innovative capability, firm size and market orientation as well). However, on the basis of the perception analysis carried out some of the factors including overseas customers and overseas market competitors emerge as dominant ones. In the case of firm-level capability building for developing new products, the regression analysis reveals that only firm-size has statistically significant relationship, while the 'pair comparison' analysis shows that various factors including top management values, policy and strategy, management and administration, R&D efforts, internal linkage and information system, the sufficient fund for undertaking R&D and human resource training, and the motivation and the reward system are dominant ones.

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ACRONYMS

5S	Seiri, Seiton, Seiso, Seiketsu, and Shitsuke
ACP Countries	African Caribbean and Pacific Countries
ACTC	Acquisitive Technological Capability
ADCET	Agro-Industry Development Centre for Export
ADTC	Adaptive Technological Capability
BOI	Board of Investment
CEICAP	Centre of Export Inspection and Certification for Agricultural Products
CFV	Other Canned Fruits and Vegetables
CIF	Cost-Insurance-Freight
CP	Canned Pineapple
CS	Canned Seafoods
DEP	Department of Export Promotion
DF	Department of Fisheries
DFT	Department of Foreign Trade
DIP	Department of Industrial Promotion
DMS	Department of Medical Sciences
DSS	Department of Science Services
EDTA	Ethylene Diamine Tetra Acetate
EU	European Union
EXIM Bank	Export-Import Bank of Thailand
FAO	Food and Agricultural Organization, The United Nations
FDA	Office of Food and Drug Administration
FTI	Federation of Thai Industries
FS	Frozen Seafoods
GDP	Gross Domestic Product
GMP	Good Manufacturing Practice
GNP	Gross National Product
GSP	Generalised System of Preferences
HACCP	Hazard Analysis and Critical Control Point
HRD	Human Resource Development
IFCT	Industrial Finance Corporation of Thailand
IFRPD	Institute of Food Research and Product Development
INTC	Innovative Technological Capability
ISIC	International Standard Industrial Classifications for All Activities
ISO	International Organisation for Standardisation
JIT	Just In Time
KU	Kasetsart University
MOC	Ministry of Commerce
MU	Mahidol University
NAFTA	North American Free Trade Agreement
NCGEB	National Centre for Genetic Engineering and Biotechnology
NESDB	National Economic and Social Development Board
NFI	National Food Institute
NRI	Nutrition Research Institute

OECD	Organisation for Economic Co-operation and Development
OPTC	Operative Technological Capability
PDCA	Plan, Do, Check, and Act
PSU	Prince of Songkhla University
QC	Quality Control
QCC	Quality Control Circle
R&D	Research and Development
RD&E	Research, Development, and Engineering
SAPPHO	Scientific Activity Predictor from Patterns with Heuristic Origins
S&T	Science and Technology
TCdnp	Technological Capability in Developing New Products
TFFA	Thai Frozen Food Association
TFPA	Thai Food Processors Association
TISI	Thai Industrial Standard Institute
TISIR	Thai Institute of Scientific and Technological Research
TPM	Total Productive Maintenance
TQC	Total Quality Control
TQM	Total Quality Management
UK	United Kingdom
UN	United Nations
UNIDO	United Nations Industrial Development Organisation
US/USA	United States of America
USFDA	United States Food and Drug Administration
VIF	Variance Inflation Factor

Approximate Exchange Rate

£1	=	60 baht
US$1	=	38 baht

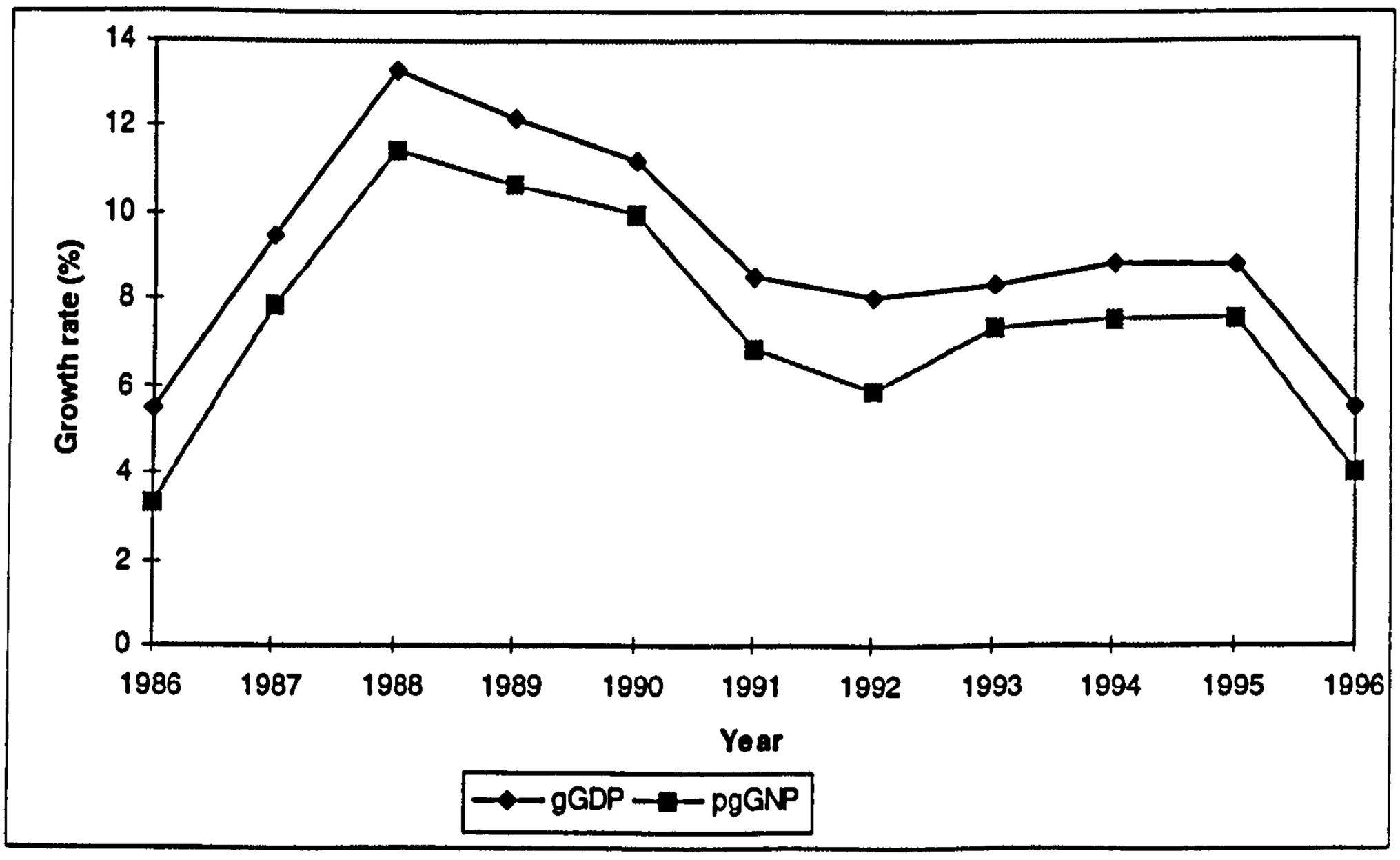
Chapter 1

INTRODUCTION

1.1 Background of the Study

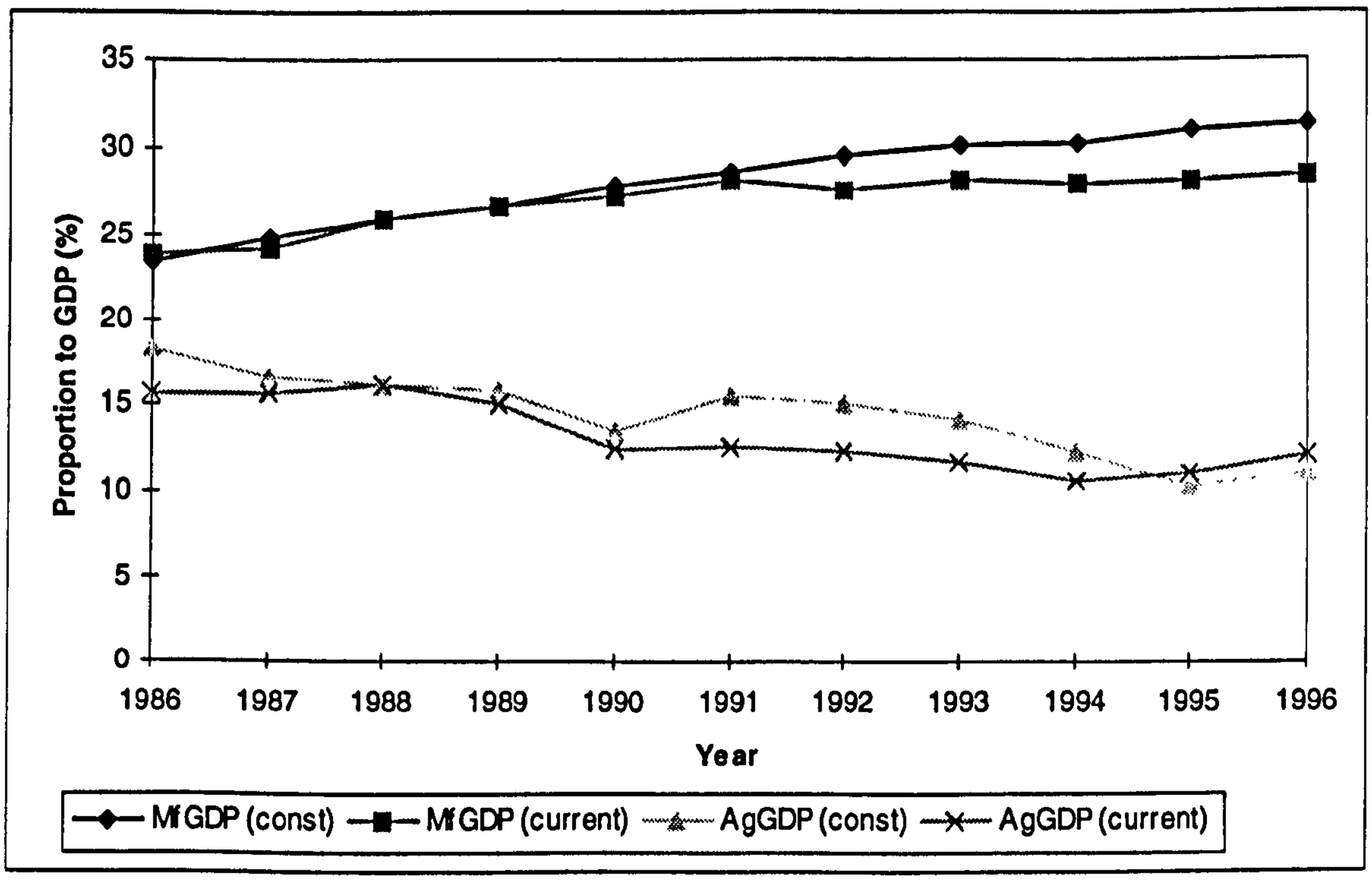
Thailand has achieved very impressive record of economic growth, in particular during the period from 1987 to 1995, achieving an increase in the level of per capita income and also an increase in the percentage of the manufacturing sector in GNP, as shown in Figures 1.1 and 1.2.

Figure 1.1 Growth Rates of GDP and GNP per Capita for the Thai Economy (1986-1996)



Note: gGDP = The growth rate of GDP
pgGNP = The growth rate of GNP per Capita
Source: National Economic and Social Development Board (NESBD), 1999.

Figure 1.2 The Proportion of Manufacturing and Agricultural Products to GDP at Current and Constant Prices for the Thai Economy (1986-1996)



Note: MfGDP (const) = proportion of the value added of manufacturing sector to GDP at 1988 prices

MfGDP (current) = proportion of the value-added of manufacturing sector to GDP at current prices

AgGDP (const) = proportion of the value-added of agricultural sector to GDP at 1988 prices

AgGDP (current) = proportion of the value-added of agricultural sector to GDP at current prices

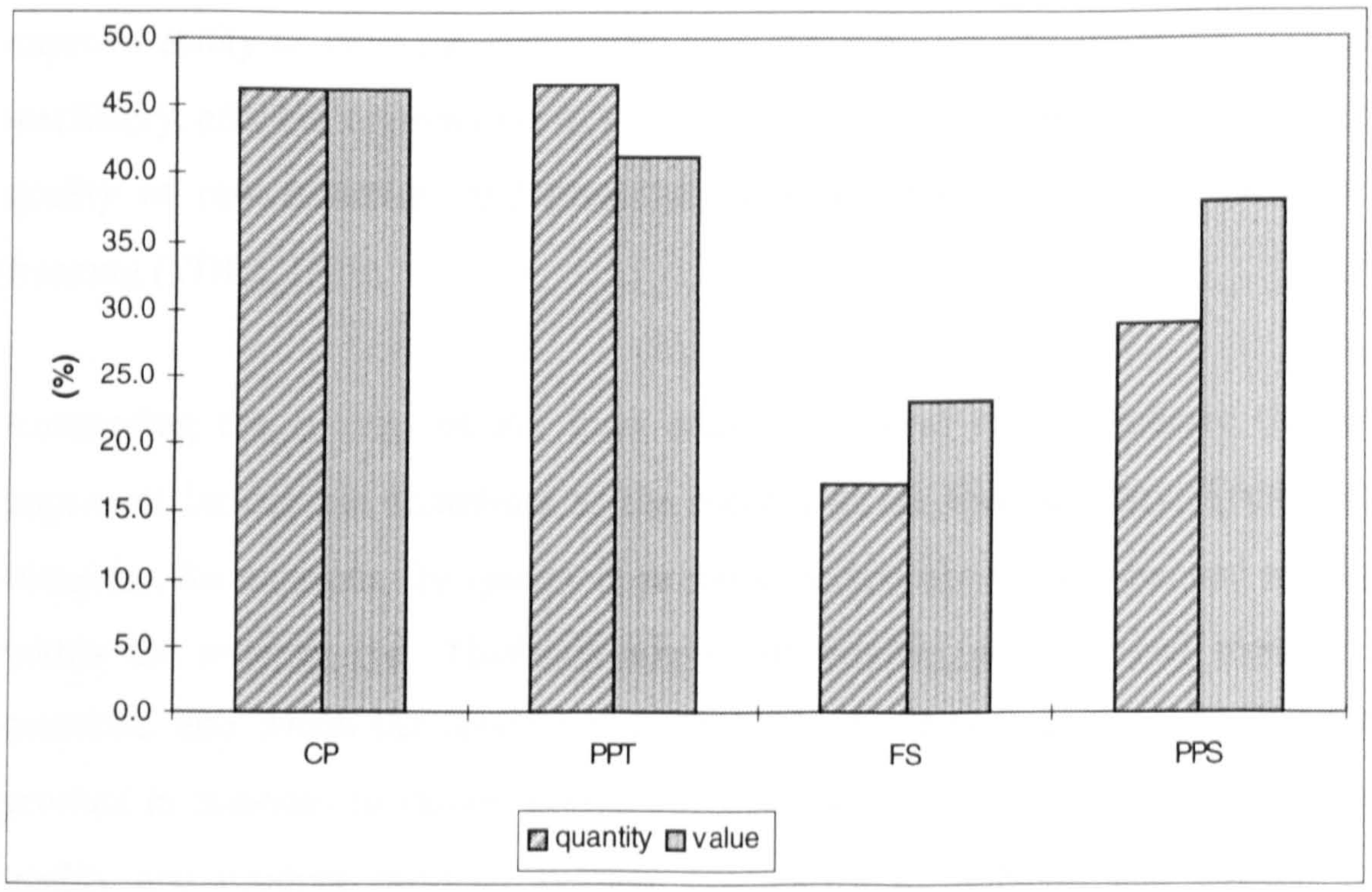
Source: NESBD (1999).

Some may argue that the growth of the Thai economy particularly in the manufacturing sector results from a strong influx of foreign investment, competitive labour costs and a favourable exchange rate (IFCT, 1991). However, the manufacturing export-led economic boom in Thailand also required a certain level of technology in the production process, especially because of its use as a means of developing efficiency in production and management, enhancing product quality and product differentiation, improving packaging and reducing prices of products. These are obviously majors factors for improving the competitive status of any industry in an economy.

Thailand's food industry, one of the country's most important manufacturing industries in terms of employment, foreign exchange earnings, and value added has

become so integral to the country's growth that food products are now one of Thailand's top ten export items. In the world market, Thailand is one of the major food suppliers, with exports valued at $US 5.75 billion in 1994. Frozen, fresh, dried and canned seafoods, poultry, fruits and vegetables of Thailand are all major contenders in the international market (Vorapanya, 1996). In food industry, Thailand is the world's biggest exporter in three main categories: i.e. (a) canned tuna, (b) canned pineapple and pineapple juice, and (c) frozen shrimps. In 1994 Thailand exported nearly 50% of the world's exports of both canned tuna and canned pineapple, as shown in Figure 1.3.

Figure 1.3. The Proportion of Thailand's Exports of Canned Pineapple, Prepared and Preserved Tuna, Frozen Shrimps, and Prepared and Preserved Shrimps, to Total World Exports in 1994



Note:

- CP = Canned Pineapple
- PPT = Prepared and Preserved Tuna
- FS = Frozen Sea-foods
- PPS = Prepared and Preserved Shrimps
- quantity: metric ton, value: US$

Source: 1.FAO (1998a) Vol. 83, Table. 80.
2.FAO (1998b, Vol. 50, Table. 62.

Moreover, new products such as instant and partially prepared foods are rapidly entering the race and winning the upperhand in competition (Vorapanya, 1996).

According to Mekanontchai (1996):

> "The food industry in Thailand has undergone many changes over the past 20 years, including highly automatic, high-speed operation and innovation in packaging formation and distribution system. ... The increased use of processed products and the rapid development of processing industries in Thailand have given rise to different systems of food distribution, legislation, quality standards and difference in consumer appeal " (p.35).

Also, as a result of the changes in the behaviour and pattern of consumption in the world economy, the demand for processed food has changed over time. Meanwhile, the taste of the consumer may increasingly be focused on food's appearance, quality, and modern packaging. This requires the development of many factors such as raw materials, machinery technology, management technology, and marketing technology, so as to enhance the quality and efficiency in the production process. Moreover, in order to gain competitiveness in the international market, the industry needs to improve ability to keep the production cost low with the help of highly productive machinery, efficient organisation of production lines, full exploitation of wastes, good quality of raw materials, and preservation technologies such as sterilisation and freezing (TDRI, 1991).

Concerning the success of the food industry, several studies indicate that many important factors can contribute to the success of the food industry. These factors comprise, for example, the quality of product meeting the regulations and legislation within the country (i.e. Thailand) where the product is made and those in the countries into which the product is expected to be imported; the improvement of product in response to market needs; a reasonable price or balance between product quality and product price by keeping cost down to standard and quality up to standard; packaging; and the creation of new products in the market. These are crucial for the producer to compete with other producers and thereby survive in the long run (IFCT, 1989a, 1989b; TDRI, 1991, 1994; Mekanontchai, 1996; Pothisiri, 1996; Aksaranan, 1996). Also, the industry has to adjust itself to international systems which are full of conditions and barriers. Needless to say, these factors directly involve technology development or the enhancement of technological capability of the firm, and thereby result in the success of the firm and of the industry as a whole. This capability refers to how the firm acquires technology (e.g. machinery

and equipment and know-how) to use, modify and improve, and to develop new processes/products.

1.2 Rationale of the Study

In Thailand, there have been several studies investigating technological capability at the firm level. For example, in the late 1980s Thailand Development Research Institute (TDRI) carried out extensive studies on three different types of industries: biotechnology-based industries, material technology-based industries, and electronic and information technology-based industries (TDRI, 1989a, 1989b; Westphal, 1989). A common approach followed by the above studies is to consider different aspects of technological capability and to investigate the level achieved (TDRI, 1989a, 1989b; Westphal, 1989). The approach followed by these studies and their findings are explained in Chapter 2 and 5. Briefly, they classify technological capability into four elements: acquisitive, operative, adaptive, and innovative capability, and examine their level achieved in Thailand compared to industrialised countries. An important finding from the above studies is that large firms in all the three types of industries appear to have a higher level of operative capability, while only in biotechnology and material-based industries large firms have achieved a high level of adaptive capability, while small and medium-firms have a slightly higher level of adaptive capability than larger firms in electronics and information-based industries. Another important finding is that promoted firms have a higher level of operative capability than non-promoted firms and foreign firms exhibit a higher level of operative capability than Thai firms.

Two other studies, in some way similar to the above, were carried out in the 1990s: the first one was by Tirapanish (1991) on the electronics industry and the second one by Sutdhiyam (1995) on electricity generation. Tirapanish (1991) explored the determinants and environmental conditions which contribute to the promotion of technological capability at the firm level, with regard to four elements of the capability (acquisitive, operative, adaptive, and innovative capability). Sutdhiyam (1995) examined the strengths and weakness of the six elements of technological capability (transforming, vending, acquiring, modifying, designing, and generating capability)

with regard to the best practice elsewhere in order to point out where efforts for capability building can be concentrated on. The findings of these two studies are also presented in Chapter 2.

However, as far as the Thai food industry is concerned, to the best of our knowledge no study has yet been undertaken for investigating its technological capability building. It is true that a number of authors have looked into the food industry of Thailand, mostly based on some specific general approaches. For example, Artachinda (1977) reviewed the situation in the food processing industry in Thailand, mainly to inform the policy makers about the state of the industry. The Industrial Finance Corporation of Thailand (IFTC) examined the trend and prospect of the exportation of Thai canned seafood and canned fruit and vegetable industries in the world market (IFCT, 1989a, 1989b). Wattanasin *et al.* (1990) investigated the problems of technology transfer in the aseptic canned food industry, focusing on three aspects: related laws (e.g. technology transfer contracts), techniques of production, and business management.[1] The Board of Investment (BOI) studied the Thai food processing and the various investment opportunities available in Thailand (BOI, 1993). Takisna (1992) and Siripanish (1995) carried out two separate studies on Thai canned seafood industry, the former appears to provide information about the dynamic development process of the industry, raw materials sources, and export, while the latter emphasised the factors which affect production and marketing conditions. TDRI (1994) also examined the canned seafood industry in order to investigate the future competitiveness of the Thai canned seafood in the international markets, providing a comprehensive study using both primary (domestic and overseas) and secondary sources, including marketing information from overseas,. Finally, TDRI (1996) carried out another study concerning the Thai food industry by emphasising the situation and prospect of employment in the food firms.

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[1] Aseptic process refers to 'a process (in) which the product and container are separately sterilised and then combined together under commercially sterilised conditions' (Department of Health, 1994, p.4).

Thus, it is apparent that although the food sector of Thailand has attracted attention from a number of contributors, no study has yet been undertaken on its technological capability building. However, the need for a study examining technological capability building in the Thai food industry can hardly be overemphasised. As already shown, the food industry in Thailand has remained an important sector in the economy, and has also been highly successful in the international market, thus demonstrating its competitive advantage. It is believed that a major factor for the success of firms is the creation of technological capability (Chapter 2), thus indicating the need for investigating the Thai food industry in this regard.

1.3 Objectives of the Study

The main objective of this study is to investigate what and how firms' internal and external factors have contributed to technological capability building in the Thai food industry. For our investigation the following four main product groups were selected: canned pineapple, other canned fruits and vegetables, canned seafoods, and frozen seafoods. Data collected from a sample survey of 62 firms have been used to analyse two main aspects, as shown below:

(a) Examine the level of technological capability of individual firms, in particular by viewing the four main elements (acquisitive, operative, adaptive and innovative capability) as found in the relevant literature, and investigate the factors which have contributed toward their enhancement (e.g. the four elements of technological capability); and

(b) Identify the level of technological capability of individual firms in developing new products, and examine the factors which have contributed towards technological capability of firms in developing new products.

1.4 Method of the Study

The methodology followed for the study is explained in some detail in Chapter 5. Briefly, as mentioned above, we collected extensive data from fieldwork conducted during the period from August-November in 1997 at two levels:

(a) Interviewing the various agencies which have been directly or indirectly involved with the development of the food industry in Thailand, and, in the process, collecting relevant published and unpublished data; and

(b) Carrying out an extensive sample survey at the firm level in the selected sub-sectors, comprising four main product groups: canned pineapple, other canned fruits and vegetables, canned seafoods, and frozen seafoods. The sample consisted of 62 firms (10 canned pineapple firms, 18 canned seafood firms, 21 other canned fruit and vegetable firms, and 13 frozen seafood firms).

Data thus collected have been carefully studied using both quantitative and qualitative approaches. Regression analyses have been carried out to see whether the factors which are often mentioned (including firm size, age of firm, foreign direct investment, market environment, and government promotion schemes) can truly emerge as explanatory variables. However, given the limitations of the type of data collected, it was considered appropriate to carry out other tests as well. Based on the firms' perceptions, we estimated the mean values of scores for the various internal and external factors, thus enabling us to see the relative importance of these factors for the development of acquisitive, operative, adaptive and innovative capability. We also carried out pair-comparison analysis for identifying firms' internal factors which have contributed towards the development of new products.

1.5 Organisation of the Thesis

The next chapter (Chapter 2) reviews the related literature. An important objective of this chapter is to illustrate what and how some factors contribute to technology development of the firm from various economists' points of view and empirical studies. Chapter 3 presents an overview of the food industry in the Thai economy, illustrating in particular the various stages of development of the industry and the contribution of the industry to the economy. Chapter 4 examines what and how government and related institutions are involved in the building of technological capability of the food industry. Chapter 5 provides the methodology of the study by

demonstrating the method of analysis used for analysing the vast amount of data collected from the firms. Chapter 6 illustrates the sample survey and the data collection from the individual firms. Chapter 7 explores whether the firm's characteristics and various internal and external factors influence the building of the technological capability of the focused industry in terms of the four elements of technological capability (acquisitive, operative, adaptive, and innovative). Chapter 8 investigates whether the firm's characteristics and the firm's internal factors have impacts on the enhancement of technological capability in developing new products of the firm. Finally, in Chapter 9 we summarise the findings of the study.

Chapter 2

TECHNOLOGICAL CAPABILITY BUILDING: SOME VIEWS

2.1 Introduction

Technology includes two main aspects: (a) technical knowledge or know-how (i.e. knowledge related to the methods and techniques of production of goods and services), and (b) capital goods (i.e. tools, machinery, equipment and entire production systems). In the first aspect, technology may include the human skills required for the application of techniques of production, whereas, in the second aspect, it can be termed as embodied technology (UN, 1987). Similarly, Dunning (1993) argued that technology includes physical assets, knowledge and human learning and capabilities that enable the efficient organisation and production of goods and services. Thus, technology may also include a management system used in the entire production, and it can be embodied in physical assets, human form, blueprint and manual or instruction, products and production process. This means technology development effort of any firm or any country needs to consider various aspects of technology.

It has been argued that technological development efforts in developing countries are different from those in developed countries since modern and advanced technologies can be created within the latter, whereas, in the former, they have to be imported or borrowed from the former (Dahlman, 1984; Bhalla, 1996). In other words, the development of technology in developing countries is largely dependent on the importation or borrowing of technology transferred from developed countries. Furthermore, developing countries have to undertake various efforts in order to achieve success in effective technology transfer, and to create indigenous capability in technology development. Moreover, efforts of local manufacturers alone may not be sufficient to achieve success in acquiring the whole body of technology (Dahlman, 1984; Dahlman *et al*, 1987; UN, 1985, 1987; Enos and Park, 1988; Amsden, 1989; Enos, 1991; Lall, 1987, 1990, 1992; Bhalla, 1996; Huq, 1995).

2.2 Some Relevant Theoretical Approaches

2.2.1 The Neoclassical Approach

According to the neoclassical view, "technology is explicit and articulated, imitable and teachable, and imbedded in a broad body of understanding which permits previously unused variants to be reliably readied for use" (Nelson, 1987, p.83). It can be freely available to all countries, within countries, and to all firms. Developing countries have no difficulties in assimilating transferred technology because they can gain access to technologies according to any factor prices and there are no problems of adaptation. All firms are equally efficient and they need not seek any technology effort (Nelson, 1987). According to such an approach, the strategy employed in industrial and technology development tends to be free from government intervention (Lall, 1992).

Concerning technological change at the firm level in the conventional neoclasssical theory, firms in a given industry are assumed to have the same production functions and select their techniques with reference to relative factor price ratios. They also do not have difficulties regarding the use of technologies acquired (Nelson, 1987). The firms are producing on both their production function and cost functions, and their operations are assumed to be maximising output and minimising unit costs from given inputs including technology.[1] It ignores the internal operation and efficiency of the firm, and focuses on the efficiency of the market (Frantz, 1988). Firms in a competitive industry are viewed as facing a set of alternatives regarding the inputs and outputs they will procure and produce. The firms operate according to a set of decision rules that determine what they do as a function of external (market) and internal (such as available capital stock) conditions. The rules reflect maximising behaviour on the part of firms (Nelson and Winter, 1982). According to the neoclassical idea, in a pure market, the only information exchanged relates to

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[1] Neoclassical short-run production function: $Q = f(K, L)$

Short-run cost function: $TC = PkK + PlL$

Q = output, K = capital, L = Labour, TC = Total costs, Pl = price of Labour, Pk = price of capital. (Frantz, 1988).

products already existing in the market and it contains only quantitative information about prices and volume (Lundvall, 1988).

2.2.2 New Growth Theories

The new growth theories were developed to overcome some of the weaknesses of conventional growth theories by recognising the central role of technical change and incorporating measures of R&D and/or education and training. In 1986, Romer presented the production function by including labour and capital and technology in his model. He emphasised the role of knowledge. In the new growth models, economic growth depends on human capital and R&D as resources available for the development of technologies.

Later, in 1990, Romer proposed a model explaining endogenous technological change by emphasising the importance of increases in the effective labour forces, effective stock of capital, technological change in generating growth in output per worker. Since technologies contain both appropriable and non-appropriable elements, a government can use incentive instruments to support innovation and their positive externalities in order to allow economic growth. For example, the government can play a major role in the economy through fiscal instruments (lump-sum taxation and subsidy schemes) to support human capital development and R&D efforts.

Other economists who have contributed to the development of the new growth theories include Lucus (1988), and Grossman and Helman (1989, 1990, 1991).

Recently, the new growth theories have been reviewed by several economists such as Nelson (1994), Pack (1994), Petit (1995), and Romer (1994). The reviewed models include investment in R&D, infrastructure and human capital through education, "which in turn generate spillovers and externalities, including economies of scale and cumulative causation" (Malecki, 1997, p.43).

2.2.3 Schumpeter's View on Entrepreneur's Role

Schumpeter pointed out that innovation refers to not only technical process or new products but also the opportunity to access a new market, the acquisition of a new

source of raw materials and semi-manufactured goods, and changes in monopoly position (Schumpeter, 1934, p.66). He argued that, in the economic system, innovation originally arises from the producer who wants to produce new things, rather than basically occurring from the pressure of consumer demand. He also emphasised the role of financial credit in technical change because it is an important factor for undertaking innovative efforts. At the same time, Schumpeter stressed the role of the entrepreneur not only who carry out their routine work, but also who acts by providing leadership to go beyond current work in order to innovate and then overcome the imitator. This can be done by innovating new techniques or creating more innovative activities. In his view, entrepreneurs broadly include those who actually fulfil the entrepreneurial function such as employees of a company (e.g. managers, members of boards of directors), those who control the majority of shares, and those who are not necessarily permanently connected with an individual firm.

2.2.4 The Evolutionary Approach

Many economists have attempted to use an evolutionary concept to explain the process of technological change at both micro- and/or macro-levels. This includes the work of Penrose (1959), Silverberg (1988), Nelson and Winter (1982), Aghion and Howitt (1990, 1992), Dosi *et. al* (1995), Silverberg and Verspagen (1994).

Concerning the evolutionary theory (or the new Schumpeterian approach) technical change is viewed an evolutionary process related to technical and organisational innovations (Freeman, 1994a). The change occurs within and between firms and the market environment outside.[2] The growth of the firm depends on external technical and market opportunities derived from the internal technological capability of the firm. As a result, the technical change of the firm is essentially dependent on the role of the entrepreneur and the manpower of the firm in dealing with the external environment. The evolutionary process occurs not only in the production firm, but

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[2] The concept of an evolutionary approach which sees the significance of the feedback mechanism from outside factors is very important in the improvement of the firm in terms of qualitative changes such as knowledge, technical skills, organisational and managerial abilities, level of economic aspiration, responsiveness to economic incentives, and capability to undertake and to adapt to innovation, whereas the neoclassical school ignores this circumstance (Rosenberg, 1976).

also in related agencies. As a consequence, technological change occurs both at micro and macro levels (Nelson and Winter, 1982).

Penrose (1959) argued for the evolutionary process of entrepreneurial perception, experience, manpower skills and knowledge, which results in technological change at the firm level. According to Penrose, the role of the entrepreneur through the interaction between his ability and (internal and external) environments, and the role of manpower services is a crucial factor for bringing about technological change in an enterprise. This requires managerial capacity, technical skills, and an ambitious and active personal style on the part of firms' personnel at senior and lower levels. Hence, the dynamic firm needs to have an owner/manager who possesses managerial competence, technical knowledge, imagination and ambition, and who understands both internal and external inducements and obstacles. These qualities are necessary for combining various factors to carry out the business. Penrose also argued the importance of the development of the technological base and selling efforts in the successful diversification of an enterprise.

In addition, concerning the role of the institutional process of technical change, Clark and Juma (1987) found from the case study of the evolution of photovoltaic technology that innovative activities do not occur only within the firms themselves (e.g. within functional units, the interaction between functional units) but also from the network between parent company, sub-contractors, universities and government agencies. In this case the public sector plays a major role in three channels: support for R&D, provision of market, and raising public awareness about the technology (pp.141-159). Dosi (1984) also argued that technological trajectories are the final outcome of a complex interaction between some functional economic factors (such as search for new profit opportunities and for new markets, tendencies toward cost-saving and automation) and powerful institutional functions (such as interest and the structure of existing firms, effects of government bodies and patterns of social conflict). Freeman (1994b) also perceived the significant role of institutions in the innovation process as he argued that:

> "those nations which prove most adept in making institutional innovation which match the emerging new techno-economic paradigm are likely to prove the most successful in growing fast, catching up or forging ahead. Those, on the other hand, which suffer from institutional 'drag' or inertia may experience a prolonged mis-match between their institutions (including management system at the firm level as well as government structures), and the growth potential of new technologies" (Freeman, 1994b, p.88).

This means that for the achievement of technological development, government and related institutions have to evolve their organisations in order to cope with changing world and dynamic economic/non-economic factors.

2.2.5 Contributions and Limitations of Some Relevant Theoretical Approaches

Different approaches mentioned above seem to point out some factors which have effects on technology development of the firm, thereby affecting the creation of firm's technological capability.

The neoclassical approach indicates how competitive environment and market mechanism have impact on technological change of the firm. The firm has not to put more efforts in acquiring and adapting technologies to its enterprise because technologies required are available in the market. However, the significance of interaction between internal related functional units, and between the firm and external parties appears to be ignored by the neoclassical approach. Thus, it cannot be used for explaining various phenomena of technological change of an enterprise because both market and non-market factors, the nature of technology, the interaction within the firm itself and with external individuals and institutions are involved in various activities. Sometimes, firms do not operate according to the principle of marginal analysis, and they are able to increase their output by making relatively simple changes in the internal organisation of the plant. Also, the outcome of firm's performance depends, as observed by (Leibenstein, 1973, p.769), on "the organisational structure of the firm, on the incentives created by personal interactions for different types of role interpretations, and on the internal and external pressure that determine the constraints on role interpretations". In the meanwhile, technology is tacit, so the firm will not easily be able to use, and/or to imitate it, as observed by

Nelson (1987, p.84): "In many technologies there is little understanding of why certain things work and others not, and hence considerable vagueness regarding what new techniques can be developed easily". Actual operating experience is needed, achieved through learning by doing efforts. Thus, it is difficult for all firms to access the understanding of the technologies and how they work. The interaction between learning through R&D and learning through experience is very important for the invention process (Nelson, 1987). In addition, as argued by Clark (1985), the neoclassical approach mainly places emphasis on the market mechanism, mainly concerns the allocation of resources in the short-run, and ignores the process of the absorption of new technology in the production process, so this results in the limited applicability to questions of science and technology policy. However, the more moderate neoclassical school allows some level of government intervention in technology development and this is characterised as neutral rather than selective intervention. This means that government may support activities which give positive externalities, such as education, and R&D rather than promote certain industries. Yet, this approach has some discrepancies because it disregards the nature of technology and costs of adoption (Lall, 1992).

Regarding the new growth theories, human capital (education and training), and R&D efforts are principal factors for technology development. Although these theories aim to explain economic growth at a macro level, they could be used for explaining the phenomenon of technological change at the firm level. This means the firm should emphasise human resource development and R&D activities for enhancing its technological capability. In the meanwhile, the government can also invest and support in such efforts because of the externalities, as well as in the development of infrastructure, for promoting technology development.

However, the new growth theories place too much emphasis on the R&D sector and externalities, and less emphasis on the context of the enterprise and institutions and the interaction between the firm and related institutions, technical change and investment (Pack, 1994; Nelson, 1981; Fagerberg, 1992; Verspagen, 1992a and 1992b). This means that these theories can be used for explaining only parts of the phenomenon of technological development efforts because the role of organisation

(i.e. firm), related institutions, the interactions between the firms within the industry and with the institutions, and the interactions between related units within the organisation itself are also very important for such efforts. Moreover, it has been argued that these theories are meant for analytical purposes rather than empirical purposes because they place too much emphasis on labour/human capital in the research sector (OECD, 1991; and Freeman and Soete, 1997).

The main contribution of Schumpeter in the explanation of technological change of the firm is the emphasis on the role played by the entrepreneur. Thus, the firms with qualified entrepreneurs (e.g. active, imaginative, and creative) have more advantages in the creation of technological capability than those which do not. However, the Schumpeterian theory appears to emphasise the significant role of entrepreneur in technological change, while it cannot explain the process of such a change (Usher, 1954; and Strassman, 1959).

The evolutionary approach recognises the significance of the interaction between related factors within the firm itself and with external environments (e.g. market environment, regulations), and technological change of the organisation through the evolutionary process. This means the creation of technological capability of the firm has to deal with these factors. Also, the behaviour of firm's personnel and the evolution of related institutions are also important factors for the enhancement of technological capability of an enterprise. Thus, this approach seems to be able to explain how the process of technological change of the firm takes place in a dynamic aspect.

In short, although various approaches are very useful in the explanation of technological change of the firm there are some important issues which need to be considered. In fact, the success or failure of technological development effort of a firm is dependent on many factors, especially as technology can be transferred though various means and channels such as embodied/disembodied forms (Gomulka, 1990), commercial/non-commercial transfer (UN, 1987), and formal/non-formal transfer (Lee *et al.*, 1988). Price and non-price, economic and non-economic factors are also involved in such efforts. Moreover, the achievement of any task also relies on related

individuals and organisations, as well as the cooperation and linkages within institutions and between them. Some factors may play a key role in some situations, while some other factors might play a principal role in the others. Furthermore, in some cases, a number of factors (e.g. role of entrepreneur, foreign investor, market mechanism, the interaction between various firm's internal functional units, the interaction and cooperation between the firm and external agencies or individuals) have to be involved in the success or failure of technological capability building of the firm. Thus, although some approaches may be very useful for explaining technological change of the firm, they may not be sufficient to be used for investigating such a change in different cases. It is, therefore, wise to take many different ideas from different approaches to examine the experience of technological development building of the firm.

2.3 Technological Capability: Various Elements

Although Desai (1984, p.245) pointed out that there is a risk of tailoring the definition of indigenous technological capability to a conclusion because it is similar to policy-oriented concepts, many authors have attempted to provide definitions of technological capability. This may be dependent on the specificity of their studies, as follows:

-Technological capability refers to the ability pertaining to various aspects of the transformation of inputs into outputs (Fransman, 1984, pp.9-10).

-Indigenous technological capability refers to a local capacity to create/adapt/modify technology, as well as the creation of some completely new technology (Stewart, 1984, p.81).

-Technological capability is the ability to make effective use of technological knowledge (Pack and Westphal, 1986, p.105).

-Technological capabilities refer to specific activities, referring to how the activity is accomplished with available technology for that activity (Sharif, 1997, p.4)

-Technological capabilities broadly refer to the entire complex of human skills (entrepreneurial, managerial and technical needed to set up and operate industries efficiently over time) (Lall, 1990, p.17). [3]

-Technological capability refers to a wide range of tasks, including the ability to undertake changes to given technologies - to equipment, materials, processes and designs; to master technology in the sense of making it operative in particular environments; to copy or select the correct technology; to assimilate technology; and to undertake innovation (Lall, 1987, pp.2-3).

In short, these definitions of technological capability can be summarised as the ability to acquire required technology, to make effective use of acquired technology in changing environments, to assimilate and develop the technology being used, and to generate new technology.

UN(1987, p.34) pointed out that the active technology transfer strategies, especially in developing countries, require the development of local technological capabilities, as follows:

(1) search and select the most relevant technology;

(2) negotiate and acquire imported technology ;

(3) assimilate imported technology to the point that permits local abilities in installing, operating, maintaining, and repairing;

(4) modify, adapt, and improve imported technology;

(5) replicate imported technology by depending on domestic design and engineering skills and related facilities;

(6) develop new technologies and production systems by using local skills and facilities.

These various stages of technological capabilities are also similar to those argued by Pack and Westphal (1986) (i.e. capability to evaluate and choose technology; to acquire and operate processes and produce products; to manage changes in products, processes, procedures, and organizational arrangement; and to create new

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[3] Lall (1990) argued that technological capability at the firm level refers to the ability used for executing all technical functions entailed in setting up, operating, improving, expanding and

technology). Similarly, Dahlman *et al.* (1987) described the technological development of the firm in terms of the capabilities that are needed to acquire, assimilate, use, adapt, change, or create technology.

This means the technology importers or recipients need to know how to acquire the technologies required; to use, adapt, modify, improve, and replicate the technologies acquired; and to develop new technologies. Therefore, they will have to create their technological capability in terms of the acquisition, operation, adaptation and (minor/major) modification, and generation of technology. In other words, if these technological development efforts are considered at the firm level, the main elements of technological capability can broadly be considered into four elements as follows:

1. Acquisitive technological capability;
2. Operative technological capability;
3. Adaptive technological capability;
4. Innovative technological capability.

Although different authors have categorised technological capability in different elements, the ability to undertake technological capability of these elements can be categorised in those four types of technological capability, as taken up below for some further elaboration.

Acquisitive technological capability

The sub-element of acquisitive capability should include various capabilities of the firm concerning how it acquires technologies. Various forms of firm's technological acquisitive efforts as argued by many authors are mentioned below.

-learning by searching, and learning procurement strategies from hired personnel (Bell, 1984)

-ability to gather information available in the world, to detect new development, and to judge what is worthwhile buying and learning in detail (Dore, 1984).

-ability to purchase technology (Desai, 1984)

-ability to acquire technology (UNIDO, 1986)

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moderninsing the firm's productive facilities (p.20).

-planning and investigation, negotiation with suppliers (Enos and Park, 1988)

-ability to search, assess, negotiate, procure and transfer technology (TDRI, 1989b)

-capability to prepare specifications for upgrading technologies, to identify sources of technologies, to evaluate, select and negotiate terms of contracts for procurement (Sharif, 1997)

-*investment capability* in terms of the capabilities needed to acquire technology (such as to select technology, to identify local needs and conditions, to collect information to broaden the field of possibilities, to evaluate costs and benefits of different choices of technologies) (Dahlman *et al.*, 1987)

-*investment capabilities* in terms of the skills needed to identify, prepare, obtain technology for design, construct, equip, staff, and commission a new facility (Lall, 1992)

Operative technological capability

After acquiring the technologies required the firm has to know how to use and manage (including to plan and control) them. This includes the capacity to maintain the machinery and equipment, and to apply any facilities in the use of technology or production. This stage also includes the capacity for installation and start up of the technology acquired or purchased. Many authors have provided various elements of technological capability in this context, as drawn below.

-learning by operating (Bell, 1984)

-abilities for plant operation (Desai, 1984)

-capability to operate and control technology, to use firm's personnel in the production, to apply techniques for planning and coordination, to undertake maintenance (Sharif, 1997)

-capabilities in production management, production engineering and repair and maintenance (Dahlman, 1984)

-installation and initial operation, production and maintenance (Enos and Park, 1988)

-capability to operate, to control, to maintain the machinery and facilities. (including the capacity to undertake quality control, skills of operating personnel, and capacity in management operations) (TDRI, 1989b)

-*production capability* in terms of capability to oversee and improve the operation facilities, and to obtain and act on the information to optimise operation, repair and maintenance of physical capital, and finding uses for possible outputs (Dahlman *et al.*, 1987)

-*linkage capabilities* in terms of basic skills comprise such as quality control, operation, and maintenance (Lall, 1992)

-*technology mastery* or building up the skills and capabilities needed to operate a technology efficiently (Lall, 1990)

Adaptive technological capability

After undertaking various operative technological activities, the firm may have to adapt or modify the technologies in order to achieve success in improving productivity and efficiency. This includes the adaptation of technology adopted to suit to available raw materials and customer demands, and other conditions. (However, this capability excludes the major improvement and radical modification of technology adopted because it may require higher capability, i.e. innovative capability). Various forms of technological capability in this regard asserted by several authors are presented below.

-independent technology learning capability (Dore, 1984)

-local development of technology elsewhere (Stewart, 1984)

-learning by performance feedback (Bell, 1984)

-duplication and expansion (Desai, 1984)

-ability to adapt technology (UNIDO, 1986)

-capacity to adapt the technologies to suit local environments, to undertake minor product/process modification to suit the market needs (TDRI, 1989b)

-capability to duplicate acquired machinery and equipment, to adapt technologies for better efficiency, to carry out minor technology improvement (Sharif, 1997)

-*production capability* in terms of capability to adapt operations to changing market environment, *investment capability* in terms of the capabilities needed to adapt and change technology, *innovative capability* in terms of capability to undertake minor innovation (modification or improvement of existing technology) (Dahlman *et al.*, 1987)

-*linkage capabilities* in terms of advanced skills required for adaptation, improvement or equipment 'stretching' (Lall, 1992)

-*minor innovation* in terms of adaptations and improvements that raise the productivity of a given technology (Lall, 1990)

Innovative technological capability

The success of the enhancement of technological capability of the firm should also include the capability to undertake major improvements and radical modifications of technologies adopted. This includes the development of new technologies (e.g. machinery, products, production process, know-how). This capability is very important for independent technology development. Various elements of innovative technological capability as argued by various authors are mentioned below.

-independent technology creating capability (Dore, 1984)

-creation of completely new technology, local modification of imported technology (Stewart, 1984)

-learning by changing (Bell, 1984)

-abilities for innovation (Desai, 1984)

-abilities to carry out basic research and testing facilities (UNIDO, 1986)

-development of improved technique in terms of major technical change (Enos and Park, 1988)

-capability to carry out R&D activities, radical product/process modification, major changes in technologies adopted, and to develop new product/process (TDRI, 1989b)

-*innovation capability* in terms of capacity to create new technology, to develop new products or services that better than specific needs, and to undertake major innovation (radical new technology) (Dahlman *et al.*, 1987)

-capability to undertake product design and modifications, to create new products for future markets, to carry out R&D for product/process innovations, to derive commercial benefits from research results (Sharif, 1997).

-*expansion production capabilities* in terms of basic skills and advanced skills, as well as the skills required for research, design and innovation (Lall, 1992)

-*major innovation* in terms of the activity leading to the introduction of new products and processes (Lall, 1990)

Based on the elements of technological capability mentioned above, the sub-elements of those four elements can be summarised in Table 2.1.

Table 2.1 Elements and Sub-elements of Technological Capability

Element of Technological Capability	Sub-elements of Technological Capability
Acquisitive Capability	- to gather information needed for acquiring technology; - search for technologies required; - identify technology required; - prepare the specifications; - negotiate with technology suppliers; - evaluate the cost/benefit, and related factors; - select the technologies proposed; and - make decision on technology adopted.
Operative Capability	- to install and start up the machinery; - operate the machinery and plant; - control the plant and equipment; - utilise technology adopted; - undertake related activities such as quality control in the production system; - maintain the plant, machinery and equipment; - apply technologies to the production; and - apply technologies for planning and coordination.
Adaptive Capability	- to duplicate acquired machinery and equipment; - adapt technologies to suit to local conditions; - undertake minor change in technologies acquired; - undertake minor modification in product/production process; - adapt technology to respond market needs; and - improve technology to increase productivity.
Innovative Capability	- to undertake major improvement in technology; - undertake radical modification in product/production process; - carry out R&D work; - undertake new technology development (e.g. product/production process development); - design new technology (e.g. product/production process); and - market the research results.

However, in order to achieve success in undertaking those technological building capabilities, the firm also needs other capabilities, e.g.

-*Supportive capability* such as learning from training (Bell, 1984); ability to train manpower and information support and networking (UNIDO, 1986); project management, project engineering and manpower training (Dahlman *et al.*, 1987), project execution (Lall, 1987);

-*Marketing capability* (capability of marketing production output (Dahlman. *et al.*, 1987); vending capability in terms of the capability to monitor external situation and evaluate performance, to identify new markets and promote sales of new products in new markets, and to provide after-sales services to enhance perceived customer satisfaction (Sharif, 1997));

-*Linkage capability* (the skills needed to transfer knowledge and technology between enterprises and from enterprises to the science and technology infrastructure (Lall, 1990)); and

-*Organisational capabilities* (Lall, 1987).

Therefore, in the study concerning the creation of technological capability, it is very useful to consider those various related capabilities apart from the main capabilities presented above. This effort can be related to how the firm carries out supportive activities, deal with market demands and external environments. This also includes how the firms cooperate or interact within their organisations and with external agencies in carrying out their technological activities.

2.4 Technological Capability Building: Role of Internal and External Factors

Needless to say, many factors are involved in the building of technological capability of the production firm. They may be derived from the firm's internal and external sources. Those from internal sources include the firm-level factors including policy, strategy, management and administration, R&D activities, the nature of the firm's personnel and the firm itself. Those from external sources can be considered as the role of government and other factors (domestic and overseas). This includes cooperation, linkage and interaction between the firm and other firms in an industry and other institutions. The role of these factors is discussed below.

2.4.1 The Role of Internal Factors

Firm Size

Larger firms have advantages over smaller firms in undertaking various activities because of the ability to access external knowhow (as a result of in-house qualified technical specialists, scientists and engineers) (Rothwell and Dodgson, 1991); ability to capture and use internal and external spillovers of knowledge (Henderson and Cockburn, 1996); the economies of scale in R&D, the ability to spread risks over a portfolio projects, and access to a large pool of financial means (Veugelers, 1997); and in terms of technological economies, and cost advantage over small firms in the introduction of new products (Penrose, 1959). This is also argued by Lall (1990) in that large size of firm may be one of the necessary conditions for building a firm's technological capabilities where complexity or risk create significant economies of scale and scope. However, smaller firms have some advantages in terms of: the use of technology better suited to local resources and relative factor prices; the ability to operate on a scale more appropriate to the size of local markets; the depth of available managerial and institutional capabilities; dynamic long-term benefits in terms of developing entrepreneurial and management capabilities; an increase in opportunities for training and human resource development at a lower cost than otherwise available through formal institutions or large firms (Steel and Webster, 1992); flexibility, adaptability, and efficient internal communication process, thereby allowing more rapid response to external opportunities and threats which may give an edge to smaller innovative firms (Veugelers, 1997). Also the advantage of small producers was argued by Albu (1997) in terms of the greater flexibility in responding to changing opportunities, or the ability to serve small and specialised niche markets.

Hence, it can be argued that the firm size itself cannot always bring about the enhancement of technological capability. However, if the large firm aim to deploy its abundant existing resources and advantages in many areas for such an effort it has more potential than the smaller firms because of many reasons mentioned above. In the meanwhile, although the small firms possess less resources, they have advantages in other aspects in the creation of technological capability. This means apart from the size of firm the policy and strategy and linkage capabilities of the firm can be

important factors in determining the conditions for upgrading the firm's technological capability.

Policy and Strategy, and Management and Administration

Firm-level policy and strategy and management and administration can influence what is the direction of the firm's business, and how various resources should be employed. Therefore, they can directly and indirectly affect both the changes of product and production process, and the improvement of technological competence. Kaplinsky (1995) argued that the crucial role of organisational and management capabilities is the enhancement of the firm's technological capability (cited in Albu, 1997, p.20). TDRI (1994) also found that the firms' internal management and administration and personnel skills are the main factors contributing to the differences in production techniques and quality control systems of the firms in the study.

It was also argued that technology strategy may be related to the ability of the managers with regard to the cultivation of in-house capability for research, product development and engineering, as well as manufacturing process improvement (Cusumano and Elenkov, 1994). However, Lall (1987, p.17) pointed out that managers may also have to give proper priority to developing organisational capabilities in order to succeed in any technology transfer. These capabilities include the ability:

- to separate different technological functions into different units in the organisation as appropriate to the size or growth of the firm;
- to grant greater autonomy to technical functions;
- to facilitate technology information transfer across different departments;
- to develop technology scanning or evaluation services;
- to establish long-term links with technology suppliers, laboratories, universities, industry associations, and in-house training programmes.

Concerning these capabilities, according to Lall (1990), the success or failure of technological capability building are dependent on not only technological capability of the firm, but also on the capability of owner/manager, cooperation between personnel

in the organisation, management and administration, and, also, linkages with external agencies.

Regarding the cultivation of in-house technological capabilities, it was emphasised that the more technologically dynamic firms in all countries make intensive use of foreign technological elements or knowledge while investing heavily in local technological efforts and technique training. These firms also use what they learn at each stage to re-evaluate their strategies in the technological area (Granstrand *et al.*, 1990; Metcalfe, 1990). This means, apart from acquiring technology from outside sources, it is very important for the firm to invest in technological development effort within its organisation.

At the same time, strategy implies a vision or intent concerning the firm's future direction. For example, some firms focus on limited strategies, but some firms pursue product diversification by exploiting technology-based extensions of existing businesses (Malecki, 1997). In the meanwhile, technology is a principal means by which the firms compete (Malecki, 1997), and it is used for both for making profit and bringing about the difficulty for competitor to imitate (Pavitt, 1994).

The technology strategies of firms in developing countries can be divided into four types: technology extender, technology exploiter, technology follower and technology leader (Sharif, 1993). These strategies are different in terms of the way the firm acquires technologies required, the sources of technology, the elements and main thrust of technologies required, adaptive and R&D activities and technology components emphasised by the firm. According to Malecki (1997) firms may use different strategies in utilising technology as a basis of competition: *offensive strategy*, d*efensive strategy*, s*imply imitation*, d*ependent firms*, t*raditional firms*, o*pportunities* or *niche* firms. At the same time, a firm in an industry may employ various business strategies: price leadership; quality leadership; niche leadership; and image leadership (Sharif, 1994a). The firm may choose to compete either in established products, or new products (Porter, 1980). Furthermore, in order to employ marketing strategy, it

has to understand its product life cycle.[4] The modification of existing products can lengthen the life cycle of the products.

However, for a long-term competitive advantage, the firm needs to put more efforts in modifying and developing new products (Porter, 1998). In the meantime, the changes and development of products involve one or more alternatives: development of new products, deletion of old or weak products, modification of existing products (differentiation) with a view to (a) improving the product performance, and (b) adapting the product for new markets (segmentation) (Majaro, 1982). In the meanwhile, a product may comprise a bundle of characteristics, and a new product may possess some different characteristics from existing products, or involve entirely new characteristics (Lancaster, 1966; James and Stewart, 1981). Therefore, the firm's efforts in the development of new products may be in terms of the increment of existing products'characteristics, and/or developing new products with few charactersics, and/or developing new products with diversified characteristics. This requires the firm to undetake minor or major modification of existing products and production process, and/or to develop new products and production process. These different firm's efforts imply different firm's technology strategies which are related to sources and elements of technology requires, how firm's resources to be used for the development of products and R&D activities, and human resource development programmes.

In practice, the firm integrates between business and technology strategies This effort can be ranged from the least cost strategy to technological superiority. However, in the competition of world business, factor cost-based comparative advantage is eroding and technology-based comparative advantage is essential (Porter,1998; Sharif, 1994a). As a result, the importance of technological capabilities as a source of

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[4] (1) The product cycle assumes that the stimulus to innovation is typically provided by some threat or promise in the market. The firms tend to be stimulated by the needs and opportunities of domestic market. In this case, the home market not only provides the sources of stimulus for innovating firms, but also plays a role for locating the actual development of innovation (Vernon, 1979).
(2) The product life cycle suggests that in order to maintain market competitiveness (including strengthening the corporate image and holding profitability at desired levels) all firms must consider generating a continuous stream of new products (Markin, 1979).

competitive advantage has increased for the firm in the world market (Justman and Teubal, 1995). In order to gain competitiveness in the world market, the firm needs to search for best-practice technology, and acquire information concerning new techniques and the action of other producers. Any effort with respect to learning, acquiring, evaluating and improving upon new technology and products of export-oriented firms has to meet international quality and price competition standards, and this stimulates firms to seek out information on new technology and ways to adapt and blend new with old technology (Malecki, 1997). In the long run, apart from low-cost strategy, it is crucial for the firm to emphasise product differentiation (i.e. the ability to provide unique and superior value to the buyer in terms of product quality, special features) (Ramanathan, 1994).

Thus, it is very important to use new technology to modify and differentiate existng products, or to develop new products. This mean the building of technological capability is necessary for long-term competitiveness. Also, it was argued that if a firm wants to formulate appropriate competitive strategies, acquire and/or develop technologies, and to cope with the challenges in the market-place, it needs to carry out operations management, gather information on markets and technologies, train staff, and carry out necessary negotiating and legal procedures. Moreover, the availability of good R&D facilities, testing facilities and engineering workshops is also very important (Ramanathan, 1994).

At the same time, the attitude of top management is very important for organisation's innovative performance[5]. Top management values serve both as guiding criteria and as motivators for people generating new ideas. Brown and Karagozoglu (1989) argued that the values of senior management significantly affect the innovation process not only through specific proposal selection and funding decisions, but also through the creation of a climate for innovation. These values affect policies regarding incentives, reward allocation, performance measurement, and personnel selection. As

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[5] The attitude of the *owners* towards technology, competitiveness, investment and risk will determine to a great extent the path that technology transfer and technology development will take (Ramanathan, 1994). Moreover, the top management's values toward risk taking (e.g. the exploration of new business) may lead to more success for the industry (Porter, 1998).

a result, the differences of firms' top management values will have different impacts on the firms' competitive strategies (e.g. new product development, low prices). In addition, according to Lee *et al.* (1988) the firms in different stages of technology development require different technology transfer strategies and elements of technology, search technology from different sources, and exhibit different internal linkages and top management involvement. This leads to different firms' technology and business policies and strategies, management and administration employed by the firms. Thus, such differences can finally affect firms' technological capability building efforts.

The Accumulation of Firm's Own Experience

The firm can accumulate its experience through learning-by-doing and other types of learning. This includes the acquisition of technology and raw materials, the operative activities (such as using and maintaining machinery and equipment, undertaking quality control, planning and controlling production), and adaptive activities (Bell, 1984; Lall, 1987).[6] This was also argued by Lall (1992) who stated that technological change at the firm level is "a continuous process to absorb or create technical knowledge, determined partly by external inputs and partly by past accumulation of skills and knowledge. Transfer necessarily requires learning because technologies are tacit, and their underlying principles are not always clearly understood" (p.166). According to the evolutionary theory, mentioned earlier, it is implied that the firm has to accumulate its own experience of how to interact with and combine between various factors from inside and outside sources in the creation of its technological capability. However, the experience accumulated by the firms may vary from firm to firm. The experience from the learning process may be geared to improve the productivity and efficiency of production, and/or to improve product quality, and/or to modify products/production process, and/or develop new products/production process. Hence, the benefit of the accumulation of the firm's own experience toward the building of its technological capability is also largely dependent on its business policy and strategy (e.g. competitive strategy).

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[6] The significance of the accumulation of the firm's own experience with regard to the preparation of raw materials was also found in TDRI (1994).

Human Resource Development Efforts

Technical skills and know-how used in the production system (and in the creation of new products and production processes) are necessary for the firm' s personnel in carrying out their work. This effort is an important factor for, in particular, operating, adapting and improving technology acquired. Furthermore, both formal training and on-the-job training are necessary for increasing technological competence of an industry (Lall, 1992; Enos, 1991). The crucial role of training programmes in the success of the building of the firm's technological capability was also found in Korean shipyards (Dahlman *et al.*, 1987).

With reference to labour management, Porter (1998) argued that labour management relationships are indeed important because they are the key elements of the firms' ability to improve and innovate. He argued that "Another important dimension is the relationship between the manager or employees and the company. ... Creating and especially sustaining competitive advantage in many industries requires ongoing investment to upgrade skills, better understand the industry, and exchange ideas across functions" (p.113). Porter further contended that the determinant of industrial behaviour and effort comprises various elements: reward systems under which employee operate, financial gain, pay and promotional practices (bonus compensations, based on individual performance and rapid promotion of the most outstanding employees); and the relationship between manager or employees and the company. He also asserted that employees who have the most sustained commitment to the firm and industry lead to comparative advantages of the firm they employed by. In addition, Enos (1991) found that the firm whose goals are projected by its leader and shared by its employees tends to have a high level of technological capability because of a motivation factor. Motivation is necessary for the firm's personnel performance as also argued by Cusella (1987) that "performance is a multiplicative combination of ability and motivation " (p.636).

The arguments mentioned above correspond to those of Leibenstein (1969, 1973) concerning the X-efficiency theory in the sense that the firm's performance is conditioned not only by formal incentive systems (e.g. financial payoffs, promotions, and potential dismissals), but also other factors (e.g. degree of approval and

disapproval of other choices, standards of reward, position, career paths, sense of responsibility for others' effort level, attitude towards authority, and attitudes on appropriateness of possible disciplinary measure). All of them determine the incentive mechanism and atmosphere within the firm. Thus, in order to achieve success in technological development efforts, the firm may have to emphasise not only the provision to their employees of financial incentives, because other incentives are also important (e.g. the participation of employees, the nature and standard of rewards, the attitude and willingness of employees towards their organisations and the owners/executives, and welfare and working conditions).

Manpower Flow, Internal Links and Information System

With regard to manpower flow within the firm, many authors have argued the crucial role of this activity. Cusumano and Elenkov (1994) pointed out that the strategic positioning of the recipient firm within an industrial or knowledge network may strongly influence the effectiveness of the technology transfer process on a recipient's technological capability. As a result, managers need to allocate relatively better quality human resources in particular critical directions in order to achieve desirable competitive positioning. Utterback (1974) also argued that transfers of technical personnel among divisions, other factors being equal, may also result in a temporary increase in communication between divisions. By transferring people, specific kinds of knowledge (and information) are also implicitly moved from one organisational unit to another. The problem-solving stage also requires integration and bridging mechanisms to coordinated R&D functions (i.e. research, development, and technical services) (Brown and Karagozoglu, 1989).

At the same time, the establishment of an internal linkage brings about the enhancement of the assimilation and improvement of imported technologies, and increase in technical abilities (Choi, 1988; Cusumano and Elenkov, 1994); and the development of new product or process (Carlsson, 1991; Davis, 1986; National Research Council, 1987). Thus, the cooperation between related functional units within the organisation (e.g. R&D, production, and marketing) and the transfer of firm's personnel who possess required skills across departments appear to be

beneficial. Furthermore, effective information flow across these functions is very useful for the successful development of innovative projects (Lundvall, 1993).

R&D Efforts

Concerning R&D effort, the establishment of an independent R&D unit within the firm is crucial, especially when technologies acquired are very complex, because the assimilation of technology cannot be handled as part of routine engineering activity (Cusumano, 1985; Rosenbloom and Cusumano, 1987). Moreover, the firm's own effort alone in R&D may not be sufficient. It may have to cooperate with external agencies. This issue will be discussed in more detail in section 2.4.2.

Also, the significant role of basic research in technology development has also been pointed out by many authors including Utterback (1974), Acs *et al.* (1992), Jaffe (1989), Mansfield (1991a, 1991b, 1992), Nelson (1959, 1986), Rosenberg (1990), David *et al.* (1988), and Pavitt (1993). This kind of research plays a critical role in the production of knowledge and enters the process of innovation indirectly, and its crucial role in industrial innovation lies in continual reinforcement and understanding of the implication of applied work.

Furthermore, the emphasis on R&D activities, especially in-house R&D, is also very important for the firm for it to be able to acquire and adopt technology from outside the organisation effectively. This has been argued by many authors because of the ability to utilise the results of externally performed research (Mowery and Rosenberg, 1989), to increase in bargaining power with external agencies (Contractor, 1983), to assimilate technology spillovers from outside (Cohen and Levinthal, 1989; Gambardella, 1992; Veugelers, 1997), to absorb external know-how effectively, to identify, assimilate and exploit existing external technologies (Veugelers, 1997), and to complement indigenous innovation (Freeman, 1991). It was argued that effective external technology sourcing (acquiring and implementing external information and know-how) depends on many factors: willingness to take on external ideas (Rothwell, 1992); sufficient expertise, suitable organisational structure (stimulate external learning), the level of commitment to R&D strategies and the firm's network structure, and the firm's own R&D activities (investment in R&D) (Veugelers, 1997).

This means the industrial firm may have to invest in R&D activities so as to acquire technology from outside, and utilise and assimilate it effectively.

2.4.2 The Role of External Factors (i.e. external to the firm)

Government Support in Technology Development

As mentioned earlier, technological development efforts have externalities. As a result, there is under-investment in R&D and the production of knowledge in private firms. Both theory and empirical studies indicate that the maximising firms invest less than socially optimal amounts in R&D (Stiglitz and Wallsten, 1999). Three principal economic characteristics result in market failure in the production of knowledge (scientific-technical information): the problem of uncertainty, externalities and appropriability, and indivisibilities (Teitel, 1984). Market failure occurs from imperfect information (technology market is imperfect) (Stoneman and Diederen, 1994). This causes ineffective interactions between factors of production. The market failure is more prevalent in developing countries than in developed countries because of many reasons: undersupply of learning and information within the country, limited ability of learning by doing and the difficulty in acquiring technologies from developed countries, inefficient and imperfect capital markets (Stiglitz, 1989). Moreover, in a technology market the sellers have control over not only the new processes and products of technology, but also the know-how required for practical application (Dunning, 1993).

Accordingly, it is necessary for the government, especially in developing country to intervene in technology development and employ explicit policy and strategy (Huq, 1999). Market failure provides a rationale for government intervention to reduce risks facing producers, to bring about higher levels of production and investment, institutional development, and export-marketing cooperation (Stiglitz, 1989), to provide the right signals and or adequate response through providing correct incentives for healthy industrial activity, to build up human capital, technological activity and supporting industries (Lall, 1990). Furthermore, government can employ policies supporting the use and development of new technology in various ways such as subsidies, banking systems, tax benefits, providing infrastructure (Stoneman and Diederen,1994; Cusumano and Elenkov, 1994).

At the same time, the government can also intervene by setting up related institutions (e.g. investment promotion, testing, quality assurance, standardisation and intellectual property protection institutions), and those are involved in S&T information services, and consultancy services. In addition, government policies related to technology, business, trade and foreign investment, finance, manpower development, environment etc. will influence the technology-based strategies of the firm (Sharif and Ramanathan, 1994). Also, the government can support technology development through trade/industry associations, government programmes via push technological strategy by introducing opportunities to business through various industry-association channels (Piper and Naghshpour, 1996).

In order to encourage technology development (through R&D activities) at a firm level, the government can intervene through tax measure and R&D fund (Stiglitz and Wallsten, 1999); the creation and fostering of a favourable atmosphere for investing in R&D activities (Choi, 1988); the establishment of intermediary agent for industrial research between the public and private, the academic and the industrial, the domestic and the foreign sector; and close linkages between government institute, universities, R&D institutions, and industry (Pavitt and Walker, 1976; Sharif and Ramanathan, 1994).

***Role of Buyers/Customers/Users/Suppliers* (i.e. market-driven factors)**

Many authors have argued that customers (or buyers) can play a crucial role in the changes and innovation of products. Customers are a good source of ideas for innovation (Hippel, 1988). Penrose (1959) also pointed out the significance of the information which the firm can obtain from selling efforts. The role of customers in the development of the Thai food industry (e.g. the changes of products and/or production process, and the development of the quality control system) has also been found in TDRI (1994, 1996).

Piper and Naghshpour (1996) asserted that a firm may employ a pull marketing strategy when the consumer or primary buyer creates demand pressure from the buyer back to the producer. Generally, this strategy requires working with the buyer who would have some influence in the development and application of products.

The process of learning occurring from the interaction between users and producers has been extensively discussed by Lundvall (1988, 1993). Producers can benefit from user-producer interaction in the process innovation in various ways such as new process equipment, new product development, potential markets for new products. In addition, the pressure of the customers' preferences makes technological innovation essential. Customers may be sensitive in terms of price, quality, feature or image. This affects to a large extent the business strategy of an enterprise, which influences efforts in technology components and capability development (Sharif, 1997). As a result, the interaction between producer and user/customer will result in learning process (e.g. learning-by-using, learning-by-doing), and the interaction between production and innovation areas within the organisation. The enterprise may also have to restructure the system of innovation, introduce new sectors, break down old, and establish new linkages in the production system (Lundvall, 1988). In addition, 'customers' attitudes and technological experience will also determine the pattern of technological activities at the firm (Itami, 1987).

However, not all user-producer relationships promote innovative activities. For instance, if a firm is faced with a technologically sophisticated and demanding customer then it has no alternative but to become technologically capable of meeting that need. On the other hand, if the customers are not technologically sophisticated then the firm may be able to exist while using old and primitive technology (Ramanathan, 1994). According to Lundvall (1988), there are four different forms of technical change occurring from the interaction: (1) stationary technology, (2) incremental innovation, (3) radical innovation, and (4) technological revolution. Thus, different forms of interaction result in different outcomes of technological capability building.

Regarding the role of technology suppliers, the achievement of cooperation between buyers and suppliers can be derived through programmes aimed at quality management and new product development (Bidault *et al.*, 1998), product development and managerial assistance (Nishigushi, 1994). Thus, technology suppliers can help the producers not only in the advice of machinery and components

but also know-how used for the development of products, and management technology.

Competitors

Competitive environments also force the firms to improve their degree of X-efficiency higher than those in a monopolistic situation because the firms which cannot respond successfully to cost reduction pressure will not survive and will finally leave the industry (Leibenstein, 1973). Thus, in order to survive, firms have to employ policy strategy and management to deal with such environments. Competitive climate can affect the firm's technological development efforts. More competitive environments can lead to cost-reducing technological development efforts and product-differentiation strategies. Market forces also bring about the changes in organisation structure of individual firms (Katz, 1984). Competitors can create pressures on firms to improve and innovate product quality and services and create new products and processes, to improve productivity and efficiency, product diversification, and to introduce new products in the market (Schumpeter, 1934; Penrose, 1959; Porter, 1998). Sometimes, the producers try to imitate the products developed by competitors, or to develop new products based on such original products. This involves various stages of technological capability building occurring from the acquisition to innovation. In this case the market forces seem to play a significant role as emphasised by neoclassical theorists. In the market, there are both imitators and innovators. However, if the manufacturer wants to gain more competitive advantage than other producers or to have long-term competitiveness, it has to put more emphasis on innovative activities (Schumpeter, 1934; Fagerberg, 1987).

Moreover, the right level of rivalry could facilitate innovative behaviour at the firm level whereby each firm tries to retain and possibly enlarge its market share by trying to meet customer demands better. Furthermore, the sharpening of competitive skills at home can help good local firms to succeed in export markets. In addition, according to Reddy and Zhao (1990), the empirical studies conducted in Indonesia, Thailand, and Tanzania indicated that the nature and degree of competition faced by the manager is a critical variable in the choice of technology of an enterprise.

Thus, the role of competitors (and customers and suppliers) can affect any firm's effort not only in setting up business and technology strategies, but also in carrying out activities concerning the enhancement of technological capability. This means any effort to investigate the firm's technological capability building may have to include the roles of these factors.

Linkage-Cluster

The firms in any industry may have some formal/informal connections with subcontractors, component dealers and manufacturers, upstream and downstream industries, and other firms in the same business groups. Moreover, they may be situated in the areas where other firms, in the same and related industries, are located. This phenomenon can be termed as a cluster of an industry (Porter, 1998). A cluster provides a set of knowledge input which may be derived from competitors, suppliers, firms in related industries, customers and other entities carrying out research, such as universities and public-funded institutions (Baptista and Swann, 1998). Jaffe (1986, 1989) and Jaffe *et al.* (1993) also found that geographical localisation has an impact on the phenomenon of knowledge spillovers and R&D activities as mentioned in the new growth theories. Moreover, the firms in the groups can participate through various types of interactions such as *technical bonds* related to the technologies employed by the firms; *knowledge bonds* associated with the parties' knowledge about each other; *social bonds* in the form of personal confidence; and *legal bonds* proceeding from the formal contracts between the firms (Cusumano and Elenkov, 1994). As a consequence, different firm connections result in different outcomes of technological capability building. For example, some linkages lead to the productivity and efficiency of production, whereas some also bring about changes and development of new products and production processes.

Cooperation with External Agencies

Wei (1995) asserted that involvement, participation, and cooperation is required from industrial enterprises, research institutions, governments and financial institutions. The cooperation between academic institutions, research agencies and industries will be crucial in determining the success of technology transfer and innovation (Cusumano and Elenkov, 1994; Sharif,1997; Sharif and Ramanathan, 1994). Peters and Fusfeld

(1982) and Faulkner and Senker (1995) also argued that effective communication both in terms of formal and informal contacts with universities and public sector research institutes is useful for the firm to learn about the progress in research, gain insight into new techniques and secure access to R&D. The SAPPHO (Scientific Activity Predictor from Patterns with Heuristic Origins) identified the role of external collaboration with users and external sources of scientific and technical expertise as of central importance. This project also found that both formal and informal networks were important, although the latter appeared to be the most important (Veugelers, 1997). Additionally, from the experience of European countries, the linkages between industry and universities may be in terms of supporting technological activity, in building on that activity to bring about new product development, and growing technological links, exchange and interdependence (Peters *et at.*, 1998). However, Mansfield (1995) pointed out that there are advantages in the firms working with the colleges and universities located nearby those firms.

Regarding the role of trade/industry associations, in an effort to generate industry-wide exposure and to create a greater level of realisation, new technology can be introduced to the business community through various gatherings of these associations. Major types of group gatherings comprise the following: trade shows, technical symposia, technology transfer conferences, trade association meetings, trade or laboratory news letters, open houses with various industries, publicity through news and education media, professional and trade association contacts, and regional economic development meetings (Piper and Naghshpour, 1996). These activities result in the diffusion of technology. Therefore, the associations appear to play an indirect role in the creation of the firm's technological capability building.

2.5 Findings from Selected Empirical Studies

This section aims to illustrate the empirical studies of the building of technological capability at the firm level in order to learn from the experiences from other cases, both in Thailand and some countries (i.e. Japan, Korea, Brazil).

Case Study of Electronic Firms (Korea)(Kim, 1976, 1980)

Kim (1976, 1980) attempted to identify the firm's external factors that may significantly affect the creation of technological capability in terms of the development of new products of the electronic firms in Korea (for the level of technological capability designed, see Chapter 5 in our study).[7] He found that various factors can influence the different stages of the development of industrial technology: (a) *the implementation stage* (the role of government (import substitution and market protection policies, and various government incentive programmes) and multinational firms (suppliers of technology, technical personnel, capital, equipment and component parts)); (b) *the assimilation stage* (consumers (changing needs of domestic consumers, overseas customers, and distributors), competitors (new products introduced by competitors)); and (c) *the improvement stage* (consumers (and users), competitors (pressure from competitors and innovative behaviour of competitors)). However, Kim's study does not classify technological capability into various elements, nor does it emphasise the role of owners/managers in the investigation.

***Firms in Biotechnology-based Industry, Material Technology-based Industry, and Electronics and Information-based Industry** (Thailand) (TDRI, 1989a, 1989b; Westphal 1989).*[8]

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[7] Kim (1976) also used a quantitative method to investigate the relationship between technology innovation and organisational structure (i.e. complexity, formalisation, centralisation, and integration). However, this method requires comprehensive data from the firms.

[8] These three studies are in the same series: 'The Development of Thailand's Technological Capability in Industry'. The first one (TDRI, 1989a) reviews the development of Thailand's technological capability with regard to 'Biotechnology-Based Industries', while the second one (TDRI, 1989b) makes a comprehensive overview of three categories of industries (Biotechnology-Based Industries, Material Technology-Based Industries, and Electronics and Information Technology-Based Industries), and the third one (Westphal, 1989) analyses the assessment method of the study. These studies classify the level of technological capability into five levels. Each component of the technological capabilities of the firms is rated between 0 to 5 (e.g. 5 refers to excellent capabilities comparable to those leading firms in industrialised countries, 1 refers to poor capabilities below local average, and 0 represents no capability). The rating of each type of capability (i.e. acquisitive, operative, adaptive, and innovative capability) is obtained by averaging the ratings of all

The findings of TDRI (1989a) indicate that, in the biotechnology-based industry, large-scale firms tend to exhibit a higher level of acquisitive, operative, and adaptive capability than small-scale firms. Another study, TDRI (1989b) also reveals similar findings, but for adaptive capability a larger firm in electronics and information-based technology appears to have a lower level of adaptive capability than a smaller firm. Also, the role of government through investment promotion appears to bring about the enhancement of operative technological capability. This may be in terms of the use of financial resources gained from the investment promotion schemes in the required activities (TDRI, 1989b). Moreover, foreign investors also seem to contribute to the creation of technological capability, all kinds of technological capability (TDRI, 1989a), and especially operative capability (TDRI, 1989b). Joint-venture firms may enjoy advantages in terms of modern organisational systems (management and administration); information concerning production, marketing and management; maintenance systems; and quality control systems. In addition, firms' external factors, such as output users/exporters, input suppliers, consulting agencies and technological infrastructure agents appear to contribute to the creation of the firms' technological capability (TDRI, 1989a). However, the TDRI's studies do not investigate the role of firms' internal factors (e.g. firms' personnel, policy and strategy, management and administration). Furthermore, they do not investigate the role of various factors, in particular, in the development of new products of the firms.

New Case Study of Electronic Firms (Thailand) (Tirapanish, 1991)[9]

In this study, the current situation of the electronics industry was reviewed and in-depth case studies of six electronics based firms in

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the components of the capability by the research team (including, economists, scientists, and engineers) (TDRI, 1989b, pp.56, 60).

[9] This study also categories technological capability into four elements: acquisitive, operative, adaptive and innovative. The findings of the study were assessed from interviews with managing directors, factory managers, and/or engineers of the firms covered in the study.

Thailand was carried out to identify the determinants and environmental conditions which contribute to the firm-level technological capability building in the electronics industry in Thailand. In his study, Tirapanish used the information derived from structured questionnaires accompanied by analysis of both successful and failing firms. It was found that the determinants of the firm's technological capability comprise both internal and external factors. The internal determinants consist of management policy and firm's own efforts, firm's resource competency, organisational structure and culture, and internal and external linkages. The external determinants include government regulations and support system, the adequacy of quality support infrastructures, the adequacy of human resources in technology development area, and the availability of related supporting industry. However, Tirapanish's study does not assess the level of various elements of technological capability of the firms, nor does it explore the role of firms' characteristics (e.g. size, age, promotion status, and ownership status). Although it attempts to identify the determinant factors in the building of technological capability, it does not compare the levels (scores) of the capability between the firms in the analysis. Also, it does not investigate the role of the various factors in the development of new products.

***Case Study of an Electronic Thermal Power Plant** (Thailand) (Sutdhiyam, 1995)*

This study aims to propose a framework for assessing technological capability of a thermal power plant in Thailand by identifying the strengths and weaknesses of the electricity generation plant with respect to best practice elsewhere. The study classifies technological capability into six categories: transforming, vending, acquiring, modifying, designing, and generating capability; and it classifies these categories into three levels (Poor, Average, High) (see Chapter 5 in our study). A qualitative approach was used to assess such various capabilities. It was found that efficient planning of operation and maintenance (because of advanced well-equipped control centres, and coordination between related functional units) resulted in the strength of transforming capability,

whereas the limitation of R&D resources and the lack of explicit objectives to undertake new product and process developments led to weaknesses of designing and generating capability. However, this study by Sutdhiyam fails to examine the role of firm's personnel (i.e. manager) in the exploration of the factors affecting the enhancement of technological capability of the firm, and, in particular, it focuses only on the public enterprise firm which the nature of business is different from other firms in other industries.

The empirical studies illustrated above indicate that the achieved success of firm-technological capability building is influenced by various internal and external factors of a firm. These findings are also similar to those revealed by Dalhlman (1984), Enos and Park (1988), and Fukasaku (1992). Dalhman (1984) indicated that the building of technological capability in three industries (automobile industry, aircraft industry, and an integrated steel plant) in Brazil began with the role of foreign investment. In most cases, the success occurs from the contribution of both internal and external factors, but there are differences of experience in some aspects. Enos and Park (1988) found that that the role of the state seems to be the most important factor bringing about the success of the acquisition of technological capability of the electronic firms (in Korea). Fukasaku (1992) found that the success of the creation of technological capability of a Shipyard firm (in Japan) seems to have largely occurred from various internal factors (e.g. undertaking reverse engineering, problem-solving and trouble-shooting activities, within-enterprise training, in-house research; learning from books and journals; and sending personnel to participate in professional societies). However, firm's external factors like licenser firms, foreign experts, the role of government (through subsidising and granting tax reduction to sophisticated modern techniques and easing related regulations), and the cooperation with external agencies (through learning process between the firms, universities, and other research institutes and professional societies) also played significant roles.

However, the principal role of the internal and external factors found in different studies may differ from case to case because the firms in the industries may be different in terms of their characteristics themselves and the economic and non-

economic conditions affecting the firms. Moreover, the findings from those empirical studies may be similar with or different from the others since firms in different industries may experience and require different efforts. Also, the methodologies used by the various authors may be different because of many reasons such as the objectives of the studies, the nature of the firms (and industries) in the study, and the limitations of the studies. Some methodologies may have advantages in some cases, but they may have disadvantages in the others.

2.6 Conclusion

Typically, most of the technology development in developing countries starts with the importation of technology. However, for long-term effective technology transfer, developing countries need to build their own technological capability, the main elements of which can be classified into four categories: acquisitive capability, operative capability, adaptive capability, and innovative capability. Moreover, the firm may also need to produce new products to sell in the market in order to maintain or improve its long-term competitiveness. Therefore, apart from the emphasis on the enhancement of the above mentioned elements of technological capability, firms may also need to recognise the significance of the development of new products.

In the meanwhile, various factors can affect the success of the creation of technological capability, both in terms of the four elements of technological capability and the development of new products. These factors can be derived from inside the organisation itself (i.e. internal factors) or from outside sources (i.e. external factors). These factors may have direct and indirect effects on the enhancement of the firm's technological capability.

The firm's internal factors include firm's size (the advantage of a large size of firm), firm's own efforts through technology and business policy and strategy, management style, the accumulation of own experience, the attitude and the commitment of the owners/top managers, human resource development and R&D efforts, manpower flows, internal linkages and information system, and motivation and reward systems.

The external factors (domestic/overseas) include the supportive role of government and related institutions, customers, competitors, competitive environment and market mechanism, foreign investors, universities, trade/industry associations, fund and technology suppliers, and cooperation of the firm with other firms in the industry. They can play direct and indirect role in technological capability building of the firm.

Thus, no single set of factors can perhaps completely bring about the success of technological capability of an enterprise. This means any effort regarding the investigation of the various factors influencing the creation of technological capability of the firm (both in the four main elements of technological capability and in the development of new products) needs to consider the role played by these factors inside and outside the firm. We have, therefore, decided to use in our study a combined approach, thus enabling us to see the influence of both internal and external factors. Furthermore, given that some of the factors are difficult to quantify, a quantitative analysis will obviously fail to bring out a proper understanding of the relevant issues, hence the need to involve qualitative analysis as well. Thus, in our study we intend to use both quantitative and qualitative analysis.

Chapter 3

THE THAI FOOD INDUSTRY

This chapter begins by reviewing the stages of development of the industry over the last three decades, by looking in particular at changes in the evolution of the industry and the involvement of the various concerned parties in the growth and improvement of the industry. Then, the contribution of the industry to the economy will be examined in terms of production, export, and employment. Next, the technology concerning the food processing industry will also be discussed. Later, competitive profiles of the industry will be drawn, i.e. competition, the structure of costs of production, and raw materials.

3.1 The Pace of Development

The new method of food processing such as sterilising food with heat and then sealing it in bottles came into Thailand around the middle of the last century. In the early 1940s small-scale manufacturers expanded their operations. These entrepreneurs began with small facilities located in their own homes or shophouses, then they began to build factories equipped with more modern technology (BOI, 1993).

During the period of the Third Economic and Social Development Plan (1972-1976), the number of manufacturers of agricultural processing products was small, and generally concentrated only on vegetables and fruits. However, these entrepreneurs realised that it was very important to further create development of the agro-industry and they also realised the need for better education and understanding of the world standards for processed foods in order to export the products to the world market. Consequently, they founded the "Thai Food Processors' Association" in 1970, with the counsel and encouragement of many persons, especially Dr Amorn Bumirattana, the former Director of the Food Research and Development Institute, Kasetsart University (Kiatsrichart, 1996). Since then the food processing industry has changed tremendously, and entered into the international market. The development stages of this industry can be classified into five main periods, as shown below.

3.1.1 Initial Stage (1970-1973)

The development of modern agro-industries started with the establishment of the Thai Food Processors' Association. In the first two years, the information about production processes, laws and regulations was gathered by the members of the Board of Directors of the Association, to ensure that the production complied with the international standards, in terms of quality and consumer safety, both in domestic and overseas markets. The R&D in this period was mostly emphasised with respect to the development of processed vegetable and fruit products (Kiatsrichart, 1996).

For modern canned fruits, the first firm was established in 1967, with a joint-venture project between Taiwan and Japan. In 1972, there were about 20 small canned fish firms situated in and around Bangkok, and most of them were operated by family members. In this year, a joint-venture Thai-Australian canned fish enterprise was established as the first large scale firm of the industry in Thailand (Artachinda, 1977).[1]

3.1.2 Development and Export Stage (1974-1979)

During this period the quality of products had been improved steadily and the products were exported to foreign markets. Exported products comprised not only processed vegetable and fruit products but also processed fishery products, such as canned tuna, canned shrimps, and canned clams. Exports of processed agricultural products during this stage rose very rapidly, rising approximately 50-100% per annum. There were about 20 processing food firms for overseas markets during this period (Kiatsrichart, 1996).

Thailand first exported canned seafoods in 1975 with an amount of 2,780 tons. In the same year, the Thai government started launching the promotion of canned seafoods for export. In this year, the first canned fish firm supported by the Board of Investment (BOI) was established (Nakalukne, 1988). This heralded a new era for the fish canning industry and the rapid development of the seafood processing industry in the Thai economy.

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[1] According to Nakalukne (1988) a seafood processing firm which used advanced production process was established in 1973 (p.595).

3.1.3 Production Expansion and Marketing Stage (1980-1985)

The number of food processing enterprises had increased dramatically during this period. On average, about 10 firms were established annually.[2] Production and exports also rose steadily.[3] Because of an increase in the market share of Thai products in the world market, several major importing countries started paying much attention to the quality of products. The customers, especially seafood product importers, were invited to inspect the product quality in Thailand. They also provided training programmes and know-how concerning the quality control testing procedures to local producers (Kiatsrichart, 1996). Both government sector (e.g. Department of Export Promotion (DEP) of the Ministry of Commerce) and private sectors (e.g. the Thai Food Processors' Association, and the Food Processing Club of the Federation of Thai Industries (under the jurisdiction of the Ministry of Industry) also worked together to promote the products in foreign markets (BOI, 1993).[4]

3.1.4 Quality Improvement Stage (1986-1990)

During 1986-1990, the Thai food processing industry improved its quality in order to comply with the requirements of importing countries. Many activities including the improvement of product quality, training, and R&D had been carried out. Various government agencies (such as the Department of Fisheries (DF), the Department of Medical Science (DMC), and the DEP) also became heavily involved in such an effort, by consulting and discussing with client countries, including the USA, Canada, France and Italy. Many staff of these organisations and various food producers also visited these countries to observe the quality inspection and to learn more about such a process. At the same time, inspectors from such countries came to Thailand to disseminate related information and knowledge concerning the inspection and quality

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[2] There were 24 canned seafood firms in 1982, and 39 firms in 1985. Most firms produce various kinds of canned seafood products, such as canned tuna, canned sardines, canned shrimps and canned crab meat, and only a few of them produce only canned tuna (Nakalukne, 1988, pp.601-602).

[3] Raw materials used were 5,000 tons in 1975, 56,000 tons in 1980, and 468,000 tons in 1986 (Nakalukne, 1988, p.595).

[4] The role of related government agencies and the trade/industry associations regarding market promotion and quality improvement will also be discussed in Chapter 4.

control procedures and provided guidelines to local producers through seminars (Kiatsrichart, 1996).

3.1.5 Production and Marketing Competition Stage (from 1991 onwards)

Since 1991, the producers have increasingly faced problems concerning both production and marketing. Furthermore, they have experienced shortage of raw materials and high prices. The price and the availability of the raw materials used for producing seafood products have fluctuated. Also, production facilities have had to be adapted and improved to comply with the standards set by the European Union (EU) (Puttanorm, and Rimpirangsri, 1995). At the same time, the producers have been facing tough competition from newly emerging countries (Kiatsrichart, 1996).

Thai producers have faced severe raw material shortage (tuna fishes) since 1993. Only 20% of domestic raw materials could be supplied to the industry in this year.[5] Consequently, prices of raw materials have continuously increased since 1993 (Puttanorm and Rimpirangsri, 1995). During 1993-1994, this problem, accompanied by the low quality of raw material, caused the cost of production to increase. Moreover, there were other serious problems: slowdown of the world economy, high competition in the international market, and rejection of Thai products from some importing countries for failing to meet standards set by those countries. This led producers to stop or reduce the scale of their production. As a result, the number of producers decreased from 58 firms to only 20 firms in this period. Moreover, the largest Thai canned tuna firm also faced both financial and management problems. Finally there was an increase in the price of canned tuna because of a sharp decrease in its local supply (Sornlum, 1996; Chintatham, 1996).

3.2 Contribution of the Food Industry to the Economy

The contribution of the food industry comprise various aspects. *Firstly*, the industry creates value added for the agricultural products. Some of the products are

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[5] In 1982, the proportion of raw materials imported from abroad was 31.2%, or the producers used about 70% of those supplied from local sources (Nakalukne, 1988, p.602).

intermediate goods such as frozen fresh seafoods, while some products are final ones such as canned fruits and vegetables, canned seafoods, and frozen cooked seafoods. *Secondly*, the food processing industry is a labour-intensive industry. As a result, it creates substantial employment in the country. However, this contribution also affects the competitiveness of the industry in an international market, when labour costs are higher than in other competiting countries. *Thirdly*, the industry can be decentralised to the regional areas since it is normally located near raw material sources so as to reduce the transportation cost and minimise damages occurring during transportation. Hence, this industry can create employment and income in the regions (see Appendix 3.1). *Fourthly*, the industry also generates a substantial amount of foreign exchange earnings for the country.[6] *Finally*, the industry has both backward and forward linkages to other production sectors, including the agricultural sector, the manufacturing sector (such as machinery and packaging industries), and the service sector (such as commerce, finance, insurance, transportation).

3.2.1 Production

In 1996 the value of Thailand's food processing industry (including food and beverages) was estimated at 140,676 million baht (at 1988 prices). Approximately 74,400 million baht, or 53% of this amount was classified as food, and the remaining 66,200 million baht, or 47% was claimed as beverages (NESDB, 1999).

The proportion of the value added of the food processing industry (food and beverages) to the total value added of the manufacturing sector has changed from 9.7% and 6.6% in 1990 to 8.0% and 6.4%, respectively, in 1996 (see Table 3.1).[7] A decrease in the share of food processing products may occur from the fact that the growth of other manufacturing sub-sectors is higher than that of the food industry. On average, during 1990-1996, the food processing industry expanded by 8.1% per

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[6] Normally Thai people prefer to eat fresh food products rather than processed ones. However, since consumption patterns of the people have changed in the last few decades, some processed products have been increasingly consumed by Thai people (BOI, 1993; TDRI,1991). Also, canned fish, like canned sardines in tomato sauce, has been known by the local people for a long time.

[7] Comparing the values of various segments of the processed food industry, the seafood industry has the highest share at about one-third of the total value of the industry in 1995 (TDRI, 1996).

annum, whereas the manufacturing sector as a whole expanded by 10.3% per annum in the same period (NESDB, 1999). However, the growth of the industry was different between the segments of the industry (i.e. different main-product groups and different kinds of processing). The sectors which experienced high growth rates were exporting industries (i.e. export > 80% of total sales), particularly canned seafoods and canned fruits and vegetables. However, the expansion of canned seafoods had slowed down later because of the shortage of raw materials (TDRI, 1996).

Table 3.1 Shares of Manufacturing Products of Thailand at Current Prices (1990-1996)

(Percent)

Item	Year						
	1990	1991	1992	1993	1994	1995	1996
Food	9.7	9.3	8.5	8.1	8.2	7.8	8.0
Beverages	6.6	6.7	6.5	6.3	6.2	6.4	6.4
Tobacco	2.9	9.3	2.4	2.2	2.4	2.1	2.1
Textiles	10.2	6.7	9.6	8.6	8.0	7.7	6.7
Wearing apparel except footwear	10.4	2.9	11.4	11.2	11.5	11.4	11.7
Leather, leather products and footwear	4.2	9.6	4.1	4.1	4.1	3.7	3.1
Wood and wood products	1.8	11.3	1.1	0.8	1.0	0.7	0.7
Furniture and fixture	3.2	4.1	3.1	3.1	3.0	2.8	2.6
Paper and paper products	1.2	1.2	1.3	1.3	1.4	1.5	1.8
Printing, publishing and allied industries	1.0	3.3	1.0	1.0	1.0	1.2	1.5
Chemicals and chemical products	2.5	1.3	2.3	2.2	2.2	2.3	2.2
Petroleum refineries and petroleum products	4.3	1.0	5.7	6.3	6.2	6.5	7.6
Rubber and plastics products	2.5	2.4	2.6	2.4	2.7	3.1	2.6
Non-metallic mineral products	6.2	6.4	6.0	5.8	5.7	5.3	5.4
Basic metal industries	1.8	1.5	6.5	1.6	1.8	1.8	1.8
Fabricated metal products	2.5	2.6	2.6	2.5	2.5	2.6	2.7
Machinery	5.3	5.7	5.8	6.0	6.3	7.3	8.4
Electrical machinery and supplies	5.8	6.4	8.0	8.5	8.8	8.1	7.8
Transport equipment	9.9	7.3	7.8	9.3	7.8	8.6	8.7
Other manufacturing industries	8.0	8.3	8.6	8.7	8.9	8.9	8.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: NESDB, 1999

Of the total 115 billion bahts value of food processing industries in Thailand in 1992, approximately 46% was consumed domestically and 54% exported. For food products, however, the larger proportion, about 81% was exported, while for beverages (including alcoholic and non-alcoholic products), the main market was domestic, with only about 11% exported (see Table 3.2).

Table 3.2 The Structure of the Food Processing Industry in Thailand, 1992

(Value in Billion of Baht)

	Food		Beverages		Total	
	Value	Share (%)	Value	Share (%)	Value	Share (%)
Exported	57	81	5	11	62	53.9
Domestic	13	19	40	89	53	46.1
Total	70	61	45	39	115	100.0

Source: BOI, 1993, Table 2.1, p.5

3.2.2 Export

The value of Thai food exports (e.g. fresh and processed products seafoods, fresh and processed fruits and vegetables, and frozen poultry) increased from US$ 13,216.6 million in 1986 to more than US$ 65,400 million in 1997. However, the share of total food exports to the total Thai exports generally decreased from 1986 to 1997, from about 14-15% of total exports to about 10% (see Table 3.3). This was mainly because of the fact that the growth of the values of other exports is higher than that of the food exports.

Table 3.3 Values of Thai Food Exports (1986-1997)*

(Million of US$)

Year	Fresh and Processed seafoods	Fresh and processed fruits and vegetables	Frozen Poultry	Others	Total food export	Total Thai Exports	The Proportion of Food Exports to Total Exports (Percent)
1986	9,119.6	2,432.2	1,186.1	481.0	13,216.6	88,685.5	14.9
1987	11,111.5	3,072.3	1,527.6	520.1	16,231.5	113,944.2	14.2
1988	15,294.8	3,872.5	1,899.8	807.9	21,878.0	153,356.5	14.3
1989	18,689.3	4,310.8	2,299.8	1,071.9	26,371.8	136,199.7	13.4
1990	21,616.3	5,427.5	2,945.0	1,229.1	31,217.9	224,128.8	13.9
1991	27,580.0	7,409.9	4,004.1	1,473.1	40,467.1	275,670.5	14.7
1992	29,130.8	7,807.3	4,113.1	1,848.4	42,899.6	313,364.4	13.6
1993	32,138.0	7,583.7	3,531.6	2,111.5	45,364.8	357,527.8	12.7
1994	39,411.6	8,022.8	3,882.3	2,639.5	53,956.2	432,288.6	12.5
1995	42,156.3	8,780.7	3,816.4	3,484.0	58,237.4	534,397.8	10.9
1996	39,684.5	8,098.3	2,661.9	2,661.9	54,011.6	536,194.9	10.1
1997	49,677.2	8,228.7	4,277.6	3,257.3	65,440.8	686,540.4	9.5

Note * - The values are converted from Thai Baht to US$ with the exchange rate in November, 1999 (38 Baht = 1 US$).

Source: Department of Business Economics, Ministry of Commerce

With respect to the exported products concerning our study (canned fruits and vegetables, canned seafoods, and frozen seafoods), their values increased from US$ 7,117.7 million in 1985 to US$ 43,165.2 million in 1996, or an increase of about 46% per annum during 1985 to 1996 (Department of Business Economics, Ministry of Commerce).[8] The proportion of the four major types of food exports is shown in Table 3.4.

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[8] The values are converted from Thai Baht to US$ with the exchange rate in November, 1999 (38 Baht = 1 US$).

Table 3.4 The Structure of Selected Thai Food Exports (1986-1996)

(Percent)

Product	Year											
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Canned pineapple	17.3	12.0	11.3	11.1	8.1	8.8	9.2	9.6	7.7	5.9	4.7	5.7
Pineapple juice	1.6	1.4	1.4	1.6	1.6	2.5	3.2	2.3	1.5	1.5	1.8	2.6
Other canned fruits and vegetables	1.0	1.3	1.3	2.0	2.2	2.7	2.8	2.7	2.5	2.2	2.5	3.1
Other fruit juices	0.1	0.1	0.1	0.3	0.4	0.3	0.3	0.6	1.3	0.9	0.7	0.8
Canned and processed vegetables	3.3	3.6	5.8	4.5	4.7	4.2	4.8	4.0	3.6	3.4	4.0	4.5
Canned seafoods	38.3	40.9	40.0	44.5	36.5	34.3	30.9	28.2	27.4	28.4	28.4	30.1
Canned Tuna	(24.3)	(28.3)	(24.8)	(31.0)	(25.5)	(21.8)	(19.4)	(15.5)	(14.0)	(13.9)	(11.6)	(10.9)
Canned Sardines	(0.5)	(0.9)	(1.1)	(0.9)	(1.2)	(0.9)	(1.0)	(1.0)	(1.1)	(0.9)	(1.2)	(1.1)
Canned other fishes	(2.6)	(2.8)	(3.0)	(1.5)	(1.4)	(0.9)	(0.8)	(0.6)	(0.8)	(0.6)	(0.6)	(0.5)
Others	(10.9)	(8.9)	(11.0)	(11.9)	(8.4)	(10.8)	(9.7)	(11.1)	(11.5)	(13.1)	(15.0)	(17.6)
Frozen fresh and cooked seafoods	38.4	40.7	40.1	40.5	46.6	47.2	48.8	52.6	56.0	57.7	57.9	53.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Department of Business Economics, Ministry of Commerce

The role of the food industry can also be seen from the ratio of export value to total value. It was found that both canned seafoods and canned fruits and vegetables have a ratio higher than that of other sub-industries. The ratios of these industries were nearly 70% in 1985 and 90% during 1990s (TDRI, 1996, p.72). In the world market, Thailand has remained the leading exporter of several processed foods, especially canned tuna, canned pineapple, pineapple concentrate juice, and frozen shrimps for many years, as seen in Tables 3.5 and 3.6.

Table 3.5 The Proportion of Selected Thai Food Exports to the World Market (1990-1995)

(Percent)

Product	Year					
	1990	1991	1992	1993	1994	1995
Canned Tuna	54.6	52.0	51.9	45.5	45.9	39.3
Pineapple juice concentrate	51.2	53.0	48.2	51.0	54.7	53.0
Canned pineapple	na.	na.	52.7	na.	50.6	na
Frozen shrimps and prawns	na	na	na	na	17.0	16.9

Source: 1. Thai Food Processors' Association (1996) (for Canned tuna, Canned pineapple, and Pineapple juice concentrate)
2. FAO (1998a),Vol. 83, Table 90 (for frozen shrimps and prawns)

Table 3.6 Thailand's Canned Seafoods in the World Market (1980-1989)

Product	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Canned Tuna										
Total products (100 ton)	n.a.	4.7	8.5	18.1	39.9	87.1	141.9	144.9	207.7	255.1
Export (mil.$US)	n.a.	11.3	19.7	39.3	78.7	170.2	285.6	316.8	510.4	536.8
World's market share (percent)	n.a.	3.3	6.2	10.5	19.9	35.8	46.3	47.4	53.0	51.5
World's market ranking	n.a.	8	6	2	1	1	1	1	1	1
Canned Sardines										
Total products (100 ton)	14.2	13.1	56.5	51.3	83.9	50.8	39.8	49.2	48.9	44.3
Export (mil.$US)	-	-	-	-	2.5	3.4	8.9	4.5	15.9	24.4
World's market share (percent)	-	-	-	-	0.8	1.1	3.2	5.3	5.7	7.8
World's market ranking	-	-	-	-	15	15	11	8	6	4
Canned Mackerel										
Total products (100 ton)	-	-	-	-	-	-	-	-	13.1	12.2
Export (mil.$US)	-	-	-	-	-	-	-	-	14.3	14.4
World's market share (percent)	-	-	-	-	-	-	-	-	19.4	16.4
World's market ranking	-	-	-	-	-	-	-	-	2	2
Canned Shrimps										
Total product (100 ton)	3.1	5.9	4.2	27.1	37.8	20.4	28.9	32.4	36.1	37.0
World's market share (percent)	16.8	37.1	37.5	79.7	82.5	75.1	78.4	77.4	73.4	75.8
World's market ranking	2	1	1	1	1	1	1	1	1	1

Table 3.6 (continued)

Product	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Canned Crab Meat										
Total product (100 ton)	1.6	16.4	4.4	5.8	4.7	8.5	20.6	33.9	26.8	27.4
Export (mil.$US)	-	-	-	-	34.0	25.8	33.0	55.7	59.2	43.7
World's market share (percent)	-	-	-	-	50.9	47.1	49.0	54.0	49.5	37.1
World's market ranking	-	-	-	-	1	1	1	1	1	1
Canned Squid										
Total product (100 ton)	0.7	0.6	1.3	2.2	1.8	1.1	2.0	3.8	4.0	4.1
World's market share (percent)	8.4	5.4	14.4	28.0	24.3	13.0	28.4	42.6	46.4	42.3
World's market ranking	3	4	3	2	2	2	3	2	2	2

Source: Takisna (1992), Table 10, p. 19.

The major markets for Thai food products comprise the USA, Japan and the EU (the market shares of Thailand's selected food exports to these three markets are shown in Table 3.7). The USA is the most important market for the products of the industries examined in this study. However, in order to export to this market, the products need to pass the United States Food and Drug Administration (USFDA) standard. Similarly, the importation of products into Japan requires a very strict inspection, so Thai producers have to intensively develop the quality of products to export to this market (Utsahagamsarn, 1993). The EU is the third major market. Other important markets are Canada, Australia, Eastern Europe, and Africa (see Table 3.8).

Table 3.7 The Proportion of Thailand's Selected Food Exports to World's Major Markets (1990-1997)

(Percent)

Market	Product	Year							
		1990	1991	1992	1993	1994	1995	1996	1997
USA	-Canned seafoods	n.a.	70.1*	72.5*	48.7	53.1	42.0	38.0	40.5
	-Canned fruits and vegetables	n.a.	n.a.	n.a.	15.5	13.7	12.7	11.8	11.8
Japan	-Canned seafoods	n.a.	93.8*	59.0*	45.0	46.8	46.6	56.2	46.8
	-Canned fruits and vegetables	n.a.	n.a.	n.a.	9.1	7.3	7.3	8.3	7.7
	-Frozen shrimps	n.a.	17.2	18.7	19.6	18.8	18.8	na	na
EU	-Canned seafoods	9.2	9.9	9.2	9.7	10.7	7.9	6.4	na
	-Canned fruits and vegetables	3.7	5.0	4.8	4.7	4.3	3.2	4.6	na

Note: * Only canned tuna
Source: Department of Business Economics, Ministry of Commerce

Table 3.8 Top-ten Major Markets of Thailand's Selected Food Exports, 1998*

Canned pineapple	Other canned fruits	Canned, prepared or preserved vegetables	All canned seafoods	Canned tuna	Canned sardines	Other canned seafoods	Frozen fresh shrimps
USA (11.0)	USA (28.2)	Japan (34.3)	USA (42.8)	USA (27.9)	USA (12.7)	Egypt (15.9)	USA (34.5)
Germany (19.5)	Hong Kong (15.5)	USA (19.0)	Japan (14.4)	UK (10.2)	Romania (9.7)	Jamaica (12.4)	Japan (21.6)
Japan (8.7)	Netherlands (6.4)	Germany (6.8)	Canada (6.3)	Canada (9.5)	Malaysia (7.3)	USA (8.4)	Singapore (8.4)
Netherlands (8.4)	Japan (5.8)	Hong Kong (6.5)	UK (5.1)	Egypt (8.9)	Republic of Dominican (6.9)	Nigeria (5.3)	China (7.7)
UK (7.6)	Singapore (5.0)	Netherlands (5.7)	Singapore (3.7)	Australia (5.4)	Hungary (6.4)	Romania (4.9)	Australia (4.3)
France (5.1)	Germany (4.7)	Australia (4.3)	Egypt (3.5)	Saudi Arabia (5.3)	Ecuador (5.6)	Australia (4.6)	Taiwan (3.6)
Canada (4.5)	France (4.7)	UK (3.9)	Australia (3.5)	Japan (4.6)	Cambodia (4.6)	Ghana (3.7)	Canada (3.6)
Spain (3.7)	UK (3.9)	Canada (2.4)	Germany (2.1)	Germany (2.3)	Australia (4.2)	Sri Lanka (3.7)	France (2.8)
Italy (2.9)	Australia (3.5)	Sweden (1.8)	Saudi Arabia (2.0)	Switzerland (1.8)	Vietnam (3.9)	Netherlands (3.1)	UK (2.3)
Belgium (2.7)	Canada (2.9)	Korea (1.6)	Netherlands (1.5)	Argentina (1.5)	Yemen (3.7)	Lebanon (3.0)	Germany (2.2)

Note: * - January - October

The figures shown in brackets are the market shares (values) of the products exported to each market.

Source: Department of Business Economics, Ministry of Commerce

3.2.3 Employment

As mentioned earlier, the food processing industry has created employment not only in the processing firms but also in other related production sectors. Moreover, the expansion of the food industry has brought about an improvement of labour skills which could create externalities to the economy in the regions. However, it was found that the ratio of the wage bill to the total value of products (W/O) in the food industry as a whole had decreased whereas the ratio of machinery's value to the wage bill (OS/W) had increased from 1985 to 1990, although the labour cost had continuously increased during this period (NESDB, 1990, 1996; TDRI, 1996). This means employment had slowed down as compared to the change of products' values (under the assumption of constant production quantity).[9] This implies that the food processing industry, in which the production has expanded, has developed by machinery replacing workers. Also, for the production which has not expanded, there was a reduction of employment (TDRI, 1996, p.48). Additionally, it was found that

[9] It was argued that the operating surplus (OS) is derived from the values of the products less labour costs, depreciation and indirect taxes. Therefore, it may be used as the values of the machinery (capital) (TDRI, 1996, p.46).

there was a decrease in employment in the large firms as compared to the small firms (TDRI, 1996).

3.3 Technology

In the past, the firms (canned seafood and canned fruit and vegetable) were originally established as household units and finally expanded or increased their capacities. These firms were small or medium scale, and they based their technological requirements on their own experience. However, for the large-scale firms like canned pineapple firms, they usually hired foreign technicians or experts (Artachinda, 1977).

According to TDRI (1991), key technologies used in the food industry can be classified into four main categories, as follows:

(1) production techniques (sterilisation, aseptic processing, freezing);

(2) management technology (ranging from the selection of raw materials, production process, and waste management) in order to increase efficiency and reduce costs;

(3) packaging technology (such as microwave-proof soft containers, cans that can be tear-opened by hand, durable and stable containers). New forms of packaging can help the producers to differentiate their products;

(4) waste management (to maximise the use of resources and generate higher returns. This could lead to lower production cost and to enhance product quality).

Moreover, technologies used in the industry comprise both physical technology (e.g. machinery and equipment) and intangible technology (e.g. know-how used in running machinery and equipment, quality control in the production and management system, in managing waste, and in designing products). At the same time, the main purpose of the use of technology in the industry may vary from firm to firm because of different kinds of raw materials involved, varying complexity of the products, and different marketing strategies. Various kinds of technologies mentioned above can be derived from the combination of local and imported technologies. Some firms may emphasise the domestic market, some may focus on the overseas market. However, in the

importation of technology from abroad, the firms may have to undertake more efforts, not only in terms of acquisition but also in terms of adaptation to suit local conditions.

Although technology can be classified into several types as mentioned above, the study in this part will mainly consider it under two main aspects: machinery and components used in the production process, including packaging technology; and management technology, in particular, a quality control system.

3.3.1 Machinery

At the early stage of modern food processing, machines used in the firms were imported from Taiwan and China, or were locally produced by using designs and technology copied from machinery produced in industrialised countries. With respect to the development of machinery used in this industry, it was found from the study of BOI (1993) that the manufactures began as small metalworking factories, manufacturers of many types of industrial machinery acquired foreign know-how, and, by studying, copying and manufacturing on a trial and error basis. As a result, they were able to gradually improve their products. Then, experience and know-how was transferred within families and among workers from generation to generation on an informal basis. At the same time, more advanced techniques used in the production of machinery and equipment to support food processing have been developed through constant interaction between food processors and the food processing machinery and equipment manufacturers. However, according to BOI (1993), the development of the modern food industry is still much dependent on the importation of foreign technology. Although local machinery from domestic sources may be cheap, they supply firms disadvantages particularly in terms of quality and usefulness.

3.3.2 Management Technology

Since the production of processed food products requires not only good or appropriate machinery and equipment but also good management, this requires the firms to implement good management programmes, especially a quality control system, so as to obtain production efficiency and acceptable products. The crucial role of the quality control systems in the food industry can be seen in Appendix 3.2.

The importing countries have been increasingly strict in the legislation regarding the quality of products by emphasising the consumer's health as a major factor. This requires food safety, hygiene, and cleanliness. Therefore, the producers of food products need to ensure good preparation of the raw materials used. TDRI (1994) proposed that all parties concerned need to participate in the implementation of several programmes such as GMP, HACCP, TQM, and food sanitary quality. In the same study, it was also found that there were differences between the firms in terms of the control ability and problem-solving efforts. The problem-solving ability is dependent on the quality control system management, firm's personnel experience, and the cooperation between related departments. Furthermore, the firms which were visited by external auditors (such as customers or the inspectors of importing countries) had better quality control management than the others. This brings about an increase in the recognition and confidence of the customers regarding the firms' products. It was also found that the most important factor leading to the adoption of a new quality control management system depends on the attitude and confidence of the firm's top manager towards this system.

3.4 Costs of Production

For all kinds of canned food, raw materials represent the largest share of cost of production. In the food processing industry (canned fruits and vegetables), raw materials represent the largest share of the operating costs, followed by packaging costs. Compared with canned fruits, fruit juice products generally have lower costs of raw materials because the raw materials used for producing the latter products are largely made up of fruit by-products from the production of the former (BOI, 1993). According to IFCT (1989b) and Takisna (1992), labour cost is the third largest share of cost of production of canned fruits and vegetables and canned seafoods (canned tuna). However, for other canned seafoods (i.e. excluding canned tuna), labour cost is the second largest share of cost of production (Takisna, 1992). Meanwhile, labour cost in Thailand is higher than that of many major competitors (e.g. the Philippines, Indonesia, China, India, Vietnam) (BOI, 1993). Moreover, prices of canned seafoods in international markets cannot be adjusted along with an increase in the cost of production because of high competition. Therefore, the countries which can produce

products with low costs appear to gain a high market share. However, it was argued that competition with respect to canned tuna is mainly concerned with the quality and taste of the products (Clinic Marketing Company, 1991). Hence, the use of advanced technology and the implementation of good management systems may be necessary for the industry to maintain or improve its competitiveness in the international markets.

3.5 Raw Materials

For the canned fruit and vegetable industry, the producers can obtain raw materials from three main channels: purchase from farmers under a contract-farming agreement, purchase from farmers or middlemen in general (commercial operation), and/or from their own plantations (BOI, 1993). Compared with other canned fruit and vegetable industries, in the canned pineapple industry raw materials are available almost throughout the year. On the other hand, other canned fruit and vegetable industries can acquire the raw materials depending on seasonal availability (see Appendix 3.3). However, many other canned fruit and vegetable firms produce various kinds of products in order to avoid the shortage of raw materials (and to increase the capacity utilisation).

For the seafood industries, the raw materials are derived from both domestic and overseas sources. The canned seafood industry in Thailand imports about 70-80% of raw materials from abroad, especially tuna fish (FTI, 1996). However, for frozen shrimps, most raw materials are obtained from domestic sources, especially through aquaculture (for tiger shrimp), and partly from overseas sources.

3.6 Competition

For certain food industries, the new emerging important competitors include China, Indonesia and Vietnam. These countries have abundant resources both in terms of raw materials and cheap labour cost, as mentioned earlier. At present, foreign investors are increasingly interested in joint-venture investment in these countries

(Utsahagamsarn, 1993). Major competitors of selected Thai food products in the world market can be seen in Table 3.9.

Table 3.9 Major Competitors of Thailand's Selected Food Exports, 1996

Product	Thailand and Major Competitors
Canned pineapple	***Thailand*** (34.5) The Philippines (24.8) Indonesia (12.5) Kenya (9.1) Malaysia (3.6)
Prepared or preserved tunas and bonitos	***Thailand*** (30.6) The Philippines (11.2) Ivory Coast (9.9) Spain (6.4) Indonesia (5.1)
Prepared or preserved sardines, sardinellas, brisling or sprats	Morocco (16.3) Ecuador (15.3) ***Thailand*** (11.5) Latvia (9.7)
Prepared or preserved mackerels	***Thailand*** (25.7) Denmark (20.9) Norway (10.3) Morocco (5.6)
Prepared or preserved crabs	***Thailand*** (25.8) Canada (14.2) China (10.3) Indonesia (8.4) Russian Fed (8.0)
Prepared or preserved shrimps and prawns	***Thailand*** (32.9) Iceland (12.9) Greenland (6.9) Denmark (9.6)
Frozen shrimps and prawns	***Thailand*** (15.0) India (9.4) Ecuador (8.5) Indonesia (7.8) Denmark (4.6)

Note : The figures shown in brackets are the percentage of the quantity of export (metric ton) to the total world exports.
Sources: FAO (1998a) (for seafood products)
FAO (1998b) (for canned pineapple)

IFCT (1989a and 1989b) found that the most important factor contributing to the success of the canned food industry is the quality of product. The improvement of the products to suit the market demand in canned seafoods is also another major factor.

Other important factors include prices, related information, customer services and packaging. According to BOI (1993), the key factors regarding comparative advantage in the major segments of the food processing industry in Thailand include the scale of production, production technology, access to raw materials, product differentiation, and distribution channels and market access. TDRI (1996, p.83) also indicated some advantages and disadvantages regarding the competitiveness of the Thai food industry in the international market, as follows:

Favourable factors: labour productivity, quality and standard of product, and marketing; and

Unfavourable factors: raw materials, especially canned tuna, labour cost (but labour productivity is higher than that of competitors), government policy and bureaucratic system.

However, TDRI (1996) argued that Thailand still has comparative advantage in the food industry, especially frozen seafoods, canned seafoods, and canned pineapple, in the world market, because the private sector has created its capability both in terms of competitiveness and technology.[10] Mekanontchai (1996) also argued that the effective ways to be successful in the food industry include four main factors: the quality requirements of the market, the cost of production, the legislation, and the management and administration of the organisation.

3.7 Conclusion

The experience of the development of the food industry in Thailand discussed in this chapter can be viewed under three main points.

Firstly, various parties concerned (e.g. the association, academics, government agencies, customers including the authorities of related agencies in importing countries, and foreign investors) have been involved in the improvement of product quality and the expansion of foreign market. It is apparent that the Thai food industry has highly achieved success in the world market, and Thailand has become a major

[10] It was argued that the high expansion of the exported food industry, e.g. fruit and vegetable processing and seafood processing, in the past occurred from the competitive advantage of the Thai industry in foreign markets in terms of resources, labour and technology (TDRI, 1996, p.76).

exporter of food products (i.e. canned seafoods, frozen seafoods, canned pineapple) in international market.

Secondly, the food industry has largely contributed to the Thai economy in various aspects including the growth of national income and foreign exchange earnings, the expansion of employment, and the expansion of related production sectors.

Thirdly, the success of the industry requires various factors to be involved, e.g. raw materials, production, and marketing. Apart from the cost of production and availability of raw materials, the competitive advantage of the industry also involves other factors, especially the quality of products and the use of technology (e.g. machinery, management) for improving product quality and developing products.

Chapter 4

ROLE OF GOVERNMENT AND OTHER AGENCIES

4.1 Introduction

As mentioned in Chapter 1, our study aims to investigate the role of both firm's internal and external factors in the building of technological capability. However, before we discuss the procedure used from collecting data at the firm level, we would like to analyse the role of various institutions (i.e. firm's external factors), mainly to examine the participation, coordination, and linkages of these institutions and their contribution to various activities affecting the building of technological capabilities of the food industry in Thailand. These institutions include the role of government (i.e. policy and strategy) and its agencies (e.g. the Board of Investment, Ministry of Agriculture and Cooperatives, Ministry of Public Health, Ministry of Commerce, and Ministry of Industry), government supported agencies (e.g. National Food Institute, the Industrial Finance Corporation of Thailand), universities, and trade/industry associations. Both primary and secondary data are used in the investigation. The primary data were collected from the survey of relevant agencies through interviewing with the key persons of these agencies (see Appendix 4.1) during August to November 1997 by using a questionnaire (see Appendix 4.2). The summary of the role of these agencies is shown in Appendix 4.3.

The roles of government and other agencies can be considered in two aspects: (a) direct roles (e.g. quality control and standardisation, the analysis of product quality, research and development, human resource development, information services, and technical service); and (b) indirect roles (e.g. raw materials development, financial services, marketing and export). These roles directly or indirectly affect the enhancement of the ability of the food processing firms regarding the acquisition of technology, the use of technology, the adaptation of technology, and the development of technology. These activities result in the expansion and quality improvement of the food products, the productivity and efficiency of the production, and the development of labour skills. Moreover, many human resource development programmes and R&D activities carried out by these institutions can create externalities (as argued by the

new-growth theorists) to the firms in the industry. This brings about competitive advantage for the industry although it has faced the problem of raw materials and high labour costs.

4.2 Government Industrial Development: Policy and Strategy

Although the food industry (e.g. canned food) has been mentioned as one of the industrial groups since the Third National Economic and Social Development Plan (1972-1976), the considerable attempt to develop agro-industries by the government has been largely emphasised since the period of the Sixth National Economic and Social Development Plan (1987-1991) in order to improve productivity, and promote joint ventures with foreign investors in order to acquire capital and technology from abroad.[1] In this period the Agro-industry Development Centre (Office of Agricultural Economics, the Ministry of Agriculture and Cooperatives) was set up. The main purpose was to carry out the whole circle of agro-industrial development. The cooperation between related agencies in undertaking such an effort involves four government bodies, as listed belows:

1. The Ministry of Agriculture and Cooperatives
   -for promoting the production of various kinds of crop to supply the demand of processing firms
2. The Ministry of Industry
   -for supervising the establishment of factories to produce the products with the standard accepted by both local and international markets
3. The Ministry of Commerce
   -for seeking markets for products
4. The Board of Investment
   -for promoting investment by assisting producers and providing privileges to them so as to reduce the cost of production. This leads to the enhancement of their competitiveness in the world market.

The food industry (e.g. processed and canned seafoods, and processed and canned fruits and vegetables) is also emphasised by the Export Development Committee for

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[1] The First National Economic Development Plan covers the period 1961-1966. The Second National Economic and Social Development Plan covers the period 1967-1971 (the first plan did not include social development).The export industry was first promoted in the period of the Third Plan (1972-1976).

giving export promotion in order to compete with other countries (Bank of Ayudhaya, 1997).

Another role of Thai government in support of agro-industrial development includes the announcement of the Investment Promotion Act in 1959, and the establishment of the Board of Investment (BOI) in the same year. Originally, the promotion policies gave tax exemption to the importation of intermediate and capital goods by promoted industries. In 1972, the industrial promotion schemes also included measures to promote export industries by granting exemption from import duties and business taxes on raw materials, necessary supplies and other items imported for use in production for export (IFCT, 1991). Later, the investment promotion schemes were revised to cover a wide range of incentives, such as guarantees, tax exemptions, income tax relief and protection, and measures for promoting R&D efforts (see Appendix 4.4). At the same time, the BOI has also adjusted its role from an incentive-granting agency to service-oriented advisor, including providing technical expertise on related issues to investment projects (BOI, 1997). Moreover, recently, the BOI has also emphasised the decentralisation of an industry to regional areas and investment promoted zones, by granting various kinds of privileges (apart from promoting export industries) (see Appendix 4.4) (BOI, 1997). These efforts appear to largely contribute to the expansion of the food industry because the majority of the food processing industry are exporting industries and these firms are located in the regional areas which are near raw material sources. Thus, these firms can obtain investment promotion schemes from the BOI.

The BOI began promoting canned seafoods in 1972. Because the products had grown substantially since 1972, the Board temporarily stopped promoting the canned seafood industry during 1981-1983. However, the promotion of this sector was continued since 1984 but only for the exporting industry (export 100%). Later, in order to promote regional development since 1993, for canned seafoods, the firms located in Zone 3 (the provinces outside those in Zone 2 and Bangkok and its vicinities) with exporting $\geq 80\%$ of total sales, and for those which are located in the industrial estates, or industrial zones situated in Zone 2 (i.e. the provinces surrounding Bangkok's vicinities) have been promoted (Sriripanish, 1995, p.16).

Regarding the canned pineapple industry, the Ministry of Industry employs a free competition policy for the establishment and expansion of canned pineapple factories. The BOI provides privileges to the production of canned pineapple and concentrated pineapple juice by the plants located in Zone 3. The BOI had stopped promoting canned pineapple investment during the period 22 November 1978 to 8 April 1993 (Tamthai, 1993, p.13) because of the oversupply of pineapple in the country. However, after that time the restriction was relaxed. With reference to other canned fruits and vegetables, and frozen seafoods, the BOI also gave privileges to the firms if they were situated in the promoted areas and their production conformed to the conditions designated.[2]

Concerning the role of government mentioned above, the promoted food processing firms can benefit from promotion schemes in various regards, such as the importation of machinery and equipment (used in production process and R&D activities), experts, and raw materials. This also includes the transfer of technology through foreign direct investment, and the development of the industry through R&D activities. In this case technology has been transferred through this channel. Moreover, some foreign investors, who came to Thailand because of the investment promotion schemes provided by the Thai government, are the major distributors in overseas markets. They may be directly involved in the development of products in terms of quality, features, diversification, and the development of production process (by sending their own supervisors or training firms' personnel) as mentioned in Chapter 3.

4.3 The Raw Materials Policy

The quality of products is largely dependent on the quality of raw materials (physical and chemical quality). At the same time, whenever the raw materials have been transformed into semi-finished or finished products the producers can learn how to

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[2] According to the Investment Promotion Act 1977, as amended by the Investment Promotion Act (No.2) (1991), various kinds of food manufacturing firms located in Zone 3 have been promoted. These also include food canning (ISIC - 31112, 31131, 31141), canning and preserving of fruits and vegetables (ISIC - 31139), and canning and preserving of seafood (ISIC - 31149) (BOI, 1997, p.26).

develop the products and/or production processes by their own efforts, or cooperate with customers or other agencies. Consequently, the technological capability of the firms can be upgraded though learning mechanism (e.g. learning by operating, learning by changing, system performance feedback) (Bell, 1984). The firms can accumulate their experience and human skills in undertaking various activities. Therefore, the role of government through the development and/or the importation of raw materials can also indirectly affect the improvement of firms' technological capability.

The government of Thailand has directly intervened in raw materials development through the Ministry of Agriculture and Cooperatives (such as the Department of Fisheries (DF), the Department of Agricultural Extension (DAE), and the Department of Agriculture (DA)). For aquatic animals, the remit of the DF covers the search for, and the promotion and the development of, raw materials so as to sufficiently supply the industrial demand. The department also cooperates with the Customs Department, the Ministry of Finance, to help the producers to obtain imported raw materials as quickly as possible (this finally affects the quality of products), and with neighbouring countries which have abundant raw materials. With regard to the development of raw materials, the acceleration of R&D concerning the preservation of the quality of aquatic animals after catching, as well as the provision of training programmes to manufacturers and the provision of related infrastructure (such as ports, fish landing stations, and primary processing places or peeling stations) to the industry, has also been emphasised by the department (TDRI, 1994; Study Survey, 1997).

With reference to the development of raw materials used for processed fruits and vegetables, the outstanding effort which has been made by the government concerning the systematic development of the raw materials used in the processing pineapple industry can also be seen in the approval of The Pineapple Development Plan (1994-1997). Such an effort aims to increase the productivity of pineapple farming, to bring about the balance between pineapple production and the production of canned pineapple and pineapple concentrated juice, and to create the linkage between farmers and canned pineapple firms. This results in the improvement of the quality of raw materials to meet the market demand. Regarding the standard of the processed products, the Thai Industrial Standard Institute (TISI) also set the standard of canned

pineapple products to suit various market demands to help the producers to sell their products in different markets (Tamthai, 1993). In addition, if the food processing firms needed to import raw materials they had to ask for permission from the Office of Food and Drug Administration (FDA) under the Ministry of Public Health. This measure is aimed at controlling the quality of the raw materials used in food processing industry (TFFA, 1997; Study Survey, 1997).

4.4 Trade/Export Policy

According to the Notification of the Ministry of Commerce (MOC) No. 43/1987, the producers who want to export frozen shrimps and squid to the USA and EU have to be members of the Thai Frozen Food Association (TFFA) (TFFA, 1997). The MOC also requires that the exporters of canned fruits and vegetables have to be members of the Thai Food Processors' Association (TFPA) (Tamthai, 1993; IFCT, 1989b; Study Survey, 1997). In the exportation of frozen seafoods, there are cooperation and interactions between producers, related government agencies and Thai Frozen Food Association in the exportation process, (TFFA, 1997) (see Appendix 4.5). This effort could bring about the improvement of technological capability of the firms (e.g. the improvement of product and production process) through the interactions between these parties. In addition, the Centre of Export Inspection and Certification for Agricultural Products (CEICAP), the Department of Agriculture, was set up in 1989 in order to inspect exporting products which use fruits and vegetables as components (BOI, 1993). These measures are designed partly to regulate the exportation of processed food products and partly to control the quality of exporting firms (Study Survey, 1997).

4.5 Quality Control and Standardisation

Various government agencies have been involved in the control of food quality in order to prevent the adulteration of food, to assure food safety, and to meet export standards. Their roles can bring about the improvement of quality products and production process of the industry, and thus affect the enhancement of the firm's technological capability because the firm has to acquire and use technology, and to

adapt and develop both physical technology and know-how to meet the regulations and standards. These efforts are necessary for the manufacturers because they have to improve the quality of their products in order to apply for the certificate used for exporting their products.

The Food and Drug Administration (FDA) has a direct responsibility for enforcing the Food Act B. E. 2522 (1979) to control the food quality (i.e. hygiene and safety). The Department of Medical Sciences (DMS), the Ministry of Public Health, and the Department of Science Services (DSS), the Ministry of Science, Technology and Environment are other government agencies which are involved in the testing of the quality and safety standards of all food products to protect consumers. The Thai Industrial Standard Institute (TISI) has a direct responsibility to develop the standard of the industry to meet international standards. The Thai Institute of Scientific and Technological Research (TISTR) also provides a testing, inspection and quality control service to food enterprises. The Department of Fisheries also supervises the quality of factory sanitary of seafood firms (Mikhanorn, 1996; Study Survey, 1997).

For the exportation of processed food products, the exporters have been required to enclose the certificate issued by the government agencies, such as the Department of Fisheries, and the Department of Medical Sciences, with other related documents in order to guarantee approval for the products (Study Survey, 1997).[3] The CEIAP has also played an important role in granting the quality control certificate to the processed food exporters, especially canned fruit and vegetables exporting firms (BOI, 1993,). In addition, the Office of Atomic Energy for Peace provides a certificate for the exportation of seafood products to Italy (TFFA, 1997).

4.6 Research and Development (R&D)

For carrying out many activities such as the test and improvement of product quality, the modification and improvement of product and production process, and the development of new product and production process, the firms have to carry out

[3] Most importing countries accept quality control certificates from government agencies only and not from private ones (BOI, 1993, p.36).

R&D activities. Regarding these efforts, many government and government-supported agencies have conducted R&D activities related to the food industry, especially the analysis of product quality. Several institutions undertake a wide range of activities, but some of them focus on only limited areas. There are also private R&D firms offering such activities. These efforts may also concern production technology (product/process development, quality improvement, etc), packaging technology, waste utilisation, and raw material development. It is also found that some small firms largely depend on government agencies regarding R&D activities, and the analysis of product and technical advice because of a lack of both personnel and facilities. Additionally, some government agencies (e.g TISI, FDA, DF, DMS) have cooperated with other related agencies to undertake R&D activities concerning the solution of food industry problems (Study Survey, 1997).

The role of the government in the promotion of the R&D activities of an industry can also be seen in terms of supply side by the offering of a fund for undertaking R&D from the Office of Technology Transfer and Promotion, the Ministry of Science, Technology and Environment. This includes the incentive provided by the BOI as mentioned earlier. The role of these two agencies directly affects the enhancement of capability of the firms in carrying out their R&D activities.

4.7 Human Resource Development

Human resource development activities carried out by various agencies are also the supportive role for enhancing technological capability of the firm. This is because the absorption of new technology, the modification and improvement of technology, and innovation require good understanding on the part of firms' personnel at every level. In the food industry, personnel development may be in the form of training, workshops, factory visits, and seminars. This needs both in-house and outside training of employees at every level.

Several agencies have offered various programmes concerning production technology and/or management technology. The related departments of several universities have direct responsibilities in terms of the creation of educated and skilled labour, especially in production technology, which will be discussed later. Several

organisations (government agencies - the FDA, DMS, TISI, DSS, TISTR, DF; government-supported agencies - NFI, NCGEB; and associations (TFPA, TFFA)) have offered various programmes concerning such efforts such as GMP, TQM, HACCP, ISO 9000, ISO 14000, etc. Some agencies can provide seminars and/or training programmes themselves, or by inviting experts from other agencies to join the programmes. Some of them work as intermediary agencies to cooperate with other agencies as well as experts from client countries to give advice to local agencies' staff and producers, as mentioned earlier. The content of seminars conducted by experts from client countries are normally related to inspection methods, product standards, and quality control activities. Additionally, the Thailand Productivity Institute (TPI) offers various programmes concerning the improvement of the utilisation of all the resources used in the industry (e.g. PDCA, QC, TQC, 5S, QCC, suggestion scheme, Kaizen, TPM, and JIT). From our survey, we found that some food firms have participated in these programmes (Study Survey, 1997).

4.8 Information Service and Technical Advice

For achieving success in their businesses, the food firms also need to acquire various kinds of information on raw materials, technology sources, food safety and quality requirements of importing countries, international standards of food products, market and marketing. Consequently, the producers need to access up-to-date information in order to produce the products according to customers' demand, and to compete with other competitors.

Various government agencies (e.g. FDA, DMS, DF, TISI), and the Department of Industrial Promotion (DIP), have provided such information which is directly and/or indirectly related to the development of the food industry (including the building of the technological capability of the industry). As with information service, a technical service regarding various activities such as production technology, management technology and waste management has been offered by several government agencies (e.g. FDA, DMS, DF, DSS, TISI, TISTR, DIP).

4.9 The Establishment of Supporting Agencies

In order to promote the development of food industry, Thai government also established independent supporting agencies which are directly related to the food industry. Since the agencies relating to the food industry are dispersed and sometimes are not well coordinated, it is difficult for the industry to function properly. In this regard, the National Food Institute (NFI) was set up in 1996, by the approval of government, as an independent agency to work as the centre for: coordination between public and private sectors regarding trade regulations, food exports, production, and the standard system of product quality; academic development, research and product development in order to solve the problem of the nation's food production and trade; and food information provided to producers/consumers. It has three main responsibilities: technical service, information service, and the testing and analysis of food product. The establishment of NFI can lead to effective and efficient cooperation between the agencies which are directly related to the food industry.

In addition, the National Centre for Genetic Engineering and Biotechnology (NCGEB) was established in order to promote the development of science and technology in the country by supporting research and development, and engineering (RD&E) to both public and private sectors, and to establish in-house research to conduct RD&E in various fields, e.g. food biotechnology laboratory, and fermentation technology (Study Survey, 1997).

4.10 Financial Services

For carrying out many activities, the firms also need financial resources. One of the outstanding roles of the Thai government in promoting industrial development is the establishment of the Industrial Finance Corporation of Thailand (IFCT) in 1959. This agency has largely contributed to the establishment of several industries, especially in the early period of industrial development (IFCT, 1991). At present, IFCT emphasises its role in providing long-term loans to small- and medium-scale industries. Moreover, this agency provides a consultancy service and other financial sources and information services (industrial activities, new production technology), and also undertakes

project feasibility for producers. From our survey, we found that many food processing firms benefited from this agency.[4]

For facilitating exportation and importation, the government also established the Export-Import Bank of Thailand (EXIM Bank) in 1993. The principal policy of this agency concerns the provision of financial services in order to enhance the competitiveness of Thai business in the world market. Its principal objectives are to operate business in promotion and support of export, import, and investment for the country's development by granting credit, issuing guarantees, and undertaking insurance against risks. The main activity of this agency is to provide credit to exporters, and to those who want to import Thai products in foreign countries but lack financial capital, and to those who want to import goods and services to be used in production of goods for export. The Bank also provides credit for the expansion of production capacity of export-oriented industrial firms (http://www.exim.go.th, 1999). As a result, the food industry can benefit from this agency because the majority of food processing firms export their products to foreign markets. Many of them can also improve their products and production process from the know-how derived from their overseas customers.

4.11 Marketing and Export

Marketing and export promotion has a direct effect on the exportation of processed food products in foreign markets. They also have an indirect role in the development of the industry as a whole, especially the product/production process.

As mentioned in Chapter 3, the Department of Export Promotion (DEP) has played a crucial role in the promotion of Thailand's food processing exports. The DEP has a direct responsibility for the promotion of the exportation of Thai products, by cooperating with related agencies (such as the Food Processing Industry Club of The Federation of Thai Industries, TFPA, and TFFA). Thirteen Thai Trade Centres and more than twenty Commercial Counsellors' Offices were established in foreign

[4] Other government-supported financial organisations for industrial development include the Small Industry Finance Corporation and Credit Guarantee for Small-scale Industry Corporation (Study

countries in order to provide the most up-to-date information (e.g. rules, regulations) on the demand of importing countries to local producers (Department of Export Promotion, 1996). The DEP has also invited food experts and technicians from importing countries to offer advice to producers, and has taken local producers to visit and observe production and testing processes in foreign countries. This has helped producers not only to produce products according to the changing specifications and standards in overseas markets, but also to ensure that the Thai processed food products meet the quality standards of importing countries. Consequently, the involvement of government in market promotion has resulted in the expansion of the processed food products, especially in overseas markets, and has helped the technology development of the producers through the role of customers and/or the firms' efforts themselves.

4.12 The Role of Universities

A number of educational institutions including universities have also contributed to the development of the food industry. Apart from their major roles in human resource development (e.g. the creation of skilled labour, training programmes), the contribution of these institutions includes the process of technology transfer, the diffusion of technology, and the enhancement of technological capability. These institutions have cooperated with many firms by sending their students to practise in the firms, as one part of their study requirements. Moreover, it was found that the Faculties of the Agro-industry of the main universities located in regional areas have designed the areas of research to be related to the concentration of the food processing firms in the regions. For example, the Prince of Songkhla University, located in the southern part of the country, focuses on the seafoods processing industry, whilst the Chiangmai University, located in the northern part, emphasises the fruit and vegetable processing industry (see Appendix 3.1) (Study Survey, 1997). Apart from the activities in the food industry in which the universities are involved, some universities established agencies directly related to the development of the industry (e.g. the Institute of Food Research and Product Development (IFRPD), Kasetsart University; the Nutrition Research Institute (NRI), Mahidol University; the

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Survey, 1997).

Agro-Industry Development Centre for Export (ADCET), Prince of Songkhla University).

Some small, medium and large firms in our study have cooperated with universities to undertake innovative activities (in terms of institutional and/or personnel contacts), human resource development and related activities, and have benefited from the information obtained from the universities. Some small firms reveal that some ideas and information used in their production have been obtained from the universities, normally in terms of informal contact. Thus, the benefits derived from the contribution of universities may depend on the policy and strategy of the firms and the relation between the firms and these institutions. However, it may be more convenient for a small firm, as compared with a large firm, to benefit from informal cooperation (e.g. personal contact) with the universities. However, according to the firms' points of view (found from our field survey), although universities possess a large amount of resources, personnel and facilities, they are not considered to be a highly influential factor contributing to the building of various elements of firms' technological capability (see Table 7.5 in Chapter 7).

4.13 The Role of Trade/Industry Associations

We investigate two main associations, namely the Thai Food Processors' Association (TFPA) and the Thai Frozen Food Association (TFFA), to view their roles in the development of the food industry in Thailand. These two associations work as bridge organisations, especially in coordinating link between the private sector (food manufacturers) and the public sector (related government agencies). Generally, they undertake four main activities: exchange of ideas between members, the solution of any problems faced by its members; cooperation with related government agencies so as to tackle the problems (such as production, marketing raw materials); arranging of seminars and workshops concerning the progress of techniques of production, the improvement of product quality, and preparation for the new inspection procedure (by inviting experts from both public and private sectors, and from major client countries to offer knowledge to the producers); and dissemination of up-to-date related information (market, regulations and standards set by importing countries) to its

members. The crucial role of TFPA can also be seen in the pace of the development of the Thai food industry presented in Chapter 3. However, the TFFA seems to provide a wider range of activities than TFPA, including market promotion by cooperating with government agencies (i.e. the DEP) (e.g. to attend trade fairs, arrange outgoing missions and incoming missions), and supermarkets; the survey of factory sanitary standards in order to classify the quality of food factories based on the GMP system; and the development of R&D firm's personnel (Buranapatimakorn, 1994; Study Survey, 1997).

4.14 Institutional Problems in the Development of the Food Industry in Thailand

Although many institutions, especially in the public sector, seem to have largely contributed to the development and growth of the Thai food industry, some institutional problems should be pointed out.

Firstly, there is the problem of the bureaucratic system. Regarding this problem, much evidence has been found both in our study survey (from the firms' point of view) and related empirical studies (e.g. IFCT, 1989a, 1989b; BOI, 1993; TDRI, 1996; Krisithisirin, 1995; TFFA, 1997). These include red tape, inefficiency, customs administration, and dispersed and uncoordinated agencies which are involved in the regulations concerning the industry. This causes many problems in the carrying out of business of the producers because of the resulting inconvenience, time consumption and an increase in transaction costs.

Secondly, the regulations and the standards of products and production processes are not clearly defined. Moreover, some regulations are too complicated and frequently changed. Also, the standards of the related government officials are, sometimes, found to vary from person to person. As a result, it is difficult for the producers to plan and carry out their businesses to conform with them.

Thirdly, sometimes, the regulations are very strict. This causes some problems to the business, especially in terms of marketing strategy because the producers cannot send their products to the customers according to the targets, or they can lose their

marketing advantages (e.g. the delay in the launching of new products in the markets, and the delivery of products to customers in time). In this regard, some producers recommend that a few regulations and measures should be relaxed for the firms which have a good record.

Fourthly, although some government services (e.g. technical advice, information service, and financial service) have been implemented, they have not been accessed by many firms. According to the survey, it was found that the existence of some services has not been communicated to the majority of firms throughout the country, especially small and medium sized ones in regional areas. Furthermore, some information provided by the agencies is not up-to-date or systematic. Therefore, they cannot access this service, or several other services. In addition, although many academic institutions appear to play a constructive role in the development of the industry, the majority of the resources may be used for instructional purpose rather than for the development of the technological capability of the industry. Many of universities also lack both personnel and facilities to provide the services for the private sector. The majority of the R&D activities carried out by the academics are not geared to industrial demands. From the survey, it was found that only some universities established special institutions to serve the industrial sector. The study conducted by the IFRPD also found that the universities which play a role in S&T development in the food industry have limited potential in the food product analysis in terms of administration, personnel and equipment (Maneepun, 1997).

Generally, the problems mentioned above are found in all sub-sectors. However, the problems of customs administration and the delay in the related paper work are largely emphasised by the seafood processing firms. This may be because many of them have to import raw materials from overseas sources and the regulations set for the processed seafood products are more complicated and stricter than those used for the processed fruits and vegetables.

4.15 Conclusion

The investigation in this chapter reveals that both government and other agencies have largely contributed to the development of the Thai food industry. Government

industrial development strategy and investment promotion, by granting various kinds of privileges (e.g. tax exemption, tax reduction, and the importation of foreign experts and technology) brings about the expansion of and technology development in the food industry. The government also intervenes in a number of ways including the development and importation of raw materials; providing financial services (e.g. for setting up the factory, carrying out R&D, and granting credits for firms' exporting activities); and marketing promotion/expansion.

Furthermore, many government and government-supported agencies have been involved in activities such as the analysis of product and product quality, R&D, quality control and standardisation, information service, technical service, and human resource development. As a consequence, firms can benefit from these efforts not only in terms of the improvement of product quality, but also in other aspects such as an increase in productivity and efficiency, the modification and development of products and production process, and an increase in personnel skills in carrying out related technological development activities.

Also, related university departments have played important roles in the creation of skilled labour, the diffusion of technology, and many activities like those provided by government agencies. At the same time, related associations are among the crucial institutions which have contributed to the success of the industry by working as a bridge agency to coordinate the food producers and government agencies in many activities, e.g. marketing promotion, the establishing of suitable regulations, and the diffusion of technology.

However, many institutional problems are also found from the exploration. Thus, in order to achieve further success, the government and related institutions have to overcome some institutional problems and their functions have to evolve because the factors concerning the development and growth of the industry have been changing over time.

In addition, even though various types of cooperation between government and government-supported agencies and the associations have been undertaken, the cooperation between such institutions and the academic institutions in terms of

linkages between these three sectors has not been extensively found in the investigation.

Chapter 5

METHOD OF ANALYSIS AT THE FIRM-LEVEL

5.1 Introduction

In a study like ours, aiming to examine technological capability building in food industry in a developing country such as Thailand, our framework of analysis has involved extensive search of literature as well as data collection from various sources, both primary and secondary. In Chapter 2, we have dealt with the literature survey which illustrates that the creation of technological capability of industrial firms can be influenced by various factors within the firms themselves and from external individuals and agencies, including the role of the state. These factors can play different roles by directly or indirectly affecting the building of the firm's technological capability.

The main objective of this chapter is to explain the method of analysis we have adopted for analysing the vast amount of information we have gathered from field surveys. We have used both quantitative and qualitative approaches for analytical purposes, as illustrated in sections 5.2, 5.3, 5.4 and 5.5.

5.2 Regression Analysis

The use of regression analysis to estimate the scores of technological capability with regard to the firm's characteristics was initiated by Westphal (1989), when carrying out a study for the Thailand Development Research Institute (TDRI).[1] In his study, the technological capability scores were used as dependent variables, whereas the firm's characteristics (size, market orientation, ownership status, and promotion status) were used as independent variables. Dummy variables were also applied to determine the qualitative values of the characteristics. Westphal classified the firm's characteristics as follows: firm's size (small, medium and large); promotion status (promoted, non-promoted); market orientation (export-oriented, domestic-oriented, both); and ownership status (Thai, joint-venture, foreign firm, non-Thai with Thai management, non-Thai with foreign management).

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[1] This is part of the studies in the same series as TDRI (1989a, 1989b), as mentioned in Chapter 2.

Following Westphal (1989), in our study we have collected data from the field survey in order to identify various firm's characteristics (internal and external factors), besides calculating firm-level technological capability. Thus identified, we have carried out two separate quantitative analyses, based on linear regression.

First, the firm-level technological capability as identified under four separate components (acquisitive capability, operative capability, adaptive capability, and innovative capability) is used as the dependent variable. For independent variables, we have taken the firm's characteristics. Moreover, dummy variables are introduced to examine the qualitative variables in the models.

The variables used in the models are as follows:

ACTC = acquisitive technological capability
OPTC = operative technological capability
ADTC = adaptive technological capability
INTC = innovative technological capability
SIZE = size of firm, defined by number of workers
AGE = age of firm, defined by number of years since establishment
OWN = ownership status:

OWN_1 = 1 if a wholly Thai-owned firm
= 0 otherwise

MARK = market orientation:

$MARK_1$ = 1 if an export-oriented firm, i.e. export ≥ 80% of total sales
= 0 otherwise

PROM = promotion status:

$PROM_1$ = 1 if a promoted firm
= 0 otherwise

PROD = main product

$PROD_1$ = 1 if a canned pineapple firm
= 0 otherwise

$PROD_2$ = 1 if a canned seafood firm
= 0 otherwise

$PROD_3$ = 1 if a frozen seafood firm
= 0 otherwise

$PROD_1$ = 0, $PROD_2$ = 0, and $PROD_3$ = 0 refer to other canned fruits and vegetable firm.

The models designed for the investigation of the relationships between the four elements of technological capability and the firm's characteristics are shown below.

$$ACTC = f(SIZE, AGE, OWN, MARK, PROM, PROD) \quad (5.1)$$

$$OPTC = f(SIZE, AGE, OWN, MARK, PROM, PROD) \quad (5.2)$$

$$ADTC = f(SIZE, AGE, OWN, MARK, PROM, PROD) \quad (5.3)$$

$$INTC = f(SIZE, AGE, OWN, MARK, PROM, PROD) \quad (5.4)$$

Secondly, as before we have used the firm's characteristics as independent variables, but for the dependent variable we have used the degree of firm's technological capability to develop new products.

The model designed for the investigation of the relationship between the degree of firm's technological capability to develop new products and the firm's characteristics is as follows:

$$TCdnp = f(SIZE, AGE, OWN, MARK, PROM, PROD) \quad (5.5)$$

where

TCdnp = the degree of firm's technological capability to develop new products

Regarding the independent variables, the firm's characteristics (i.e. size, age, ownership status, market orientation, promotion status, and main-product group) are included in the models owing to some issues discussed below.

First, the size of firm (SIZE) (e.g. small, medium, and large) may affect the ability of, or the potential for, the creation of technological capability of the organisation.[2] This study uses the number of workers (during the peak period) as a criterion for the following reasons:

(1) the difficulties inherent in obtaining the relevant statistical data (e.g. annual sales) and the capacity production from the firms (although such data can

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[2] In order to identify the size of firm, different methods have been used. Some studies have used the number of workers (Tiralap, 1990; OECD, 1967; Tether, 1998; Freeman and Soete,1997; and Soete 1979), some have used the capacity of production (annual raw material used in production) (TDRI, 1994), some have used the values of fixed assets (excluding land) of the firm (TDRI, 1996), some have used annual sales of the company (Cohen *et al.*, 1987; Rothwell and Dodgson, 1994), and some others have used the value of total production (Kumar and Saqib, 1996). Westphal (1989) used number of workers, registered plus paid-up capital, and sales revenue.

be obtained from secondary sources such as the Stock Exchange of Thailand, and the Ministry of Commerce, the obtained data do not cover all sample firms and many of them are not up-to-date).

(2) the firms in the study comprise various main product groups. Some firms also produce more than one main product. For example, some firms produce both canned pineapple and other canned fruits and vegetables, while some produce canned seafoods and canned fruits and vegetables. Hence, it is difficult to determine the size of firm by considering the raw materials used in the production.

Secondly, the age of firm (AGE) is used to explore whether an old firm's technological capability is different from a young firm's. In other words, if it is believed that most firms attempt to undertake learning-by-doing in the enhancement of technological capability, the older firm may have more advantages than the younger one in this regard.

Thirdly, the market-oriented strategy (MARK) is used to examine whether the firms with different market orientation have different levels of technological capability. The firms in this study are classified into two groups: export-oriented and non-export-oriented. The export-oriented firms refer to those which sells their main products in foreign markets, exporting at least 80% of total sales each year. This criterion has been used by Westphal (1989) and BOI (1997).[3]

Fourthly, the ownership structure (OWN) is used to determine whether foreign investors play an important role in the enhancement of the industry's technological capacity. The firms are classified into two main categories: wholly Thai-owned firms, and non wholly Thai-owned firms (or foreign or joint-venture firms).[4]

Fifthly, the promotion status (PROM) aims to measure the role of government through industrial promotion schemes such as tax exemption from import duties on machinery and equipment, corporate tax exemption, tax reduction on R&D

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[3] In Tiralap (1990) the export-oriented firm was identified as the firm in which more than 80% of its products were exported.

[4] In this study there is only one wholly- foreign-owned firm. Most of the non-wholly-Thai-owned firms are joint-ventures.

expenditures, and the importation of foreign experts, and whether this affects the creation of technological capability.

Finally, since the firms included in the study comprise different main-product groups (PROD), namely, canned pineapple, other canned fruits and vegetables, canned seafoods, and frozen seafoods, these differences may affect the level of technological capability as do other firm level characteristics.

In the use of the models illustrated above, however, some variables have to be changed in the 'log' form in order to lessen the problem of normality, functional form and heteroscedasticity, as shown in Tables 7.1, 7.2, 7.3, 7.4 (Chapter 7), Table 8.2 (Chapter 8), and Appendices 7.1, 7.2, 7.3, 7.4, and 8.1.

The regression analysis in this study uses a *Microfit Programme* (Pesaran and Pesaran, 1997). In examining the level of multicollinearity, the study uses a *SPSS Programme* (SPSS Inc, 1996a, 1996b; Wanishbancha, 1997).

The following sub-sections explain further the approaches used.

5.2.1 Firm-Level Technological Capability

The four main elements of firm-level technological capability are selected according to the discussion presented in Chapter 2. Thus, the major types of technological capability comprise: acquisitive capability, operative capability, adaptive capability, and innovative capability. These classifications also follow those categorised in TDRI (1989a, 1989b), and Tirapanish (1991). The sub-elements of each component of technological capability are selected from those illustrated in TDRI (1989b) and Sutdhiyum (1995) (see Tables 5.2A, 5.2B, 5.2C, and 5.2D).

The Assessment of the Level of the Four Elements of Firm's Technological Capability[5]

Low, Medium and High scores are used for measuring the various levels of each technological capability, as follows: 1 - refers to a low level of capability (or complete dependence on external resources, or few resources and facilities, or no use of computerised system); 2 - refers to a medium level (or partial dependence on external resources, or some resources and facilities but not enough, or partial use of computerised system); 3 - refers to a high level of technological capability (or complete dependence on own resources, or adequate resources and facilities, or extensive use of computerised system) (see Table 5.1). Other criteria include the sources of information for searching, the rate of defect of production, and the establishment of maintenance programme (see Tables 5.2A and 5.2B). These criteria are modified from Sutdhiyum (1995). (Sutdhiyum categorised the level of technological capability of each element into three levels: Poor, Average, and Good. The overall level of each element of technological capability is derived from the average level of all sub-elements of each type of technological capability). The scores designed for measuring these groups of criteria in our study are also divided into three levels (i.e. low, medium, and high).

[5] The score of each component of technological capability is measured in terms of relative values instead of the absolute ones because of the limitation of the study caused by the fact that it is difficult to obtain comprehensive data which can be quantified from the sample firms. Regarding this difficulty, many previous authors have attempted to assess the firm's level of technological capability in terms of relative values: by comparing the firm's technological capability with the state-of-the-art technology (Alwis, 1991; Panda and Ramanathan, 1996), with the technologies used in leading firms in certain industries in industrialised countries (TDRI, 1989b; Cruz, 1992), and by setting the criteria to measure the level of each component of technological capability (Sutdhiyum, 1995).

Table 5.1 Criteria and Score Used in Assessing Technological Capability of Each Sub-element

Level	Low	Medium	High
Score	1	2	3
Criteria	-complete dependence on external resources, or -few resources and facilities, or -no use of computerised system	-partial dependence on external resources, or -some resources and facilities but not enough, or - partial use of computerised system	-complete dependence on own resources, or -adequate resources and facilities, or -extensive use of computerised system

In the event that two criteria are used to evaluate the level of one sub-element of each component of technological capability (see Tables 5.2A and 5.2B), the total scores of each level of the capability is also rated the same score as designed above (i.e. 1 - low, 2 - medium, and 3 - high). The level of technological capability of each component is an average score of its sub-components. Regarding the use of average scores, Sharif (1994b) mentioned the following observation: "Given limitations in theory and data, relative assessments are usually more valuable to decision makers than are attempts at absolute assessment. ... Once the individual positions are assigned to the attributes (with predefined scores), a simple weighted average can give the overall dynamics of the system structure" (p.102).

However, if any activity has not been undertaken the score is equal to 0. Sub-elements of technological capability and the criteria used for measuring the level of the four elements of technological capability are shown in Tables 5.2A, 5.2B, 5.2C, and 5.2D.

The analysis of this part attempts to investigate the relationships between the firm's characteristics (i.e. size, age, ownership status, promotion status, market orientation, and main-product group) and its levels of the four elements technological capability.

5.2.2 The Degree of Technological Capability in Developing New Products

Apart from the technological capability required for undertaking four major activities (acquisition, operation, adaptation, and innovation) illustrated in section 5.2.1, the

firms in the industry may also exhibit different levels of changes and development of existing and new products (and production process). Some firms may produce products without any change and development of technology. Some firms have carried out many activities concerning the changes, improvement and development of new products. This requires different degrees of technological capability.

For evaluating the level of technological capability in developing new products, the criterion mainly places emphasis on the degree of technological capability in adapting and improving products and production processes, and developing new products. For this measurement, a firm which just performs only the production without modifying or creating new product and/or production process is scored 1, while a firm that produces products which are unique and completely different from the existing products in the market is scored 6 as shown in Table 5.3.[6] The score is obtained from interviews with the owners/managers or relevant persons of the firms. This measurement is modified from Kim (1976). Kim defined indigenous technological capability as "the degree of indigenous capability in developing new products. A firm which performs a simple assembly operation of 100% foreign parts for foreign-designed products is scored 1, while a firm that produces products which are unique and entirely different from the existing products of the developed countries is scored 6" (Kim, 1976, p.69). However, in our study, the details of the criterion (i.e. various elements of the level of technological capability) have been modified in order to be suitable to the characteristics and conditions of the food industry and the firms investigated in the study.

The analysis of this part attempts to investigate the relationship between the firm's characteristics (i.e. size, age, ownership status, promotion status, market orientation, and main-product group) and its degree technological capability in developing new products.

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[6] The measurement of indigenous technological capability is also designed according to the process of effective technology transfer in developing countries. As discussed in Chapter 2, the effectiveness of technology transfer process involves the ability to acquire, use, adapt, and develop or innovate the new technology which finally results in the changes or development of product or production process of an industry in recipient countries. Moreover, it implies the prospect of the competitiveness of the industry in the market in the long run.

5.3 Firm's Perception Approach

This section aims to explore the factors contributing to the creation of technological capability of all firms in the study from the firms' perspectives. The analysis looks at both *selected internal factors* and *selected external factors.*[7]

Selected internal factors refers to four internal factors (i.e. firm's policy and strategy, management and administration, the accumulation of the firm's own experience, human resource development or staff training programmes).

Selected external factors refer to fourteen external factors (i.e. government regulations, government tax and other incentives, government technical advice, government technological information services, domestic customers, overseas customers, machinery and equipment suppliers, fund suppliers, domestic market competitors, overseas market competitors, consulting agencies, trade/industry associations, universities, and related documents).

Following Kim (1976), to measure the level of these influential factors, the scores are designed as follows:

1 - no influence at all;

2 - very little influence;

3 - some influence;

4 - substantial influence;

5 - very strong influence; and

9 - not applicable.[8]

(see Appendix 6.1).

The analysis of this part is based on the comparison of mean values of the influence of selected internal and external factors in the enhancement of the four selected elements of technological capability: acquisitive, operative, adaptive and innovative.

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[7] These factors are taken from Kim (1976), Tirapanish (1991), TDRI (1989a), Sugihato (1993), and various arguments discussed in Chapter 2.

[8] Kim (1976) used these criteria to examine the level of influence of external variables which influence the firm in undertaking the activities related to the organisation's technological capability building.

For estimating the mean values of the influence of those factors, this study uses the *SPSS Programme* (SPSS Inc, 1996a, 1996b; Wanishbancha, 1997).

5.4 The Pair-comparison Approach

The purpose of the analysis of this part is mainly to examine the role of the firm's internal factors whether they have impacts on the creation of technological capability of the firm in developing new products. The analysis applies a 'pair-comparison approach'. This approach is adapted from Tiralap (1990). He used this method of analysis by following a study carried out by the Science Policy Research Unit, University of Sussex, concerning the factors contributing to the success and failure of the firm's innovation on the SAPPHO project. The technique employed was a pair-comparison approach where a successful innovation was compared with an unsuccessful innovation. Tiralap used this approach to investigate the role entrepreneurial functions and manpower services in the process of firms' technical change. In his analysis, two pairs of firms (a pair of joint-venture firms in consumer electronics, and a pair of Thai firms in industrial electronics; and each pair of the similar firms comprises one 'progressing' and one 'stagnant' firm) were selected from the 36 sample firms to examine the case studies in more detail.

In our investigation, eight pairs of firms (1 pair of canned pineapple firms, 2 pairs of other canned fruit and vegetable firms, 3 pairs of canned seafood firms, and 2 pairs of frozen seafood firms) will be used in the analysis.[9] Each pair of firms comprises one low- and one high-degree of technological capability in developing new products. The

[9] Although the results of the comparison may not reveal the differences of internal factors of all firms with different levels of technological capability in developing new products, the comparison may reveal some significant evidence that can explain why and how the firm's internal factors affect the capability of the firms in developing their new products, apart from the role of the firm's characteristics examined in section 5.2.2.

firms under study are mainly controlled for some similar characteristics (main-product group, size, and market orientation), so as to eliminate these factors affecting the technology development effort or the enhancement of technological capability of the firms. The factors included in the analysis are shown in Table 5.4.

Table 5.2A Criteria for Measuring the Level of Acquisitive Technological Capability

Element	Low	Medium	High
Capability to search for sources of required technologies	-All searching activities are undertaken by external consultants. -Sources of information are formal.	-Searching activities are undertaken with some help from external consultants. -Sources of information are both formal and informal, but main sources of information are still formal.	-All searching activities are undertaken by in-house personnel. -Good mix of formal and informal sources of information.
Capability to prepare specifications to upgrade existing technological resources	-All specifications are planned by external consultants.	-Specifications are planned with some help from external consultants.	-All specifications are planned by in-house expertise.
Capability to assess technologies offered	-All assessments have been done by external consultants.	-Carries out assessment and approval with some help from external consultants.	-All assessments have been carried out by in-house expertise.
Capability to negotiate the terms of acquisition	-Negotiation has been done by external consultants.	-Negotiation has been undertaken with some help from external consultants.	-Negotiation has been carried out by in-house expertise.
Capability to decide upon the mode of transfer of technology, and technology strategy	-The decision making has been carried out by external expertise.	-The decision making has been carried out with some help from external expertise.	-The decision making has been carried out by in-house expertise.

Table 5.2B Criteria for Measuring the Level of Operative Technological Capability

Element	Low	Medium	High
Capability to install and start up machinery and facilities	-All work can be done by depending on external expertise.	-The work can be done with some help from external expertise.	-All work can be done by in-house personnel.
Capability to operate and control plant and equipment	-Unable to attain 50% of capacity utilisation.	-Able to attain 50% -75% of capacity utilisation.	-Able to attain more than 75% of capacity utilisation.
Capability to plan and control production activities	-Unable to attain 75% of planned production. -More than double the industry standard rate of defect.	-Able to attain 75%-90% of planned production. -More than the industry standard but less than double the standard rate of defect.	-Able to attain greater than 90% of planned production. -The rate of defect is equal to or less than the industry standard.
Capability to maintain the plant and equipment	-Ad-hoc maintenance programme. -Much dependence on external sources (such as supplier) for maintenance.	-Routine maintenance programme -Partial dependence on external sources for maintenance.	-Routine and preventive maintenance programme. -Much dependence on own personnel for maintenance.
Capability to undertake quality control for production process	-All work needs to be assisted by external expertise.	-The work is undertaken with some help from external expertise.	-All work is undertaken by in-house expertise.
Capability to apply the computerised system to quality control activity	-No use of computerised system for quality control activity.	-Partial use of computerised system for quality control activity.	-Extensive use of computerised system for quality control activity.
Capability to apply computerised system for planning and coordination of production operation	-No use of computerised system for production planning and coordination of production operation.	-Partial use of computerised system for production planning and coordination of production operation.	-Extensive use of computerised system for production planning and coordination of production operation.

Table 5.2C Criteria for Measuring the Level of Adaptive Technological Capability

Element	Low	Medium	High
Capability to duplicate *acquired machinery and equipment*	-If necessary, the work is undertaken by *external expertise.*	-The work is partially undertaken by external expertise.	-All work is undertaken by in-house expertise.
Capability to adapt available machinery and equipment to raw materials and other factors	-If necessary, all adaptations are carried out by external expertise.	-Adaptations are undertaken by depending partially on external expertise.	-All adaptations are undertaken by in-house expertise.
Capability to undertake minor improvements in acquired technologies	-If necessary, they are undertaken by external expertise.	-The work is undertaken by depending partially on external expertise.	-All activities are undertaken by in-house expertise.
Capability to undertake minor process modification	-If necessary, the work has to depend on external expertise.	-The work has to depend partially on external expertise.	-All work is carried out by in-house expertise.
Capability to undertake minor product modification	-If necessary, the work has to depend on external expertise.	-The work has to depend partially on external expertise.	-All work is carried out by in-house expertise.

Table 5.2D Criteria for Measuring the Level of Innovative Technological Capability

Element	Low	Medium	High
Capability to undertake major improvements in acquired technologies	-If necessary, they are undertaken by external expertise.	-The work is undertaken by depending partially on external expertise.	-All activities are undertaken by in-house expertise.
Capability to undertake radical process modification	-If necessary, they are undertaken by external expertise.	-The work is undertaken by depending partially on external expertise.	-All activities are undertaken by in-house expertise.
Capability to undertake radical product modification	-If necessary, they are undertaken by external expertise.	-The work is undertaken by depending partially on external expertise.	-All activities are undertaken by in-house expertise.
Capability to undertake R&D work for process/product development (the sufficiency of facilities and personnel to conduct R&D)	-Few R&D facilities and personnel.	-Some R&D facilities and personnel, but not enough.	-Adequate R&D facilities and personnel.
Capability to undertake new product development	-If necessary, they are undertaken by external expertise.	-The work is undertaken by depending partially on external expertise.	-All activities is undertaken by in-house expertise.
Capability to undertake new process development	-If necessary, they are undertaken by external expertise.	-The work is undertaken by depending partially on external expertise.	-All activities are undertaken by in-house expertise.
Capability to derive commercial benefits from R&D results	-All commercial R&D results are achieved by external expertise.	-Some commercial R&D results are achieved by external expertise.	-All commercial R&D results are achieved by in-house expertise.

Table 5.3 Criteria used for Measuring Technological Capability in Developing new Products

Degree of Technological Capability	Firm's performance
1	The firm buys all technologies and performs only operation.
2	The firm buys technologies, but it adapts its own products and packaging in order to use available raw materials.
3	The firm produces similar products available in the market, but it develops and modifies its own products in order to meet market needs.
4	The firm produces similar products available in the market, but it also improves production processes and performances through the efforts of its own and/or external R&D and related personnel.
5	The firm produces similar products available in the market, but it also improves production processes and performances through the efforts of its own and/or external R&D and related personnel. Furthermore, the firm has introduced its own new products which are similar to other products in the market.
6	The firm designs and produces its own unique products, which are not the imitation of other products in the market.

Table 5.4 Firm's Internal Factors Included in the Pair-comparison Analysis[10]

Selected Internal Factors of the Firm	
Policy, Strategy and Management -The major characteristics of the firm's successful products -The major sources of the firm's technology -Technological development strategy emphasised by the firm -The elements of technology required by the firm -The major technological thrust of the firm -Key persons who introduce new technologies to the firm. -Key persons who introduce market opportunities to the firm. -The contribution of workers regarding the changes and improvements in production process, products and/or market opportunities of the firm. -The involvement of the firm's top management in technology development activities -The characteristics of the top management values of the firm -The characteristics of the firm's organisational structure -The characteristics of manpower flows in the firm	**Human Resource Development (HRD)** -Manpower development activities -The promotion and reward systems for employees -The financial support for undertaking HRD activities **Research and Development (R&D)** -The establishment of R&D unit -The characteristics of the R&D activities of the firm -The financial support for undertaking R&D activities **Information and Linkage Systems** -The characteristics of information flows in the firm -The internal links between related departments (such as marketing, R&D, and production departments) regarding technology development within the firm -The external links between the firm and related agencies

[10] As mentioned earlier, these factors are taken from Tirapanish (1991), TDRI (1989a), Sugihato (1993), and various arguments discussed in Chapter 2.

Chapter 6

FIRM-LEVEL DATA: SAMPLE SURVEYS

This chapter attempts to illustrate the data collection process from the firms in the study. Data collection was carried out in Thailand, for four months (August-November), in 1997. In order to obtain the data used for analysing the factors involved in technological capability building of the firms in the study, various stages of data collection from the food processing firms in Thailand had been conducted. These efforts are explained in the following sections.

6.1 The Questionnaire Design

The questionnaire was originally designed according to the information needed for analysing the role of both firm's internal and external factors which may influence the technological capability building of the food processing firms in the Thai food industry. The information contained in the questionnaire was drawn from relevant theories, arguments and empirical studies, especially those discussed in Chapter 2.

The information included in the questionnaire used for collecting data from the firms comprises 6 main elements relevant to the methods of analysis, as follows:

(1) the firm's characteristics;
(2) the level of technological capability of the firm in developing new products;
(3) the level of firm's external dependence in undertaking the four major types of technological capability (acquisitive capability, operative capability, adaptive capability, and innovative capability), and other information which can determine the level of such elements of technological capability;
(4) the level of influence of selected internal and external factors with regard to the enhancement of the four components of technological capability from the firms' points of view;
(5) policies, strategies and management, human resource development, research and development, information and linkage systems;

(6) the role of foreign partner(s);

(7) the role of government and related institutions (from the firms' points of view).

(See Appendix 6.1)

Before the author went to collect the data in Thailand, the questionnaire had been modified in order to suit the methods of the analysis, both quantitative and qualitative. Also, the questionnaire had to be translated into the Thai language. Then, the author consulted with experts who have experience in field surveys from industrial firms, and with some managers in food processing firms. Next, the questionnaire was applied to collect data from relevant sources. For collecting data from the firms, after using the questionnaire at a few of the sample firms, they had also been adjusted so as to ensure a reliable and valid survey.

6.2 The Sampling Method

Since this study attempts to explore the experience of four categories of the food industry (i.e. canned seafoods, canned pineapple, other canned fruits and vegetables, and frozen seafoods) in the enhancement of technological capability, for the sampling method, it was obviously necessary to include manufacturing firms from those industries. Moreover, in order to carrying out an effective analysis, in the sampling method we included various aspects of the firm's characteristics, such as firm size, age, ownership status, market orientation, and promotion status. For this reason, the multi-stage sampling method had been employed.

The process of sampling method is divided into four stages, as follows:

Firstly, the food firms operating in the industry were divided into four groups, according to their main products, namely, canned seafood, canned pineapple, other canned fruits and vegetables, and frozen seafoods. The lists of the firms were gathered from the associations (TFPA and TFFA), and the Ministry of Industry. *Secondly*, within each product group, firms were divided further according to their ownership status, promotion status, market orientation, and age. *Thirdly*, within each sub-group, firms were classified according to their size. *In the final stage*, it was

attempted to randomly select the firms in each sub-group. In practice, however, there were some difficulties in gaining access to the selected firms. Therefore, the study could not collect the data from the randomly selected firms. In order to solve this problem, the study attempted to collect the data from the firms which exhibit various characteristics as much as possible in each sub-group so as to obtain the information used in the analysis. Attempts were made in gaining access to and collecting data from the firms as follows:

(1) Cooperation with the provincial industrial offices' staff in the provinces in which the targeted firms are located. This effort was achieved with the help of some officers in the areas by issuing an official letter to ask for cooperation from the firms. In this case, some firms had good cooperation with the author when the data collection took place.

(2) The use of personal contact through third persons (friends, relatives and colleagues).

(3) Direct travel to the firms by the author. The majority of the data collection was achieved through this strategy. This effort was successful through the good cooperation of many firms' personnel.

(4) In some cases, the author was introduced to other firms' senior personnel with the help of the firms' owners/managers who knew the author from third persons.

6.3 Data Collection Process

For collecting the data from the firms, the letters from the University of Strathclyde (in English) and from the Sukhothai Thammathirat Open University (in Thai) were used for informing the firms that the data required will be used only for conducting the thesis and neither the names of the firms nor the respondents will be mentioned in the thesis.

As mentioned above the firms obtained questionnaires by hand or by post. In the event that the questionnaires were given to the firms' personnel directly by the author, the author explained the main elements of the questions contained in the questionnaires to respondents. The respondents were also informed that their names and organisations will not be mentioned in the thesis. Then, the appointment for the

interview was arranged. Next, the author interviewed the respondents at the firms. In the meantime, some questionnaires had been filled in by the respondents already. However, when the data were obtained through questionnaires, a follow-up visit to the firms or telephone discussion with the firms' relevant persons concerning the contents of information shown in the questionnaires obtained were conducted in order to complete the information required (e.g. unclear and missing information). Most firms in the study were visited more than one time.

The respondents comprise various levels of firm's personnel, such as owners, managing directors, plant managers, production managers, senior technical managers, and senior supervisors. In some firms, the data were collected from more than one person. These people have different backgrounds and experience, thus, helping to bring out an in-depth understanding of the relevant issues raised.

In the firm survey, extensive data were collected from 62 firms (comprising 10 canned pineapple firms, 21 other canned fruit and vegetable firms, 18 canned seafood firms, and 13 frozen seafood firms) (see Table 6.1). The sample survey covers different percentages of the firms in the selected sectors. Both canned seafood and canned pineapple sectors show a high percentage of sample, about 53% and 42%, respectively. These two sectors exhibit a high percentage because they have small number of total firms, and their locations are more concentrated in particular areas. The locations of canned seafood firms are more concentrated than that of those of frozen seafoods because the latter use raw materials not only from the sea but also from the shrimp farms (tiger shrimp). The location of other canned fruit and vegetable firms are also scattered. As a result of the limitation of the field survey, the percentage of sample firms of other canned fruit and vegetable firms, and frozen seafood firms are smaller than those of other two sectors (28.0% and 22.0%, respectively).

It should be noted that the total number of frozen seafoods and other canned fruits and vegetables firms shown in Table 6.1 are less than those registered at the Ministry of Industry because of many reasons as follows:

(a) Many firms expand their businesses by setting their factories more than one location, but our study counts that each of them represents only one firm.

(b) For other canned fruit and vegetable firms, many of them are small scale which employ less than 30 workers. Most of them produce fermented products and fruit juices to sell in local market. In our study, these firms are excluded because the study attempts to include only the firms which may have potentials in selling products in foreign markets.

Table 6.1 Number of Firms in the Food industry in Thailand and the Number of Sample Survey Coverage

Main Product	Total Number of Firms*	Number of Sample Firms	Percentage of Sample Firms to Total Firms (%)
Canned Seafoods	34	18	52.9
Canned pineapple	24	10	41.7
Other canned Fruits and Vegetables	75	21	28.0
Frozen Seafoods	59	13	22.0
Total	194	62	31.9

* - 1. Excluding the branches of some firms which are situated at more than one location.
2. Excluding the firms which stopped running their businesses found from the survey
2. Some firms produce more than the one main product shown in the table.
3 For other canned fruit and vegetable firms, those firms are excluded:
-the firms which produce only fermented products are excluded;
-the small firms which employ less than 30 workers.
4.For frozen seafoods firms: the firms which carry out only a cold storage activity, and those which also produce frozen fruits and vegetables are excluded.
5 The total number of all kinds of firms were collected from the firms registered at the Ministry of Industry, in 1997.

Sources:1. The Ministry of Industry
2. Thai Food Processors' Association
3. Thai Frozen Foods Association
4. Study Survey, 1997

The sample firms also exhibit various characteristics as shown in Table 6.2. (The sizes and ages of firms are not shown in the table because they are classified by number of workers and years, respectively). Table 6.2 shows that the majority of sample firms in all sub-sectors are wholly Thai-owned firms, and export oriented firms. However, in the other canned fruits and vegetable sector, there is a high proportion of non-Thai firms because many of the firms located in one of the main areas (where from we

collected data, i.e. in the western region) are joint-venture firms. In terms of promotion status, the majority of the sample firms are promoted firms, except other canned fruits and vegetables. One of main reasons may be because of the fact that machinery and equipment, and raw materials used in many of these firms can be available within the country; they have not to get benefits from the promotion schemes in the importation.

Table 6.2 Classification of Sample Firms by Ownership Status, Market Orientation, and Promotion Status in Each Main-product Group

Characteristic	Main-product Group			
	Canned Pineapple	Other Canned Fruits and Vegetables	Canned Seafoods	Frozen Seafoods
Ownership Status				
Wholly Thai-owned (42)	8	12	13	9
Non-wholly Thai owned (20)	2	9	5	4
Market Orientation				
Export ≥ 80% (49)	9	13	16	11
Export ≤80% (13)	1	8	2	2
Promotion Status*				
Promoted firms (44)	8	9	16	11
Non-promoted firms (18)	2	12	2	2
Total number of firms in each group	10	21	18	13

Note: * The promoted firm is the firm which receives the privileges from the Board of Investment (BOI). The non-promoted firm is the firm which does not receive the privileges from the BOI.

Number shown in the brackets are the total numbers of the firms in each characteristic.

Source: Study Survey, 1997

Chapter 7

ANALYSIS OF THE MAJOR TYPES OF TECHNOLOGICAL CAPABILITY BUILDING

This chapter attempts to examine the factors which may influence various activities concerning the building of technological capability of the firm in four main aspects: acquisitive, operative, adaptive, and innovative. For the analysis, we would like to view in particular various internal and external firm-level factors in the enhancement of the four elements of technological capability.

We have used two methods for our analysis. *First*, the regression analysis has been conducted in order to examine the role of firms' characteristics (i.e. size, age, ownership status, market orientation, promotion status, and main-product group) which contain some of both internal and external factors whether they have impacts on the building of the level of the four elements technological capability. For dependent variables (the four elements of technological capability), the level of each element of technological capability is derived from the average scores of all sub-elements of each capability according the criteria designed in Chapter 5. For independent variables, the values used for identifying each characteristic of the firms have been presented in Chapter 5.

Secondly, we have carried out 'a firms' perception approach' in order to investigate the role of various internal and external factors in the enhancement of each element of technological capability, from the firms' points of view.

7.1 Firm's Characteristics and the Four Elements of Technological Capability

Results of the regression analysis we have carried out examining the four elements of technological capability and related statistical values can be seen in Appendices 7.1, 7.2, 7.3, 7.4, and 7.5.

7.1.1 Firm's Characteristics and Acquisitive Technological Capability

As presented in Table 5.2A (Chapter 5), acquisitive technological capability (ACTC) is divided into five sub-elements. Therefore, a high level of ACTC implies that the firm can undertake acquisitive activities (e.g. searching for technology required, negotiating with suppliers, evaluating the choices of technology, and making decision) by relying to a large extent on its own resources, whereas a low level of capability implies that the firm is characterised by much external dependence the carrying out such activities. The relevant relationships obtained between various firm-level characteristics and the level of ACTC are shown in Table 7.1.

Table 7.1 Firm Level Characteristics and Acquisitive Technological Capability

Dependent Variable	Independent Variables	Coefficient	Standard Error	T- Ratio	Probability	F - Statistics
ACTC						
	Constant	2.5299	0.2422	10.4457	0.000	R^2 = 0.2761
	LnSIZE	0.0569	0.0464	1.2259	0.226	$\overline{R}^2$ = 0.1668
	AGE	- 0.0036	0.0062	- 0.5861	0.560	
	$PROM_1$	- 0.3081	0.0916	- 3.3615	0.001	$F(8, 53)$
	OWN_1	- 0.1902	0.0772	- 2.4651	0.017	2.5265
	$MARK_1$	- 0.1089	0.0881	- 1.2359	0.222	(0.021)
	$PROD_1$	0.0863	0.1207	0.7156	0.477	
	$PROD_2$	- 0.0579	0.1136	- 0.5096	0.612	*DW - Statistic*
	$PROD_3$	0.0015	0.1162	0.0127	0.990	= 2.2145

The result reveals that both promotion status and ownership status have negative relationships (statistically significant at the 1% and 5% levels, respectively) with the level of ACTC. Since the level of ACTC is mainly measured in terms of the level of external dependence, it implies that the promoted firms tend to have a lower level of ACTC than the non-promoted ones, and that the wholly Thai-owned firms tend to have a lower level of ACTC than non-wholly Thai-owned firms (joint venture and/or foreign firms). In other words, the promoted firms and/or wholly Thai-owned firms are dependent on more external resources than the non-promoted firms and/or foreign and joint-venture firms regarding the enhancement of acquisitive technological capability. However, other variables (size, age, market orientation, and main product type) do not have statistically significant impacts at the 10% or lower level on the

level of ACTC. In the meanwhile, the independent variables in this equation can explain the variation of ACTC only by 17%.

7.1.2. Firm's Characteristics and Operative Technological Capability

As illustrated in Table 5.2B (Chapter 5), operative technological capability (OPTC) is divided into seven sub-elements. Thus, the firm which has a high level of OPTC is highly dependent on its own resources; has high capacity utilisation (sufficient raw material supply to use in production), high achievement in planned production and low rate of defects of production, a good maintenance programme, and extensive use of the computerised systems in its business. The relevant relationships obtained between various firm-level characteristics and the level of OPTC are shown in Table 7.2.

Table 7.2 Firm level Characteristics and Operative Technological Capability

Dependent Variable	Independent Variables	Coefficient	Standard Error	T- Ratio	Probability	F - Statistics
OPTC	Constant	1.8307	0.2415	7.5785	0.000	R^2 = 0.2034
	LnSIZE	0.0452	0.0463	0.9763	0.333	$\overline{R}^2$ = 0.0832
	AGE	0.0039	0.0061	0.6360	0.528	
	$PROM_1$	- 0.0486	0.0914	- 0.5315	0.597	F (8, 53)
	OWN_1	- 0.0443	0.0770	- 0.5754	0.567	1.6923
	$MARK_1$	0.0035	0.0879	0.0404	0.968	(0.122)
	$PROD_1$	0.2008	0.1203	1.6687	0.101	
	$PROD_2$	0.0319	0.1133	0.2811	0.780	*DW - Statistic*
	$PROD_3$	0.2167	0.1159	1.8693	0.067	= 2.6507

It is found that, overall, there is no statistically significant relationship (at the 10% level) between the dependent variable (the level of OPTC) and the independent variables (firm's characteristics).[1] This may be due to the fact that the criteria used to

[1] Even though *individually* $PROD_3$ has statistically significant relationship (at the 10% level) with the level of OPTC, *collectively* (the overall model) all the independent variables do not have statistically significant influence on the dependent variable (the level of OPTC). This can be seen through the *F*-test (at the 10% level), the computed *F* value of 1.69 is far less than the critical *F* value ($F_{8,53} = 2.95$).

examine the level of operative capability include three main aspects: (a) the external dependence of installation and starting up, maintenance, and undertaking quality control activity; (b) the ability to control the plant and equipment, and to plan and control production activities; and (c) the ability to apply the computerised system for production planning and coordination, and for the quality control activity. In other words, criteria require not only firm's own resource competence (e.g. personnel skills and experience, financial resources), but also the availability of raw materials. At the same time, the high or low level of OPTC of the firm needs those various aspects combined (i.e. the level of OPTC is derived from the average scores of all sub-elements of OPTC). Our findings thus imply that the level of OPTC across various categories of firms does not have statistically significant differences. This could be due to the fact that although some firms (e.g. large-scale firms, joint-venture firms) have competent personnel and financial resources they do not have adequate raw materials to support production, thus finding it difficult to enhance their operative capability.

7.1.3 Firm's Characteristics and Adaptive Technological Capability

As presented in Table 5.2C (Chapter 5), adaptive technological capability (ADTC) is divided into five sub-elements. Hence, the firm which has a high level of ADTC is the firm which can undertake adaptive activities with a high level of dependence on its own resources. The relevant relationships obtained between various firm-level characteristics and the level of ADTC are shown in Table 7.3.

Table 7.3 Firm Level Characteristics and Adaptive Technological Capability

Dependent Variable	Independent Variables	Coefficient	Standard Error	T- Ratio	Probability	F - Statistics
ADTC	Constant	2.2944	0.4037	5.6837	0.000	R^2 = 0.0897
	LnSIZE	- 0.0277	0.0795	- 0.3477	0.729	$\overline{R}^2$ =- 0.0476
	LnAGE	- 0.0737	0.1109	- 0.6645	0.509	
	$PROM_1$	0.0454	0.1549	0.2929	0.771	F (8, 53)
	OWN_1	- 0.1745	0.1288	- 1.3549	0.181	0.6532
	$MARK_1$	- 0.0657	0.1506	- 0.4367	0.664	(0.730)
	$PROD_1$	0.2991	0.2029	1.4740	0.146	
	$PROD_2$	0.0505	0.1920	0.2629	0.794	*DW* - Statistic
	$PROD_3$	0.0913	0.1953	0.4673	0.642	= 2.3580

It is found that no variable affects the level of ADTC (statistically significant at the 10% or lower level). Most firms are found to depend particularly on external (i.e. external to the firm) agencies or individuals (e.g. customers, machinery suppliers, consultant agencies, universities, and government agencies) in carrying out various kinds of adaptive activities. At the same time, the level of adaptive capability is only measured in terms of external dependence (i.e. outside the firm). Thus, the results from the regression analysis imply that the differences between the level of external dependence in carrying out adaptive activities of the firms across various characteristics are not statistically significant.

7.1.4 Firm's Characteristics and Innovative Technological Capability

As presented in Table 5.2D (Chapter 5), innovative technological capability (INTC) is divided into seven sub-elements. Therefore, the firm which possesses a high level of INTC is the firm which has a high level of personnel skills and sufficient related resources required for carrying out innovative activities. The relevant relationships between various firms' characteristics and the level of innovative technological capability are shown in Table 7.4.

Table 7.4 Firm Level Characteristics and Innovative Technological Capability

Dependent Variable	Independent Variables	Coefficient	Standard Error	T- Ratio	Probability	F - Statistics
INTC						
	Constant	0.3195	0.4752	0.6723	0.504	$R^2 = 0.4228$
	LnSIZE	0.2499	0.0937	2.6677	0.010	$\bar{R}^2 = 0.3357$
	LnAGE	- 0.0877	0.1306	- 0.6719	0.505	
	$PROM_1$	0.5138	0.1823	2.8181	0.007	F (8, 53)
	OWN_1	- 0.2884	0.1517	- 1.9013	0.063	4.8525
	$MARK_1$	- 0.2998	0.1772	- 1.6916	0.097	(0.000)
	$PROD_1$	- 0.1596	0.2388	- 0.6684	0.507	
	$PROD_2$	- 0.3448	0.2260	- 1.5259	0.133	*DW* - Statistic
	$PROD_3$	- 0.2052	0.2299	- 0.8923	0.376	= 2.0936

It is found that firm size and promotion status have positive relationships (statistically significant at the 1% level) with the level of INTC, whereas market orientation and ownership status have negative relationships (statistically significant at the 10% level)

with the level of INTC. This implies that larger firms are found to have a higher level of INTC than the smaller firms, and promoted firms have a higher level of INTC than non-promoted firms, whilst the export-oriented firms and wholly Thai-owned firms tend to have a lower level of INTC than the non-export-oriented firms and non-wholly Thai-owned firms, respectively. However, other factors (age, main-product type) do not show any relationships (statistically significant at the 10% or lower level) with the level of INTC. It is found from the field survey that the difference between the level of INTC of the firms in the study mainly occurs from the difference in the number of innovative activities undertaken by the firms rather than the difference in the level of external dependence.[2] However, the level of explanation of independent variables regarding the variation of the level of INTC is only about 34%.

7.1.5 Firm's Characteristics and the Four Elements of Technological Capability: Discussion

The regression analyses reveal that the role of foreign investors is found to be important factor in developing acquisitive capability (significant at the 5% level) and innovative capability (significant at the 10% level), while the promoted firms show negative impact on acquisitive capability (significant at the 1% level), but positive effect on innovative capability (significant at the 1% level). Regarding the role of foreign parties, it is found that foreign partners may be involved in several roles such as marketing, finance, technology development, human resource development, and management and administration. Some of them may intervene in all or most activities, but others are involved in only limited activities. This may be dependent on the nature of the joint venture and foreign investors. For the firm which has a foreign partner only in terms of a sub-contractor or marketing distributor in a foreign market, it may also receive the know-how used in the improvement, changes and development of the products and production processes. Therefore, many foreign parties have directly and/or indirectly contributed to the creation of technological capability. Their contributions may include the acquisition of technology from overseas sources, the modification and improvement of products and production process and other related

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[2] Normally, most firms need partial help from external agencies or individuals in carrying out their innovative activities.

R&D activities.[3] The foreign and/or joint-venture firms could obtain some resources, such as financial and human resources, and technology competence from foreign partners and/or parent firms. As a result, foreign and joint-venture firms tend to have a higher level of acquisitive and innovative capability than wholly Thai-owned firms.

Concerning the promoted firms (i.e. the firms which receive benefits from various investment promotion schemes such as tax exemption and other benefits, see the discussion in Chapter 4, and Appendix 4.4), they have negative relationships with the level of acquisitive capability because these firms have to be much dependent on external resources (e.g. individuals, agencies) in the acquisition of technology, as compared with non-promoted firms. In this case, the promoted firms receive the benefits from the Board of Investment (BOI) in terms of the importation of machinery and equipment, and experts from abroad. The BOI also works as a bridge agency which brings technology suppliers to meet with the producers, and as an advisory agency, especially in setting up a business (BOI, 1997; Study Survey, 1997). Thus, in the acquisition of technology, the promoted firms can benefit from this kind of government intervention. With reference to innovative capability, the promoted firms can receive benefits from the investment promotion schemes which are specially provided to R&D activities (i.e. the exemption of corporate income tax, and the exemption of import duties on the machinery and equipment used for R&D activities). Also, the promoted firms may use the benefits (i.e. financial resources) partly derived from the investment promotion schemes provided for other purposes (e.g. export promotion, foreign direct investment promotion, factory relocation) to invest in innovative activities.

In innovative capability, two other independent variables are also found to have positive relationships with the level of capability: firm size (significant at the 1% level), non-export orientation (significant at the 10% level). Regarding the firm size, the larger enterprises have more sufficient resources of their own, such as skilled

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[3] This finding seems to be consistent with TRDI (1989a), Panchareon (1983), and Khanthachai *et al.* (1986). Wattanasin *et al.* (1993) also found that technology transfer through technology transfer contracts and joint-venture projects appears to be more successful than the transfer through 'disclosed information' and the firm's own experience.

personnel, facilities, financial support; have better organisational systems and quality control system; and/or have more possibilities to carry out the changes of product and/or production process, and innovative activities, as compared to the smaller companies. However, it is found from the survey that some medium-sized firms have carried out innovative activities by cooperating with other firms in the business group or external agencies. Thus, apart from the size of firms, other factors (e.g. business links, external linkages) may also affect the development of innovative capability. Regarding the non-export-oriented firms (i.e. firms which export less than 20% of total sales), these firms emphasise both local and overseas markets. Since these two markets are more diversified, products of these firms are likely to have more diversified characteristics than those of other firms because of the need to sell products in markets with different characteristics and competitive environments. For selling products in the local market, these firms have to produce finished complete products (e.g. by imitating or modifying other products existing in the market and/or by developing their own products). These firms may also carry out product and/or production process modification to suit market demands and local conditions. As a result, the non-export-oriented firms may have undertaken a variety of R&D activities, and thereby raise the level of innovative capability. On the other hand, the export-oriented firms tend to have a lower level of innovative technological capability than the non-export-oriented ones, although some may argue that the former face more competition than the latter because of the larger size of the market and the number of competitors. As a result, these firms are forced to upgrade their technological capability, especially to change or develop products and production processes (Braga and Willmore, 1991; and Kumar and Saqib, 1996). However, in many cases, although these firms have to produce products at the quality required by their overseas customers, they do not have to undertake radical modification or development of new products and/or production processes. Some foreign customers also order low value-added and/or semi-processed products which do not need radical development of products and/or production process. Moreover, some export-oriented firms have contracts with their permanent customers in foreign markets for which the products' features and specifications have been already designed. However, these firms have to undertake some R&D activities, especially the test and improvement of product quality to meet customer requirements and the standards (e.g. hygiene and

cleanliness) set by the importing countries. Thus, these firms may have to carry out less innovative activities than the non-export-oriented firms.

Our study also finds that age of firm does not have any statistically significant relationship (at the 10% or lower level) with any type of technological capability although the accumulation of firm's own experience can be an important factor in undertaking many activities. This implies that new and old firms may not have significant differences in the levels of those four capabilities. The main reason is that even though a new firm is newly established, when it wants to carry out some activities concerning the development of technological capability it can acquire and mobilise the experienced and skilled personnel from other firms, or those in the same business group, and the assistance from external people and agencies, technology suppliers, or foreign partners, for undertaking the activities concerned. Furthermore, according to the survey, it is found that many managers and supervisors, even unskilled labour, used to work in other firms in the same industry.

7.2 Analysis Based on Firms' Perception

In the regression analysis, we have examined the role of various characteristics of the firms in the building of the four elements of technological capability. However, other factors may also play a significant role in this effort, and it is not possible to examine the role of these factors through the regression analysis. Moreover, the role of these factors can be considered from the firms' points of view (i.e. their perception). These factors also include both internal (firm-level) and external factors.

This section aims to examine, from the firms' perspectives, the role of various internal and external factors, whether they play an important role in the enhancement of the four main elements of technological capability. In this section the exploration is divided into four sections: the enhancement of acquisitive capability; operative capability; adaptive capability; and innovative capability. The factors included in the study in this part consist of four selected internal factors and fourteen selected

external factors as outlined in Chapter 5.[4] The analysis focuses on the mean value of the influence of each factor perceived by all firms in the study in the enhancement of each technological capability.

7.2.1 Factors Influencing the Enhancement of Acquisitive Technological Capability

Overseas market competitors appear as the most important factors (the mean level is 3.83 (on a scale of 5)) for the enhancement of a firm's acquisitive technological capability, followed by fund suppliers (3.81), overseas customers (3.77), management and administration (3.70), policy and strategy (3.64), government tax and other incentives (3.54), the accumulation of its own experience (3.49), and machinery suppliers (3.44).[5] It is also found that universities are the least influential factors (2.59). Other following less important factors comprise trade/industry associations (2.70); texts, journals and reports (2.91); and domestic customers (2.98).

7.2.2 Factors Influencing the Enhancement of Operative Technological Capability

Overseas customers are found as the most influential factor (3.91), and overseas market competitors as the second most important one (3.74) for the enhancement of operative technological capability. Other influential factors include the accumulation of its own experience (3.64), policy and strategy (3.54), management and administration (3.51), fund suppliers and staff training programmes (3.42), and machinery suppliers (3.27), respectively, while the least three influential factors are the same as those found in terms of acquisitive activities.

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[4] *Internal factors* include firm's policy and strategy, management and administration, the accumulation of the firm's own experience, human resource development or staff training programmes.

External factors include government regulations, government tax and other incentives, government technical advice, government technological information services, domestic customers, overseas customers, machinery and equipment suppliers, fund suppliers, domestic market competitors, overseas market competitors, consulting agencies, trade/industry associations, universities, and related documents).

[5] The levels of influence of various factors perceived by the firms are divided into 5 levels as illustrated in Chapter 5.

7.2.3 Factors Influencing the Enhancement of Adaptive Technological Capability

As far as the enhancement of adaptive capability is concerned, the three most influential factors are the same as those found in terms of operative technological capability (i.e. overseas customers (3.85), overseas market competitors (3.71), and the accumulation of its own experience (3.51)). However, some other firm's internal factors are also found to be highly influential, these include staff training programmes (3.41), domestic market competitors (3.37), management and administration (3.33), and policy and strategy (3.26), respectively. Meanwhile, the rankings of the least important factors are different from those mentioned in the previous two activities. Trade/industry associations are found as the least important factor (2.53). Other less influential factors are related documentary sources (2.65), and universities (2.68) (see Table 7.5).

7.2.4 Factors Influencing the Enhancement of Innovative Technological Capability

Concerning the enhancement of innovative technological capability, the two most influential factors are the same as those found in the operative and adaptive technological capabilities (i.e., overseas customers (3.83) and overseas competitors (3.79)). Other most important factors include fund suppliers (3.44), the accumulation of its own experience (3.33), policy and strategy (3.32), management and administration (3.31), and staff training programmes (3.27), respectively. The least important factors as viewed by the firms include universities (2.34), trade/industry associations (2.41), and government regulations (2.67) are considered by the firms, respectively (see Table 7.5).

Table 7.5

Major Factors (in priority) Influencing the Enhancement of the Four Elements of Technological Capability, as Perceived by the Firms

The Enhancement of Acquisitive Capability	The Enhancement of Operative Capability	The Enhancement of Adaptive capability	The Enhancement of Innovative Capability
Overseas market competitors (3.83)	Overseas customers (3.91)	Overseas customers (3.85)	Overseas customers (3.83)
Fund suppliers (3.81)	Overseas market competitors (3.74)	Overseas market competitors (3.71)	Overseas market competitors (3.79)
Overseas customers (3.77)	Accumulation of its own experience (3.64)	Accumulation of its own experience (3.51)	Fund suppliers (3.44)
Management and administration (3.70)	Policy and strategy (3.54)	Staff training programmes (3.41)	Accumulation of its own experience (3.33)
Policy and strategy (3.64)	Management and administration (3.51)	Domestic market competitors (3.37)	Policy and strategy (3.32)
Government tax and other incentives (3.54)	Fund suppliers (3.42) Staff training programmes (3.42)	Management and administration (3.33)	Management and administration (3.31)
Accumulation of its own experience (3.49)	Machinery suppliers (3.27)	Policy and strategy (3.26)	Staff training programmes (3.27)
Machinery suppliers (3.44)	Consulting firms (3.19)	Fund suppliers (3.24)	Domestic market competitors (3.15)
Domestic market competitors (3.40)	Domestic market competitors (3.18)	Consulting firms (2.98)	Domestic customers (3.13)
Staff training programmes (3.39)	Government technical advice (3.16)	Government technical advice (2.96) Domestic customers (2.96)	Government tax and other incentives (3.03)
Government technical advice (3.22)	Government tax and other incentives (3.11)	Government tax and other incentives (2.90) Machinery suppliers (2.90)	Consulting firms (3.00) Government information service (3.00)
Government regulations (3.19)			

Table 7.5 (continued)

The Enhancement of Acquisitive Capability	The Enhancement of Operative Capability	The Enhancement of Adaptive capability	The Enhancement of Innovative Capability
Consulting firms (3.16)	Domestic customers (3.04)	Government information service (2.90)	Government technical advice (2.97) Machinery suppliers (2.97)
Government information service (3.11)	Government regulations (3.03)	Government regulations (2.85)	Texts, journals and reports (2.75)
Domestic customers (2.98)	Government information service (3.00)	Universities (2.68)	Government regulations (2.67)
Texts, journals and reports (2.91)	Texts, journals and reports (2.79)	Texts, journals and reports (2.65)	Trade/industry associations (2.41)
Trade/industry associations (2.70)	Trade/industry associations (2.66)	Trade/industry associations (2.53)	Universities (2.34)
Universities (2.59)	Universities (2.28)		

Note: * Fund suppliers refer to the availability of investment fund used for undertaking related activities.
The rankings of the factors are derived from the comparison of the mean levels of their influence.
The factors shown at the top of the table refer to the highest level of influence, whereas those shown at the bottom of the table represents the lowest level of influence.
The figures shown in the brackets are the mean values of the level of influence. These values were computed from the *SPSS Programme*, as explained in Chapter 5.

7.2.5 Role of Internal and External Factors (from the Firms' Perception): Discussion

Many internal and external factors are perceived by the firms to have played important roles in the building of the four elements of technological capability. However, there are some differences between the significance of the role of these factors from the firms' points of view. For example, external foreign factors such as overseas customers and overseas market competitors are found very important, with mean scores varying from 3.71 to 3.91, out of a total maximum score of 5. These two factors are perceived as the most important ones in most capabilities. Regarding the availability of investment fund (fund suppliers), it is perceived as an important factor. with the estimated mean scores ranging from the middle to high level (3.24 to 3.81). This factor is found very important in the building of acquisitive capability and innovative capability with the mean scores at 3.81 and 3.44, respectively. However, other domestic external factors (e.g. domestic market competitors, domestic customers, tax and other incentives, government technical advice, and government regulations) are found to be wide-ranging. Although these factors are also identified as important by the sample firms, their individual mean scores as estimated are found to vary generally from the middle range to the low range level. Among the roles of government, tax and other incentives are perceived as a high score (3.54) in the acquisitive capability. Machinery suppliers (local and/or foreign sources) are other important factors, especially in terms of acquisitive capability and operative capability, with the mean scores at 3.44 and 3.27, respectively. With regard to firm's internal factors, there are four main internal factors as identified by the firms (firm-level experience, management and administration, policy and strategy, and staff training programmes) and the mean score of each of these is found to vary from 3.26 to 3.70. The accumulation of firm-level experience shows the highest scores among the internal factors in terms of operative capability, adaptive capability, and innovative capability, with the mean scores at 3.64, 3.51, and 3.33, respectively, whilst management and administration exhibits the highest score of the internal factors in terms of acquisitive capability with the mean level at 3.70. From these findings, how those internal and external factors play roles in the building of various elements of technological capability are discussed next.

Customers

In the food industry, producers normally produce their products according to market (customer) demand, including existing demand and the new application of the products in the market. In many cases, producers have to produce the products according to the customers' 'orders'. Whenever the producer accepts the new 'orders' from the customers it may undertake related activities by depending wholly on its own resources and/or by depending partly on external resources. This depends on the firm's own technological competence and/or the complexity of the product. Sometimes, the customers send their staff to give advice or training to the firm's personnel and to supervise the production at the firm. For undertaking the new product (and production process) in responding to the customers' demands, the firm may have to install new machinery and equipment and to adopt the know-how required. The interactions between producers and customers may differ from firm to firm because the nature of customers may be different in many forms as follows:

- large distributor (to buy finished products);
- final producer (to import semi-processed products from Thailand to produce final products to sell in their local markets);
- supplier and customer (to make a subcontract with the firms located in Thailand by supplying raw materials and know-how to the producer, and to buy final processed products from the producer to sell in the foreign markets).

The role of overseas customers can be summarised according to the four elements of technological capability as follows:

- acquisitive capability → introduce, advice;
- operative capability → operation, quality control;
- adaptive capability → minor adaptation of product/production process and technology;
- innovative capability → radical modification of product/production process and technology, development new product and/or production process, R&D activities, and R&D commercialisation.

Normally, the customers do not give any details as to how to produce the products required, so the firm needs to seek for the detail of how to produce for themselves. This may indicate why overseas customers are not perceived as the most important factor in terms of acquisitive capability (see Table 7.5). In addition, the influence of the customers involves not only the application of new products (and production process) but also the indirect force toward the producer to modify, develop and/or innovate new production process and to raise its technological capability after accepting the new 'orders' from the customers. This effect is crucial when customer requirements are more sophisticated (e.g. high quality, diversified features).

Competitors

In this study, the effect of overseas market competitors is most crucial in terms of the acquisitive capability. Competitors can create pressure on firms. If the firm wants to survive and grow in the competitive market, it has to maintain and gain more technological competence to carry out many activities to improve productivity and efficiency, product quality and product diversification, and to introduce new products in the market. In this case, the competitors do not directly help the producer to undertake the activities required, but they indirectly force the firm to adapt, improve, modify, develop and innovate new products and production processes. Sometimes, the producers try to imitate the products developed by competitors, or to develop new products based on such original products. This involves various stages of technological capability building occurring from the acquisition to innovation and production stages. The firm may have to change policy and strategy, employ more resources, improve its management and administration, and cooperate with external agencies in order to carry out the required activities. At the same time, the existence of free trade in the world market can put more pressure on the producers. In this case the market forces seem to play a significant role as emphasised by neoclassical economists.

In addition, apart from the competition based on the prices of products, the producers face other problems (e.g. non-price competition). For example, the Thai exporters have to compete with the ACP countries which can export their seafood products (canned tuna) to the EU without paying any import duties, whilst the Thai exporters

have to pay import duties at 24-25%. Other measures include food safety standards to protect the health of the customers of importing countries such as automatic detention (by using personnel skills to examine the quality of products), and food contamination, export quota, environment reasons (to protect sea turtle, dolphin, and mangrove areas) (Puttanorm and Rimpirangsri, 1995; Siripanish, 1995). Furthermore, many countries located in the same regions have established economic zones, such as NAFTA and the EU. As a result, the producers from Thailand receive more pressures from their competitors in the world market. This may result in the more improvements in productivity and quality of products which are related to the building of technological capability.

The Role of Government

The role government through tax and other incentives, regulations, technical advice and information service can also influence the firms in undertaking various technological capability. However, the government tax and other incentives are perceived as the highest score (3.54) in acquisitive capability among all government factors. This finding can support those found from the regression analysis that investment promotion schemes play an important role in the acquisition of the (promoted) firms in the study.

Fund Suppliers (availability of investment fund)

As mentioned before, fund suppliers are one of the very important factors, in particular for enhancing acquisitive capability and innovative capability. This is because financial resources are a crucial factor in determining the possibilities of the firm in the acquisition of new technology, and investing in R&D activities. In this case, the fund suppliers also influence the firms in terms of the analysis of the feasibility of new investment project before lending money to the producers.

Machinery and Technology Suppliers

Machinery suppliers can play role in the firm's technological capability building in various aspects, such as advising new machinery and know-how to producers, providing training courses to producers regarding the operation and maintenance of new machinery. Some suppliers also advise new know-how (i.e. the modification of existing products and the development of new products) to the producers through

new technology embodied in new machinery. In this case, some manufacturers state that machinery and component suppliers are major factors which contribute to the product development of their firms. In our study, these factors are perceived as important factors in acquisitive and operative capability.

According to our survey, many firms can acquire machinery and equipment used for producing canned foods, especially small firms, from local producers. These producers imitate the machinery imported from abroad, or rebuild the imported old machinery. Some of them cooperate with domestic producers to produce the machinery required. However, many medium and large firms still need the machinery from overseas suppliers acquired through agencies located in Thailand and/or direct purchase. Sources of machinery are varied. For canned foods, they include countries such as Taiwan, USA, Spain, and Italy (especially packaging technology). For frozen seafoods, Japan is the main source.

The Role of Firm' Internal Factors

As found from the firms' perception, four main internal factors (the accumulation of firm's own experience, policy and strategy, management and administration, and staff training programmes) are important for carrying out various technological capability building. Firm's policy and strategy and management and administration will determine what and how the firm use its resources required for enhancing its technological capability. In this case, our findings appear to indicate that these two factors are very important in terms of the acquisition of technology. At the same time, the accumulation of the firm's own experience (e.g. through learning-by-doing, learning-by-using) seems to be very important in terms of operative capability, adaptive capability, and innovative capability. This is because these various types of capability need skills and experience of the firm's personnel in order to achieve success in the activities.

7.3 Conclusion

The chapter, which has attempted to investigate the role of the various internal and external factors in building technological capability in the food industry in Thailand, uses firm-level data collected from a sample survey carried out in Thailand during

August-November 1997. Technological capability building relating to four particular elements (acquisitive capability, operative capability, adaptive capability, and innovative capability) is investigated at some length.

A number of major conclusions, including the following, have emerged. First, an important finding of the regression analysis carried out is the positive role played by foreign investors in developing acquisitive and innovative capability, while the promoted firms show negative coefficient for acquisitive capability (largely because of their heavy dependence on external agencies especially on the Board of Investment), although they show positive correlation for innovative capability (mainly because of tax exemption and other benefits they receive for conducting innovative activities). In innovative capability, two other independent variables are also found significant: (i) non-export orientation of the firm (as these firms often have to compete in the market with finished products backed by their own innovative efforts) and (ii) firm size (because of higher capability on the part of bigger firms to conduct innovative activities).

Secondly, in building the four key elements of technological capability, it is apparent that the various factors, both internal (firm-level as well as non-firm level) and external, are viewed essential by the firms, although there is some variation as to the degree of importance attached by the firms to each of the factors.

Thirdly, the importance of the firm-level internal factors and also of the external factors perhaps cannot perhaps be over-emphasised; their mean scores (as estimated based on firm-level perceptions) are found to be on the high side (out of a scale of 5, their individual score is always above 3 and, for some of the factors, even near 4).

Fourthly, the external domestic factors as identified by the firms are found to be wide-ranging, over a dozen in number (including domestic market competitors, government technical advice), however their mean scores are found to be generally on the low side, varying from 2.28 to 3.44. However, the availability of fund is perceived by the firms as a highly influential factor with the scores varying from 3.24 to 3.81. Also, government tax and other incentives are considered as important factors, especially for enhancing acquisitive technological capability, with a mean score of 3.54.

Chapter 8

ANALYSIS OF THE DEVELOPMENT OF NEW PRODUCTS

8.1 Introduction

In the previous chapter, we examined the role of various firms' internal and external factors, by using both regression analysis and firms' perception, in the building of the main elements of technological capability. However, as discussed in Chapter 2, apart from the improvement of productivity and product quality, and the production of outputs to meet market demand, a firm in an industry may have to emphasise the development of new products for its long-term competitive strategy. This means the firm also needs to use its technological capability for developing new products, and the creation of this capability may be dependent on many factors. Therefore, this chapter aims to examine the role of various factors which can affect the building of technological capability of the firm in developing new products.

The firms in the study may have different levels of technological capability in developing new products. Some firms just produce products without any changes or improvement in technologies adopted in products and/or production process. Some firms have undertaken only minor modifications but some of them carried out major changes in such efforts. Moreover, some have introduced their own new products in the markets. The sample firms exhibit various degrees of such technological capability as shown in Table 8.1. The majority of the firms in the study seem to have undertaken efforts to improve products and/or production processes. Many of them have also introduced their own new products through imitation efforts in the markets, and some introduced their own unique products in the market, although some of the sample firms, as shown by capability 1, 2, and 3 have not carried out radical product modification, and major improvements in the production processes.

Table 8.1 Number of Sample Firms and the Level of Technological Capability in Developing New Products

Level of technological capability*	1	2	3	4	5	6
Number of sample firms in each level of technological capability	1 (1.6)	2 (3.1)	12 (19.4)	23 (37.1)	12 (19.4)	12 (19.4)

Note: * - See the criteria designed in Table 5.3, Chapter 5.
Figures shown in brackets are the percentages of the sample firms in each level of technological capability to the total sample firms (62 firms).
Source: Study Survey, 1997

The differences of the level of technological capability in developing new products mentioned above may be determined by various firm-level internal and external factors. In our study, two methods are used in the investigation. *First*, regression analysis is also used in the exploration. However, for dependent variables, we use the level of technological capability of the firms in developing new products obtained from the field survey. Independent variables also include size of firm, age of firm, ownership status, market orientation, promotion status, and main-product type. Thus, in the regression analysis, we examine the impact of the size of firm, age of firm, role of government through investment promotion schemes, role of foreign investors through direct foreign investment, and role of market environment. *Second*, we use a pair-comparison approach for examining the role of internal factors (e.g. policy and strategy, management and administration, and various activities carried out by the firms) by comparing such factors between the firms with low and high level of technological capability in developing new products.

Thus, regarding the different firms' performances in developing new products, the analysis in this chapter comprises two sections:

1. Regression Analysis: the relationship between the firm's characteristics (size of firm, age of firm, ownership status, promotion status, market orientation, and main-product type) and the level of the firm's technological capability in developing new products.

2. Pair-comparison Analysis: the investigation of the firm's various factors (including policy and strategy and management, human resource development and management, R&D efforts, and internal linkage and information system) which may affect the degree of the firm's technological capability in developing new products.

8.2 Regression Analysis

The relationships between the level of technological capability in developing new products and the firm's characteristics can be seen in Table 8.2 (see also Appendix 8.1).

Table 8.2 Firm Level Characteristics and Technological Capability in Developing New Products

Dependent Variable	Independent Variables	Coefficient	Standard Error	T- Ratio	Probability	F - Statistics
TCdnp	Constant	-0.0269	0.7855	-0.0343	0.973	$R^2 = 0.5307$
	LnSIZE	0.7325	0.1505	4.8662	0.000	$\overline{R}^2 = 0.4599$
	AGE	0.0090	0.0200	0.4527	0.653	
	$PROM_1$	0.2513	0.2972	0.8453	0.402	$F(8, 53)$
	OWN_1	- 0.1400	0.2503	-0.5594	0.578	7.4923
	$MARK_1$	- 0.2736	0.2858	-0.9570	0.343	(0.000)
	$PROD_1$	- 0.4796	0.3914	-1.2254	0.226	
	$PROD_2$	- 0.1758	0.3686	-0.4768	0.635	*DW- Statistic*
	$PROD_3$	- 0.3474	0.3769	-0.9216	0.361	= 2.1832

There is a positive relationship, statistically significant at the 1% level, between the level of technological capability in developing new products and the size of firms. The main reason for this phenomenon could be explained by the fact that the larger firms may have more resources required for undertaking new products as discussed in Chapters 2 and 7. Meanwhile, other factors including age of firm, promotion and ownership status, and market orientation do not seem to have a statistically significant relationship (at the 10% or lower level) with the level of technological capability building in this regard. It could be explained that the level of such capability of the

firm does not significantly vary from firm to firm among firms which possess these different factors.

However, the level of explanation of the variables in the model ($\overline{R}^2$) is not very high (46%). This may result from the fact that other factors, especially the firm's internal factors, also affect the upgrade of the degree of technological capability of the firm in developing its new products.

8.3 Firm's Characteristics and Technological Capability in Developing New Products: Discussion

In our analysis, firm size is only one factor that is found statistically significant (at the 1% level) for enhancing the degree of technological capability of the sample firms in developing new products. As discussed in Chapter 7, large firms have more advantages than small firms in undertaking many technological development activities. Large firms can use their advantages in terms of manpower skills, financial resources, R&D facilities and market position for the development of new products. These firms may also have international connections with foreign enterprises in terms of the use of experts and know-how in such an effort. However, some large firms have not carried out any radical product modification and/or the development of new products and production processes. They just produce products to serve market demands with no sophistication (i.e. low value-added products). These types of firms are considered as the firms with low technological capability in developing new products. In the meanwhile, it is found that some medium-sized firms have carried out innovative activities (i.e. new product development), thereby raising their technological capabilities in this regard. This results from many factors such as good cooperation with external agencies (e.g. firms in the same business group, consulting firms, universities) in developing new products, and various internal factors (which will be discussed later). Therefore, the firm's size by itself may not be sufficient to be used as the indicator by which to consider whether the firm has low or high technological capability in developing new products. However, it can be argued that the large firm tends to have more potential and opportunities than the small firm in the creation of

technological capability in terms of developing new products, if it aims to undertake new product development.

Other characteristics at the firm-level (e.g. promotion status, ownership status, market orientation, and age) are not found to have significant impacts on the level of technological capability in developing new products, although some of them show an important role in the building of some elements of technological capability found in the previous chapter. The promoted firms may not always have a high level of technological capability in this respect (although they can use benefits obtained from the investment promotion schemes for undertaking some innovative activities) because some of them may only aim to produce low value-added or semi-processed products for export that are not radically modified or even newly developed to sell in the markets. They can receive investment privileges because the nature of their businesses conforms to the promotional conditions (e.g. export enterprises, special investment promotion zones, and factory relocation in regional areas). At the same time, the foreign investors do not seem to always greatly influence the enhancement of technological capability in developing new products because they may invest in the firm which just produces low value-added or semi-processed products, or which benefits from resource endowment (e.g. raw materials, low labour cost advantage) and investment promotion schemes. They do not emphasise new product development. Moreover, this kind of joint-venture projects may cause an adverse effect on the competitiveness of the industry in the long run because the investors may move to invest in other countries which still have abundant natural resources and low labour costs for the foreseeable future, as discussed in Chapter 3. Also, the findings in this chapter reveal that different market orientations do not significantly affect the degree of technological capability of the firms in developing new products. This is because some export-oriented firms have contracts with their permanent customers in foreign markets for which the products' features and specifications have already been designed, and they may not need to produce their products by competing with other producers, or to introduce their own new products to the market, as discussed in the previous chapter. In the meanwhile, although some non-export oriented firms may have undertaken several innovative activities, their efforts do not significantly focus on new product developments because their business strategies do not aim to

introduce their own unique products in the markets. In addition, the main-product group is also not found to be an significant factor in the analysis (i.e. the level of technological capability in developing new products between the firms across various sub-sectors does not have statistically significant differences). This may be because of the fact that any firm in different main-product groups may have opportunities to upgrade such technological capability if its aim to develop own new products, and potential and capability to carry out related activities. These efforts may be in terms of the adaptation and modification of existing products and production process, and the development of new products. The new products can be in the same as or different from the existing main-product groups.

8.4 Pair-comparison Analysis

In the regression analysis, it was not possible to examine the role of many firm's internal factors because they are related to the policy, strategy, management, and the characteristics of organisation. These factors cannot be quantified. Thus, our study attempts to use a qualitative approach in the analysis.[1] We use a qualitative method (i.e. pair comparison) to explain whether they have impact on the technological capability building of the firms in developing their new products.

Some of the firm's internal factors, i.e. policy, strategy and management, and related activities such as human resource development, R&D efforts, and information systems and the cooperation between functional units within the organisation implemented by the firms, as well as the behaviour, background and attitude of owners/managers, may have impacts on the building of the firm's four elements of technological capability (see Table 5.4, Chapter 5). The information used for the investigation is mainly derived from the survey of firms conducted by interviewing the owners/managers and/or relevant persons of the firms, as mentioned in Chapter 6. Concerning that purpose, some firms in each main product group are selected so as to examine those internal factors through descriptive analysis.

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[1] Bidault, Despres, and Butler (1998) also recommended to use a qualitative approach to investigate the factors involved in the way organisation and management behave with respect to the cooperation between buyer and supplier in the product development process.

The study compares the selected firms with low and high levels of technological capability in developing new products of each main product group, namely, canned pineapple (CP) firms, other canned fruit and vegetable (CFV) firms, canned seafood (CS) firms, and frozen seafood (FS) firms.

However, in the present study, a pair of firms cannot be controlled by most characteristics of the firms as applied in Tiralap (1990) (as mentioned in Chapter 5) because of the limitations of the comprehensive data derived from the firms in the same groups of characteristics from the survey. Consequently, a pair of firms, mainly controlled by main-product group, size and market orientation, will be used for the investigation.[2] The control of the two characteristics (size of firm and market orientation) could be useful in the comparison because this study and several previous studies seem to indicate that the size of firm could affect the firm's technological capability. Meanwhile, the control of market orientation may be useful in terms of the exploration of the firms' efforts in responding to the similar market environment

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[2] (1) The firms' sizes are classified by number of workers employed in the firms as follows:

Small	: <200	persons
Small - medium	: 200 - 500	persons
Medium - large	: >500 - ≤1,000	persons
Large	: > 1,000	persons

This classification is different from the size used in the regression models because the firm's size variable in the equation refers to the numbers of firm's workers.

(2) Market orientation is classified by the amount of annual sales of the firm's products in each market as follows:

Domestic orientation : ≥ 80% of total sales in domestic market.

Export orientation : ≥ 80% of total sales in foreign market.

regarding the activities related to the study. In the study, comprehensive data that can be used in the pair-comparison approach are available for 8 pairs of firms and are included in the comparison. Consequently, 2 canned pineapple firms (CP3, and CP5), 4 other canned fruit and vegetable firms (CFV3, CFV8, CFV12, and CFV19), 6 canned seafood firms (CS1, CS2, CS4, CS5, CS9, and CS18), and 4 frozen seafood firms (FS2, FS9, FS10, and FS11) are chosen in the comparison. Therefore, 16 firms are included for pair comparison analysis (as shown in Tables 8.3). The conceptual ideas used for the analysis are mainly derived from the theories and empirical studies discussed in Chapter 2.

Table 8.3 Selected Firms in the Pair-comparison

	Canned Pineapple		Other Canned Fruits and Vegetables				Canned Seafoods						Frozen Seafoods			
Firm	CP3	CP5	CFV8	CFV12	CFV3	CFV19	CS1	CS2	CS4	CS9	CS5	CS18	FS2	FS9	FS11	FS10
Level of TCdnp	4	5	4	5	4	6	3	6	3	6	5	6	4	6	4	5
Size of firm	Small - medium	Small - medium	Small	Small	Small - medium	Small - medium	Large	Large	Large	Large	Medium - large	Medium - large	Large	Large	Medium - large	Medium - large
Market orientation (%)	X - 100	X 100	D - 5 X-95	X-100	X - 80 D -20	X -100	D - 5 X - 95	D - 5 X - 95	D - 1 X - 99	D - 0.75 X - 99.25	D - 1 X 99	D - 5 X - 95	D-10 X-90	D - 3 X - 97	X - 100	D - 20 X - 80

Note: TCdnp = technological capability in developing new products, D = percentage of products sold in domestic market, X = percentage of products sold in overseas markets.

The firms' sizes are classified by number of workers employed in the firms as follows:

Small : <200 persons
Small - medium : 200 - 500 persons
Medium - large : >500 - ≤1,000 persons
Large : > 1,000 persons

Source: Study Survey, 1997

8.4.1 Selected Canned Pineapple Firms

Comparing CP3 (low TCdnp) and CP5 (high TCdnp)

There are some differences between the internal factors of CP3 and CP5 (see Appendices 8.2A and 8.2B). CP3 puts emphasis on the improvement and modification of products but it is mainly dependent on the technology supplied by the machinery producers/suppliers (this can also be seen from the elements of technology required by this firm). However, CP5 appears to make more efforts in the building of technological capability than CP3. It tries to develop technology from its own efforts, such as R&D, the accumulation of experience, and human resource development, whereas CP3 mainly develops technology through acquiring and adapting technology from overseas sources. CP5 can also acquire technology from its foreign partner, both in terms of production and management technology. Both firms emphasise the acquisition of state-of-the-art technology, but the elements of technology required by CP5 include both production and design technology. CP3 aims to use technology for the producing outputs at low costs and acceptable quality and for the development of products for existing needs, whilst CP5 mainly aims to use technology for the development of products for existing needs and for the development of new products to serve existing markets. Also, there are some differences in terms of top management values between these firms. The top management values of CP3 focus on the proper use of resources, the growth of current business and the exploration of new business, whereas the top management values of CP5 also put emphasis on various factors (e.g. R&D orientation, markets, production and finance), apart from those as emphasised by CP3, in dealing with the firm's external factors. This means the top management of CP5 has more dynamic aspects towards the firm's business. The plant manager of CP5 also has innovative culture, a dynamic vision of his responsibilities, and a food science background. However, there is no difference in the involvement of the top management of these two firms. Compared with CP3, CP5 undertakes more activities concerning human resource development, R&D, and information systems. Since CP5 is a joint-venture firm, some of its personnel have been sent to train and observe similar operation in foreign parent firm. Concerning the promotion and reward systems, CP3 offers only salary and bonus, whereas CP5 provides both in-cash and in-kind benefits, especially welfare and study tour.

Regarding R&D activities, CP5 also emphasises not only the development of new products and production process (as emphasised by CP3), but also basic, applied and development research. In the meanwhile, CP3 emphasises only the analysis of product quality and the modification of product to respond to market demand. However, in some cases, i.e. the contribution of workers in the improvement of machinery efficiency and manpower flows, the CP3 makes more efforts than CP5. Although CP5 does not have the contribution of workers concerning improvement of machinery effiency, there are good interactions between the firm's personnel at middle and senior levels regarding the problems which emerge. In terms of manpower flows, even though CP5 does not emphasise this activity, its personnel can undertake different responsibilities.

8.4.2 Selected Other Canned Fruits and Vegetable Firms

Comparing CFV8 (low TCdnp) and CFV12 (high TCdnp)

CFV8 has some different experiences from CFV12 regarding technological development efforts, except in terms of major technological thrust, the contribution of workers, and human resource development efforts (see Appendices 8.3A and 8.3B). Although both firms consider that product quality and low prices are the first and second most important characteristics of their successful products, CFV12 seems to place more emphasis on the application of new technology in its operation than CFV8. This is because CFV12 states that the use of new technology is the third most important factor, whereas CFV8 considers this factor as the least (seventh) important one.

Regarding the major sources of technology, even though both of them mainly acquire technologies from company's machinery suppliers and practise product imitation as the first two important sources, CFV12 also acquires technology from other sources such as R&D, the purchase of technology, exhibitions, related documents, and government agencies. The technology development strategy of CFV8 emphasises the acquisition and adaptation of technology from domestic sources. However, regarding this effort, CFV12 also cooperates with domestic technology suppliers. The elements of technology required by CFV8 are focused on general production technology, but those required by CFV12 include both general production technology and some state-

of-the-art (design and production) technology. However, both firms aim to use technology for the same purposes, i.e. for producing products at low cost and of acceptable quality. Regarding the key persons introducing new technologies to the firm, CFV8 derives technology from machinery producers/suppliers, whereas CFV12 obtains technology from both the suppliers and customers. It can be seen that the former seems to be mainly concerned with the technology in terms of physical technology, whereas the latter is concerned both in terms of physical technology and know-how. For acquiring market opportunities, CFV8 is mainly dependent on overseas customers or brokers, whereas CFV12 is dependent on both its own effort and agents. The difference in efforts (active and passive) between these two firms can thus be seen.

The roles of top management regarding the building of technological capability of these firms are also different. The top management of CFV8 not only assigns and delegates responsibility to its technical manager, but it is also involved in major related activities. However, the top management of CFV12 allocates a budget for technology development and gives full support to all related activities. Meanwhile, although both firms emphasise the survival and expansion of existing business, the top management of CFV12 also emphasises the growth of current business and the exploration of new business. The organisational structure of CFV8 is less informal and has less extensive communication among functional areas than CFV12. Additionally, CFV12 has more manpower flows and better interaction between related departments than CFV8. Regarding human resource development activities, even though the two firms do not have many differences in such activities and in the incentive systems, CFV12 has established systematic training programmes provided to different groups of its personnel (Study Survey, 1997).

Concerning R&D efforts, CFV8 puts more emphasis on the analysis and improvement of product quality, and minor adaptation of product and production process, than on the development of new products. On the other hand, CFV12 places more emphasis on the development of new production process more than the improvement and analysis of product quality. This firm also emphasises the importance of the minor adaptation of product and production process, the development of new product, and

packaging development, respectively. Furthermore, CFV8 has not established a separate R&D unit from other departments and it lacks financial support for undertaking R&D activities, whereas CFV12 has established such a department and does not have this problem. With reference to the information systems, CFV12 also has better information flows, having more aspects of information and more systematic links between related departments than CFV8. Moreover, the coordination between related departments of CFV12 focuses on more areas of information flows than that of CFV8.[3]

Comparing CFV3 (low TCdnp) and CFV19 (high TCdnp)

There are many differences of policy, strategy, and management and administration between CFV3 and CFV19 (see Appendices 8.3A and 8.3B). With reference to the major characteristics of successful products, the relatively important factors mentioned by these firms are, to some extent, different. Both of them mention that product quality, the use of new technology, and a large size of market are all important factors. However, CFV3 indicates that product quality and product differentiation are the first and second most important factors, whereas CFV19 states that several factors share the same level of importance. Another factor mentioned by CFV19 is a follow-on to the problem of customers. This may result in a consequent improvement of products both in terms of quality and in other aspects such as the characteristics and components of products.

Their major sources of technology are also different. CFV3 mainly acquires technology from machinery suppliers and trade/industry exhibitions, whereas CFV19 acquires technology from R&D, the purchase of technology, and accumulation of its own experience. Concerning technology development strategy, CFV3 emphasises the imitation and acquisition and adaptation of technology from domestic sources. On the other hand, CFV19 focuses on R&D activities and the continuous accumulation of technology and human resource development. Also, CFV3 requires only general production technology while CFV19 requires general and some state-of-the-art

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[3] The internal information flows of CFV8 mainly focus on market, production and quality control, whilst those of CFV12 focus on market and marketing, technology development and production.

production and design technology. CFV3 aims to use technology for producing products at low cost and of acceptable quality, whereas CFV19 aims to modify and/or improve existing products, and to develop products for market demand. Regarding the key persons introducing new technologies to the firm, for CFV3, machinery suppliers (and the FTI - concerning only environment management) play this role. Unlike CFV3, the firm's personnel and customers are the key persons who contribute to this effort for CFV19. With reference to the contribution of workers to the changes and improvement of products and production process, CFV3 does not have this experience, but CFV19 has experience in terms of the improvement of efficiency and productivity. In particular, CFV19 emphasises a 'teamwork strategy' (i.e. cooperation between personnel from related functional units) in carrying out related activities. Regarding the role of top management, even though that of CFV3 seems to have more involvement in technological development activities than that of the latter firm, its values regarding technological and business strategy appear to be less active and dynamic than that of CFV19 since the top management of the latter emphasises not only the survival and expansion of existing business, but also many other aspects (see Appendix 8.3a). CFV19 also has more manpower flows within the firm than CFV3. However, CFV3 appears to have a more informal organisational structure than CFV19.

Concerning human resource development, CFV3 has offered more activities to its employees than CFV19, but it has fewer incentives provided to its employees than the latter. It also faces financial problems in supporting human resource development activities. As far as R&D efforts are concerned, although both firms have separated its R&D unit (and related activities) from other departments, CFV19 places more emphasis on R&D activities than CFV3. Unlike CFV3, CFV19 also has sufficient financial support for undertaking R&D activities. Regarding the information systems, CFV19 has better links, both in terms of information flows and internal links between related departments, as compared to CFV3, because the former has both internal and external information flows and employs a teamwork strategy.

8.4.3 Selected Canned Seafood Firms

Comparing CS1 (low TCdnp) and CS2 (high TCdnp)

There are many differences between the internal factors of CS1 and CS2, especially in terms of major sources of technology, technology development strategy, major technological thrust, key persons introducing technology to the firm, top management values, top management involvement, incentive systems, and information systems (see Appendices 8.4A and 8.4B).

There is not a great difference in terms of major successful products. However, CS2 seems to put more emphasis on the use of new technology than CS1. CS2 also has set the policy to produce products to serve customers in middle and premier markets, and to produce high value-added products. It is found that CS1 develops technology by depending on imitation as the first priority, whereas CS2 attempts to undertake such a task by depending on its own efforts (e.g. R&D, learning from related documents). Concerning the major technological thrust, CS1 only aims to produce products for existing needs whereas CS2 aims to develop products both for existing needs and for new applications (introducing new products to the market). New technologies of CS2 have been largely introduced by its staff, whereas those of CS1 have been introduced by external people (machinery suppliers), and trade/industry exhibitions. As far as the top management is concerned, the top management of CS2 has a high level of involvement in technology development activities, and has more a progressive attitude towards both static and dynamic aspects. Particularly, it largely emphasises R&D activities concerning the firm's external environments. With reference to human resource development, CS2 provides more activities to its employees, and has a better incentive system than CS1. Concerning R&D activities, CS1 puts more emphasis on the analysis and improvement of product quality and minor adaptation of production process than the development of new products and production process, whilst CS2 emphasises the improvement of product quality and development of new products and production process than the analysis of product quality. Also, CS2 has carried out basic, applied and development research. Moreover, CS2 has good information flows and internal links between related departments in undertaking various activities, and the aspects of information comprise technology development, market and marketing.

On the other hand, CS1 has information flows only relating to marketing, and internal links which focus on consumer demands.

Comparing CS4 (low TCdnp) and CS9 (high TCdnp)

Compared to the previous pair of canned seafood firms, there are fewer differences between the internal factors of CS4 and CS9 (see Appendices 8.4A and 8.4B). Although there are generally fewer differences in such factors, the comparison of these two firms may reveal some implications which result in the different levels of technological capability in developing new products between them.

With respect to major characteristics of successful products, both firms have the same first two important characteristics (i.e. product quality and product differentiation). However, for the third most important factors, CS4 states low prices whereas CS9 indicates the use of new technology. Regarding the major technological thrust, although CS4 emphasises both the development of new products for existing needs and for new applications, it is likely to have less emphasis on innovative activities than CS9. This may be because CS9 also aims to use technology for the modification and/or improvement of existing products, apart from the development of products for existing needs and for new applications. There are also differences in terms of the sources of technology and the elements of technology required by the two firms. Both firms derive technology from various sources, but CS9 mainly acquires technology from internal sources (R&D) and product imitation as the first and second important sources, whereas CS4 acquires technology from machinery's producers/suppliers and R&D as its first and second important sources, respectively. However, the top management of CS4 has more involvement in technological development activities than that of CS9. The top management of the latter just assigns and delegates responsibility to the technical manager. Moreover, CS4 also has a more informal structure and frequent and extensive communication between related departments than CS9. At the same time, the firms do not have a great difference in terms of activities related to human resource development, and research and development. However, CS9 states that its top management gives full support to R&D activities because they are crucial factors in the firm's future, it also carries out packaging design and development. In addition, CS9 has better information systems and internal

links, particularly in quality control activities, than CS4, by applying a computerised system. Although CS4 has more human resource development efforts, R&D activities, and information systems than many firms in this study, the firm's policy mainly focuses on the production of products to serve the market at lower and middle levels. It has not produced its own new unique high value-added products for introducing to the market. On the other hand, CS9 aims to sell its products in middle and premier markets, and has attempted to introduce its own new high value-added products in the markets. The elements of technology required by CS4 comprise production technology, whereas those of CS9 include design and production technology, and some state-of-the-art design and production technology (in this case, the elements of technology required may imply the production of different classes of products).

Comparing CS5 (low TCdnp) and CS18 (high TCdnp)

There are some differences between the internal factors of CS5 and CS18 (see Appendices 8.4A and 8.4B). For the major characteristics of successful products, both of them indicate that product quality and product differentiation are the first two important factors, respectively. However, CS5 mentions that a large size of market, low prices, and having low market competition are the following important factors, respectively, whereas CS18 states that the third important factor is the use of new technology. For the sources of technology and technology development strategy, CS18 has more emphasis on internal sources (R&D) than CS5. Concerning technological thrust, CS5 aims to produce products at low cost and of acceptable quality. On the other hand, CS18 aims to develop new products for both existing needs and new applications. For the key persons introducing new technologies to the firm, CS5 mainly derives technology from the government and foreign agencies, whereas CS18 obtains technology from various sources, such as customers, foreign partner, and the company's machinery producers/suppliers. Regarding the involvement of top management of these two firms, there is no great difference. However, the top management's values of CS5 emphasise only the survival and expansion of existing business, whereas those of CS18 emphasise the growth of current business and the exploration of new business. There are also some differences in terms of the promotion and reward systems provided to their workers. Regarding the incentive systems, CS5 offers only bonus whereas CS18 offers various kinds of

incentives (e.g. bonus payment, sending its employees to attend training programmes and seminars, and supporting its employees to continue their studies). With reference to R&D activities, although both firms emphasise the improvement of product quality and the development of new products as the first two priorities, CS18 undertakes more R&D activities than CS5 by attempting to carrying new production process and packaging design development. Furthermore, CS18 has more sufficient resources and better policy to support the activities, indicating that further investment in R&D equipment is necessary for the development of the food industry (so as to develop new products). Although, these firms do not emphasise manpower flows within firms, CS18 states that key activities can be undertaken by several individuals. Concerning the information systems and internal links between related departments, CS18 has made better efforts than CS5. CS18 has information flows within the firm and with external sources, covering various aspects of information, and good internal links. Meanwhile, CS5 has only information flows within the firm, mainly focusing on quality and production. Furthermore, this firm does not put emphasis on internal links.

8.4.4 Selected Frozen Seafood Firms

Comparing FS2 (low TCdnp) and FS9 (high TCdnp)

There are many differences in terms of policy and strategy between the two firms (see Appendices 8.5a and 8.5b). Regarding the relative importance of major characteristics of successful products, FS2 mentions that they comprise two factors: product quality and the large size of market, respectively, whereas FS9 states that they comprise many factors, including product differentiation, and the use of new technology. With reference to the important sources of technology, FS2 mainly acquires technology from the company's machinery producers/suppliers, whereas FS9 derives the technology from various sources such as foreign partner, the company's own R&D, the company's machinery producers/suppliers, related documents and government agencies. In other words, FS9 acquires technology from both formal and informal sources, and in terms of physical technology and know-how.

Concerning the technological development strategy, FS2 mainly develops technology through the acquisition and adaptation of technology from domestic sources, whereas

FS9 attempts to develop technology from both internal and external sources, as well as through cooperation with domestic and overseas agencies. With respect to major technological thrust, FS2 aims to use technology for producing products for existing needs, whereas FS9 aims to develop the new products both for existing needs and for new applications. However, it was found that the executives of FS2 are the key persons who normally introduce new technology to the firm although the top management of this firm have less involvement in the technology development. Regarding the top management values, those of FS9 has more both static and dynamic aspects than those of FS2 as the former emphasises both current and new businesses, especially various factors in dealing with external environments. However, it was found that FS2 has more extensive manpower flows than FS9.

Concerning human resource development efforts, FS9 provides more activities and better incentive systems to its employees than FS2. For the incentive systems, FS2 provides only incentive payment, whereas FS9 provides incentives both in terms of cash (bonus) and rewards for attendance and special work, and study promotion. Regarding the R&D activities, FS9 has emphasised both the development of new products and production processes, and the improvement of product quality, whereas FS2 has mainly emphasised the improvement and analysis of product quality. With reference to the information system, FS9 seems to have a better system both in terms of information flows and internal links between related departments than FS2. FS9 has both internal and external information flows, whereas FS2 has only internal information flows. Furthermore, there are always the exchanges of ideas between the top managers and lower-level employees in FS9.

Comparing FS10 (high TCdnp) and FS11(low TCdnp)

There are some differences between the internal factors of FS10 and FS11 (see Appendices 8.5A and 8.5B). Although both firms state that the most important characteristic of successful products is the product quality, FS10 indicates that other factors are also important: product differentiation, a large size of market, and the use of new technology, whereas FS11 mentions a large size of market, and having advantage from government support as being important factors. As far as the major sources of technology are concerned, both firms acquire technologies from several

sources. The most important source mentioned by FS10 is the new staff (who gained experience from other firms), whereas the most important sources perceived by FS11 is its foreign partner. However, other sources of technology stated by the two firms do not seem to be greatly different. In terms of technological development strategy, FS10 emphasises various activities such as R&D activities, the continuous accumulation of technology and human resource development, imitation, and the acquisition and adopt technology from domestic sources, whereas FS11 mainly focuses on the accumulation of technology and human resource development. Concerning the major technological thrust, FS10 aims to use technology for developing new products for both existing needs and for introducing new products to the market, whereas FS11 aims to use technology for developing products only for existing needs. Although the two firms do not have great differences in terms of the contribution of workers regarding the changes and improvements of products and production processes of the firms, FS10 appears to provide more opportunities to its employees in the participation (the managers and workers always exchange their ideas in this firm).

There are some different degrees of involvement of the top management of the two firms. The top management of FS10 is involved solely through giving policy, direction and targets and approving proposals, whereas that of FS11 is involved in major related activities. However, the top management of FS10 has a more progressive attitude towards technology development than that of FS11. The former firm emphasises both the growth of current business and the exploration of new business, as well as various factors such as R&D, markets, production, and finance in dealing with a firm's external environments, whereas the latter mainly focuses on the survival and expansion of existing business.

Manpower flows at executive and manager levels within FS10 are not emphasised, whereas FS11 has manpower flows in general. However, there are extensive flows of personnel at lower levels, and always interactions between related areas within FS10. Compared with FS11, FS10 provides more human resource development activities and better incentive systems than FS11.

With reference to R&D efforts, FS10 has more emphasis on R&D. This could be seen in terms of the establishment of their R&D unit, the characteristics of R&D activities and financial support, whereas FS11 has not separated such a department from the others, and has insufficient personnel and equipment supporting the activities. Regarding R&D activities, FS11 emphasises only the improvement and analysis of product quality, whereas FS10 emphasises the development of new products, and applied and development research as its first two priorities. FS10 also gives importance to the improvement and analysis of product quality, and minor adaptation of products and production processes as the following priorities.

Furthermore, although both firms have information flows within the firms, the aspects of information needed by FS10 consist of technology development, market, marketing, and R&D, whereas those of FS11 focus only on raw material sources. In addition, FS10 has internal links between marketing and R&D departments, whereas FS11 does not have such links.

8.5 Pair-comparison Analysis: Discussion

In this section, the study will discuss why and how the variation in internal factors can affect the creation of technological capability in developing new products.

Business Policy and Strategy

Firm's business policy and strategy can affect the building of technological capability because they influence the direction of the firm's business (e.g. marketing strategy) and the use of firm's resources. Therefore, they can directly and indirectly affect both the changes and improvement of product and production process, and the development of new products.

In our comparisons, although all firms indicate that the product quality is the most important characteristic of their successful products, most firms which realise that the use of new technology is one of the high priorities of their successful products tend to have a higher level of technological capability in developing new products than those that do not. It can be argued that the use of new technology results in the advantage of new product development. As mentioned in Chapter 2, Penrose (1959) emphasised

the improvement of the technological base within the firm in order to cope with changing markets by acquiring technological superiority, thereby resulting in a high degree of technological competence and the ability to undertake product diversification. Schumpeter (1934) also indicated some aspects of innovation such as the introduction of new products and the method of production used by the entrepreneur. This normally involves the use of new technology. The policy towards product differentiation is also found in the firms with high technological capability in developing new products as compared to the firms with a lower level.[4]

Technology Strategy and Sources of Technology

There are various kinds of technology strategies employed by the firms. These strategies are related to how the firm acquired the technology used in production, and the sources of technology emphasised by the firm. Some firms emphasise technology development through imitation or reverse engineering, depending on the advice of technology suppliers (domestic/overseas machinery and equipment suppliers), cooperating with technology suppliers and external agencies, undertaking R&D activities, continuously accumulating technology and human resource development, and/or depending on foreign partners.

In the comparison, most firms with high degree of technological capability in developing new products emphasise the development of technology through R&D activities, and the continuous accumulation of technology and human resource development, whereas those with low capability emphasise the imitation of machinery and equipment available in the market, and the acquisition of technology from technology suppliers. The main sources of technology emphasised by the former are both internal sources (e.g. firm's own R&D activities, learning from related documents) and external sources (e.g. technology suppliers, trade/industry exhibitions, new staff who gained experience from other firms), while those of the latter are technology suppliers.

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[4] However, this difference is not found in the case of canned seafood firms, since most firms of this product group produce various kinds of products.

R&D activities may involve the firm's own efforts to analyse, adapt, modify, and develop the products and production processes, whereas machinery and equipment suppliers normally assist the producer to improve productivity and product quality, rather than to sufficiently diversify and enhance the value-added of the products since the producer also needs additional know-how to design and produce the products. If the firm wants to achieve success in product diversification and the development of high value-added products, it needs to put more efforts not only into physical technology, such as machinery and equipment, but also into related know-how. However, some modern machinery and equipment may bring about the changes of product and production process, but this may not be sufficient.[5]

Therefore, the firms which emphasise the development of technology by acquiring technology from both internal and external sources, and both physical technology and know-how are likely to have more opportunities and potential in the building of technological capability (i.e. the ability of the firms in developing products' characteristics or product differentiation, and high value-added products) than those which solely emphasise the acquisition of technology from external sources, especially machinery and equipment suppliers.

Elements of Technology Required, and Major Technological Thrust

The element of technology emphasised by the firm can imply the business strategy of the firm as follows:

- production technology → product quality, productivity (low cost);
- design technology → product diversification, new product/production process;
- state-of-the-art (production and design) technology → more productivity, quality, complicated, high value-added products.

Therefore, the more state-of-the-art production and design technology adoption there is, the more technological capability in developing new products can be enhanced. In

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[5] The firm which mainly emphasises the development of technology through the acquisition of modern physical technology (for cost-based strategies) may lose its competitiveness in the long-run because the new product innovations can be replicated by the competitors who can purchase the latest equipment and facilities (Porter, 1998, p.582).

the meanwhile, the firm's major technological thrust can imply the emphasis of the enterprise's technology and business strategy (short-term or long-term competitive strategy). It is found from the comparison that most firms with high degree of developing new products acquire both production and design (state-of-the-art) technology, whilst those with low capability tend to acquire only production technology. At the same time, most firms with low technological capability in developing new products aim to use technology for producing the product at low cost and acceptable quality, and developing the product for existing needs, whereas those with high capability aim to use technology not only for the modification, improvement and development of product for existing needs, but also for the development of new products for new applications.

Key Persons Introducing New Technology to the Firm and the Contribution of Workers

As found in the comparison, most firms with low technological capability in developing new products, especially canned fruit and vegetable firms, realise that technology (machinery and equipment) suppliers are the key persons who introduce new technology to the firms, whereas those with high capability perceive that both technology suppliers and customers are the key persons. This may be due to the fact that the former emphasise only product quality and productivity, and they mainly emphasise the production of products at low cost with acceptable quality, not the diversification and/or high value-added products, whereas the latter emphasise the product quality, product diversification, and new features of products. This means the former appear to emphasise only the acquisition of physical technology, but the latter seem to emphasise the acquisition of both physical technology and related know-how required for new product development.

Top Management Involvement and Top Management's Values.

The involvement of the firm's top management regarding technological development activities does not seem to be clearly different between the firms with different levels of technological capability in developing new products (both within and between the main-product groups) in the comparison. This may be because of the fact that the involvement of top managers is dependent on the structure and characteristics of the firms, backgrounds of the owner/manager, and the structure of qualified personnel

employed by the firm. For example, in the firm in which the top management is more interested in technology development and has a background and experience in this area, its top management may be involved more in such activities. In the firm which employs highly skilled and experienced managers and staff, its top management may not have to be largely involved in technological development activities.

However, in terms of top management's values, there are clear differences between the firms with low and high technological capability in developing new products. Concerning these issues, most firms with high technological capability tend to have dynamic top management values by emphasising both the short-term and long-term business strategy to deal with external factors (e.g. the growth of current business, the exploration of new business, and various factors in dealing with external environments). This can be explained by the evolutionary approach which implies that the firm needs to learn how to interact with its external environment. On the other hand, those with low capability emphasise only short-run business strategy (e.g. the survival and growth of current business and/or the understanding of market place and proper use of resources). At the same time, the behaviour of top management is important to the building of technological capability in developing new products. The firm which employs the manager who has experience, good vision in his career can create more changes in the product and production process (e.g. the case of CP5).[6] In addition, the top management values mentioned above also influence the firm's policy and strategy and the implementation stage which may have some important implications for related activities. This can bee seen, for example, in terms of R&D activities, discussed below.

Research and Development (R&D) Activities

It is found that the firm whose top management emphasises only the short-run strategy, its R&D activities focus on the test and analysis of product quality. On the other hand, the firm whose top management looks beyond the current work (the emphasis on both short-run and long-run strategies) its R&D activities focus not only on the analysis and test of product quality, but also on the development of new

[6] The success of CFV19 was also largely derived from the contribution of former firm's plant manager who possesses active and innovative behaviour (Study Survey, 1997).

products and production process. Moreover, basic and applied research and development research are also undertaken by some medium and large sized firms, especially those with high technological capability in this aspect.

In the meanwhile, many firms with high technological capability in developing new products set policies and emphasise that R&D is the key to the success of the business in the future, and the top management gives full support to R&D activities (e.g. the cases of CS9 and CS18). In this case, the commitment of the top management is very important to the firm in terms of both business and technology strategies, especially in the development of new products.[7] Moreover, R&D activities not only lead to the radical modification and development of product and production process, but also to more opportunities to absorb technology from outside as discussed in Chapter 2.

In addition, as discussed in Chapter 2, the establishment of R&D unit within the organisation is crucial for the firm in the development of its technological competence. Our comparison also finds that all firms with high technological capability in developing new products established R&D units, as separated from other departments, in their enterprises.

Information Flows, and Internal and External Linkages

Among functional areas, information and communication is very helpful for carrying out any business activities. It is found that some firms with high technological capability in developing new products have a wider scope of related information and a systematic link between related functional areas, including technology development, production, R&D, and marketing. Some firms with high technological capability in this regard have intensive cooperation between related departments and firm personnel at various levels. For instance, CFV19 has set joint targets among related departments in undertaking R&D, and developing new product and production process. CS2 has a daily meeting between related departments to mobilise the ideas

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[7]The emphasis of the firm toward R&D activities can also be seen from the level of in-house R&D expenditure (Veugelers, 1997, Acs and Audretsch, 1988). However, in our study this kind of expenditure is not included in the investigation because of the lack of comprehensive data supplied by the sample firms. Therefore, the emphasis of the firm toward R&D activities may be seen from the R&D activities emphasised by the firms and the commitment stated by the companies.

and feedback to solve the problems which emerge and to develop their work. Moreover, most firms with high technological capability in this respect give more opportunities to their employees to participate in various activities. This could give more opportunities to employees to exchange ideas not only in their routine work but also in the improvement and development of product and production process, and welfare and working conditions.

In addition, some firms have linkages not only within the organisation but also with external agencies, such as universities and government agencies. Some firms located in regional areas have cooperated with universities regarding R&D and related activities, especially those firms with high levels of technological capability in developing new products, like CFV12 and CS9. Some firms have linkages with the firms within their business groups in various activities, such as technology development, acquisition of raw materials, management, R&D, financial resources, and marketing. However, the firm which is a member of a business group does not always have a high level of technological capability in this regard because its policy may not aim to radically modify and/or develop its own new product. Some firms may cooperate with their members only in terms of management and administration, raw material acquisition, finance, and the test and analysis of product quality.

Human Resource Development and Reward System

Most firms in the comparison realise that personnel training is one of the important factors for the activities relating to the creation of technological capability. However, there are some different programmes implemented by the firms in some main-product groups. The firms with high technological capability in developing new products in canned pineapple and frozen seafood industries have carried out more human resource development programmes than those with low capability in the same group. It is also found that only foreign and partly Thai-owned firms (both low and high such a capability) have sent their personnel to train in their foreign parent firms.

Additionally, it is found that a good incentive and reward system, including both in-cash and in-kind benefits (such as continuing study, seminars, study tours, a good environment within the firm, and overseas travel) has been employed by many firms which possess high technological capability in developing new products. The

promotion and reward systems may have a direct effect on the labour mobility and on retaining competent personnel. A good reward system attracts not only the existing employees to contribute to technological development and other activities, but also attracts the qualified and experienced personnel from other organisations to come to work in the firm. This may also result in the contribution of the workers through various activities concerning the creation of technological capability of the firms they are employed by.

8.6 Conclusion

In concluding this chapter, the main findings can be highlighted.

According to the regression analysis, the firm's size has a positively significant relationship with the degree of technological capability in developing new products. The main reason is that large firms have sufficient capability and resources required for such an effort, which result in more opportunities than small firms in carrying out new product development.

Apart from the firm's size, other factors are not found to have statistically significant relationship. A number of reasons can be listed. First, the government investment promotion schemes have not specially emphasised the capability of the firms to be promoted in developing (own) new products (although the benefits are also provided to the firms in undertaking R&D activities). Second, foreign investors may or may not focus on the radical modification and development of new products. Third, firms' market orientation (i.e. export-oriented or non-export-oriented) does not have significant impacts on the firms in developing (own) new products.

The pair-comparison of firms brings out some findings which reveal that the firms with different levels of technological capability in developing new products exhibit many different internal factors: (a) business and technology policies and strategies, management and administration; (b) top management values; (c) incentive systems provided to their employees; (d) information and linkage systems; and (e) R&D activities. The findings show that the firms with high degree of technological capability in this regard emphasise on the development of technology from both

internal and external sources, and through both physical technology and know-how; have dynamic top management values; employ good incentive and promotion systems; have good internal and external links and information system; emphasise both static and dynamic R&D efforts, and have sufficient fund in undertaking R&D and human resource development.

Chapter 9

SUMMARY AND CONCLUSIONS

9.1 Main Findings

This study mainly focuses on the building of technological capability at the firm level. The emphasis follows from the relevant literature, especially coming out in the 1980s and the 1990s, which points to examination of technological capability building in developing countries (Dahlman, 1984; Dahlman *et al.*, 1987; Enos and Park, 1988; Enos, 1991; Lall, 1987, 1990 and 1992; Huq *et al.*, 1992 and 1993). The principal efforts of technological capability building concern the acquisition, use and management, adaptation (involving minor modifications), improvement (improving productivity of the original technology and/or quality enhancement of output) and development (involving radical modifications as against minor modifications) of technology (Dore, 1984; Desai, 1984; Stewart, 1984; Bell, 1984; Dahlman, 1984; Dahlman *et al.*, 1987; Enos and Park, 1988, UNIDO, 1986). These efforts can generally be grouped under four main elements: acquisitive technological capability, operative technological capability, adaptive technological capability, and innovative technological capability. In the meanwhile, the emphasis of the firm on the development of new products is also important for its long-term competitive strategy (Porter, 1998). Some literature also points out that various factors from inside and outside the firm can bring about the success of the creation of technological capability, although they may play different roles from one circumstance to another (Utterbak, 1974; Kim, 1976; Dahlman, 1984; Hippel, 1988; Lundvall, 1988, 1993; Katz, 1984; Porter, 1998; Brown and Karagozoglu, 1989; Enos, 1991; Kaplinsky, 1995). In our study, four major sub-sectors of the food industry in Thailand were selected for some in-depth investigation. Data collected from the field have been used for our investigation. Both quantitative and qualitative analyses have been carried out, involving regression analyses and evaluations based on firms' perceptions towards technology capability building and pair comparison of firms.

General Findings:

An overall finding is that technological capability building in the four main elements is the result of various firm-level internal and external factors playing a combined role. These factors include *internal factors* (i.e. firm-level experience, management and administration, firm's policy and strategy, and staff training programmes), *foreign external factors* (e.g. foreign investors, overseas customers and overseas market competitors), and *domestic external factors* (especially investment promotion schemes or government tax and other incentives). At the same time, other domestic external factors (including availability of investment fund, government technical advice, and domestic market competitors) are also found important. Firm-size, and machinery suppliers (domestic and overseas) are also some of the influential factors for technological capability building.

It appears that the co-operation between the government and the industry (trade/industry associations) can play an important role, especially in improving products and production process to comply with overseas customers' requirements, and meet the international standards (Chapters 3 & 4). Apart from many roles which are directly related to the improvement of products and production process, other indirect roles (raw materials development, financial services, marketing and export) are also important for upgrading technological capability of the industry.

However, the upgrade of technological capability for the development of new products is largely derived from the firm's internal factors, comprising firm's size, policy and strategy, management style (including the co-operation between functional units), attitude and behaviour of owner/mangers, R&D efforts, linkages with outside sources, and promotion and reward systems. This means the long-term competitive strategy and any effort to achieve this goal are importantly conditioned by the firm itself. However, in practice, the success of such an effort may also be supported by other factors from outside the firms, such as the supportive role of government and related agencies, new ideas and related information from customers and competitors, and the pressure from competitors. Thus, for the success of technological capability building, both firms' internal and external factors need to complement each other.

Another general point which needs to be emphasised is that the success or failure of the industry, even in terms of technological capability building cannot be considered only in terms of technological development effort. This is because the quality of product, the productivity and efficiency of production involve not only the production process, but also the quality and availability of raw materials, management and administration, and market (e.g. the quality standards required by customers).

Moreover, our findings enable us to conclude that the achievement of technology development has not derived solely from a single approach, e.g. the role of *market mechanism* (as emphasised by the neoclassical approach), or the *role of entrepreneur* (as emphasised by Schumpeter), or *human resource development and R&D* (as emphasised by the new growth theories), or the *evolutionary process of the firms* (as emphasised by evolutionary theorists). It may occur from a combination of different approaches or from parts of them. This conclusion may be useful for examining the technological development of an industry in developing countries. This is because only one approach or parts of different approaches may not be sufficient for examining such efforts of the industry. Additionally, these findings can also be used for exploring the experience of technological development of other industries in Thailand and/or other developing countries.

Specific Findings:

In **acquisitive capability**, foreign investors, overseas market competitors, availability of investment funds, overseas customers, and investment promotion schemes of the government (including tax exemption and others) are found significant. Firm-level factors (i.e. management and administration, policy and strategy, and the accumulation of its own experience) are also perceived as very important factors by the firms. Also, machinery suppliers (domestic/overseas) are important factors. Foreign investors have played role in the acquisition of technology through investing in the food firms. Technology (e.g. machinery, know-how, experts) has been transferred through this channel. Overseas market competitors force the firms to adopt new technology because of competitive reason. Overseas customers help the firms in the acquisition of technology through the introduction of new product

specifications and production process and management technology (e.g. quality control), and, sometimes, technology required for the production of new products. They also directly force the firms to acquire technology used for the production of new products. The firms can also benefit from government promotion schemes (tax and other incentives), and the roles of the Board of Investment in the acquisition of technology (e.g. machinery, experts) from abroad. However, other factors (e.g. size of firm, age of firm, market orientation) are not found significant in the regression analysis.

As in acquisitive capability, for **operative capability** overseas customers and overseas market competitors are found very important. But foreign investors and government promotion schemes, as well as other factors (e.g. size of firm, age of firm, market orientation) do not appear as significant variables in the regression analysis. Firm-level factors (i.e. the accumulation of its own experience, policy and strategy, management and administration, and staff training programmes) and availability of investment funds are also very important. As in acquisitive capability, machinery suppliers are also important for the firms in operative capability.

Like operative capability, for **adaptive capability** the various explanatory variables tested (size of firm, ownership status, market orientation, promotion status, age of firm, and main-product type) do not appear significant in our regression analysis. However, analysis carried out on the basis of perception of firms for the enhancement of adaptive capability reveals high scores for factors such as overseas customers, overseas market competitors, firm-level experience, staff training programmes, domestic market competitors, management and administration, and policy and strategy.

In **innovative capability,** foreign investors, investment promotion schemes, and non-export orientation are some important explanatory variables. As in acquisitive capability, foreign investors play this role through investing in the food firms, and they can supply technology and resources required for undertaking innovative activities. The firms also can use benefits derived from tax exemption and other schemes provided by the Board of Investment to invest in innovative activities. Non-export

oriented firms may be able to identify customer demands in domestic market and they may also have undertaken more innovative activities (e.g. changes and modification of products, and R&D for finished products) to sell products in this market. Size of firms also shows a positive relationship with the level of innovative capability, that is large firms have more capabilities (the competence of resources required) in carrying out innovative activities. Based on perception studies, overseas customers, overseas market competitors, availability of fund, and firm-experience are found very important factors. Also, other firms' internal factors (i.e. policy and strategy, management and administration, and staff training programmes) are important.

In terms of the **development of new products**, as in innovative capability, size of firms appears as a significant variable. However, no other variables including ownership status, market orientation, promotion status, age of firm, and main-product type (which we have tested in the regression analysis) emerge as significant. In the meanwhile, our analysis based on the pair-comparison approach reveals that some of the firm-level internal factors such as policies and strategies, management and administration, the commitment and attitude of the owners/managers, R&D efforts, good internal and external linkages and information system, the sufficient of fund for conducting R&D and human resource development, and good promotion and reward systems are found as determinants of this effort.

9.2 Policy Implications

Given that technological capability building is the result of various internal and external factors playing a combined role, one finds a case for close and systematic co-operation between producers (through associations), government and various other agencies including universities and R&D institutions directly or indirectly involved in the building of technological capability. In the meanwhile, it is important to recognise that the long-term success of the industry depends on various factors being involved in the entire production process e.g. raw materials (production, harvesting, storage, and transportation), production (machinery and equipment, techniques, management and quality control system, packaging, waste utilisation), market (local, overseas) and marketing (market research, new product development, sales promotion, distribution

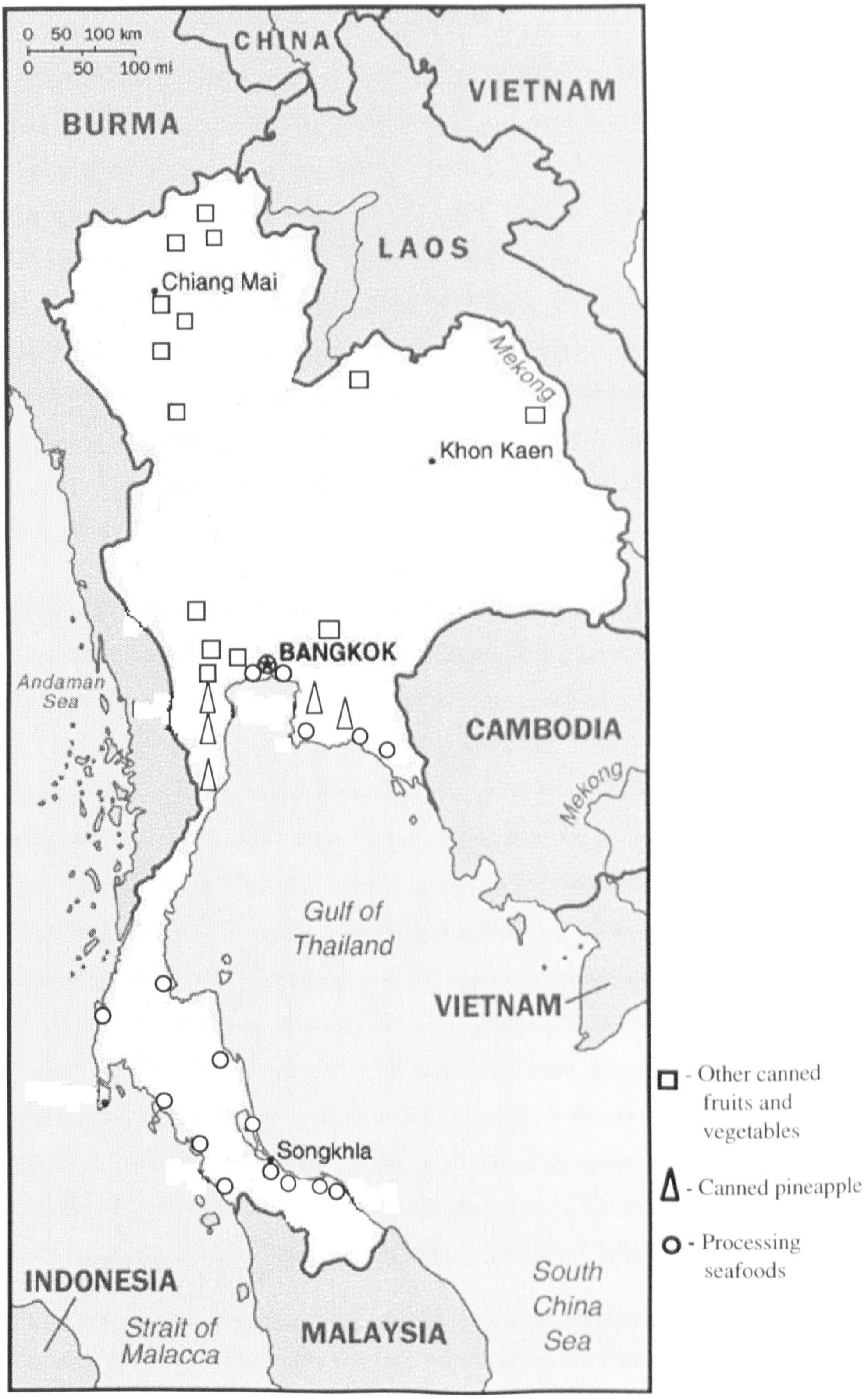
channels (Pass *et al.*, 1993)), and environment management. This means the co-operation may have to consider the whole process of the industry.

Furthermore, although the study finds that the competitive pressure is one of the important factors bringing about the enhancement of the firm's technological capability, large firms appear to have advantages over small and medium firms in undertaking many activities. Thus, the intervention of government may be necessary to help small and medium sized firms, especially those located in regional areas. One of the beneficial interventions is the creation of supportive activities, such as the development of S&T infrastructure, information and technical services, human resource development, and financial services. Moreover, in order to enable R&D activities, which extend to major improvement or development of new products and production processes to be undertaken by many firms, the support for technological R&D, to ensure that these firms have access to information and advice on the application of new technology or to ensure that they can be supplied in areas where they lack sufficient resources and capacity to pursue the activities themselves, would be beneficial.

In addition, this study finds that various internal factors can largely influence the enhancement of the industry's technological capability. Hence, any effort to bring about the realisation and implementation of these factors by the manufacturers is important. A critical point is how the new management system, and long-term and dynamic competitive strategy are perceived and realised by the firms' owners/managers. This also includes active strategies through attempts to improve internal technical capacity, human resource development, good reward systems (and the improvement of working conditions and welfare), systematic information flows, close co-operation between various units (such as R&D, marketing, and production), and active participation in technological activities by the firm's personnel at various levels.

APPENDICES

Appendix 3.1 Main Locations of the Food Processing Industry in Thailand



Appendix 3.2

The Quality Control Systems

Normally, the quality control (QC) system refers to the efficient and continuous work of management so as to bring about the qualified products responding to consumer's demand or satisfaction. Since the food industry directly affects the health of the consumer, the quality of products is extremely important. The QC can be classified into several systems, such as Total Quality Control (TQC), Total Quality Management (TQM), Good Manufacturing Practice (GMP), Hazard Analysis and Critical Control Point (HACCP), and Quality Control Circle (QCC). Although these systems are different in terms of the scope of work, the preparation of teamwork and executive, and the requirements of customers, they need the same final results to satisfy customers. This requires good understanding by the firm's personnel at every level (Edward, 1996).

In the food industry, the international food standard committee has improved the standard of food by using HACCP as a guideline. Many importing countries such as the USA, Canada, the EU, Australia and New Zealand have employed this system in the control of aquatic animal products, including the importation of the products from other countries. Japan also has to adapt its QC system to be consistent with the HACCP principle. Moreover, the United States Food and Drug Administration (USFDA) has required the producers who want to export their seafood products to the US to implement the HACCP system in their production since 18 December 1997. Regarding this requirement, the producers/exporters have to prepare a HACCP plan for the US importers, including the details of practice and evidence of the implementation. They have to ask for a HACCP certificate from the government or private agencies (recognised by the USFDA) (for exporting products to USA, the producers have to ask for a certificate from government agencies in exporting countries, or undertake the factory and production inspection by USFDA officials or a Third party, or permit a random check for importing products)[1] (Food Journal of

[1] The USFDA requires both domestic and overseas producers to register and submit the details of processing techniques directly to it so as to guarantee the safety of low-acid canned food (Siripanish, 1995, p.29).

Thailand, 1997, p.35) The roles of government and related agencies concerning the quality control activities will be covered in Chapter 4.

The tests of food safety, hygiene and cleanliness required by some importing countries are as follows:

USA - Orandeptic test (or sensory test) to test for the decomposition of products;
- The contaminate inspection of the USA comprises filth analysis (for inspecting foreign components such as insects and hair, micro analysis (for inspecting Clostridium Botulinum), and food composition (outside appearance - colour and smell));

Japan - Food sanitary law (regulation and quality test of Japan);

EU - Veterinary and phytosanitary control;
- the test of Ethylene Diamine Tetra Acetate (EDTA) substance contained in canned seafoods.

(Siripanish, 1995, pp.28-29; and Chittungsomboon, 1996, p.34)

Appendix 3.3 Seasonal Availability of Major Fruits and Vegetables in Thailand

Type	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fruits												
Pineapple	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
Rumbutan				▬	▬	▬	▬	▬	▬			
Longan						▬	▬	▬	▬			
Lychee			▬	▬	▬	▬	▬					
Mango			▬	▬	▬	▬						
Guava							▬	▬	▬			
Passion fruit							▬	▬	▬	▬		
Vegetables												
Baby corn	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬
Bamboo shoot							▬	▬	▬	▬	▬	▬
Asparagus					▬	▬						
Tomato	▬	▬	▬	▬								▬
Ginger											▬	▬
Mustard leaf	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬

Source: BOI (1993), Annex A, Table A5.2.

Appendix 4.1

Sources of Primary Data from Relevant Agencies

The Office of Food and Drug Administration, The Ministry of Public Health

Department of Medical Sciences, The Ministry of Public Health

Thai Industrial Standard Institute, The Ministry of Industry

The Northern Industrial Economic Centre, Office of Industrial Economics, The Ministry of Industry

The Southern Industrial Economic Centre, Office of Industrial Economics, The Ministry of Industry

Department of Science Services, The Ministry of Science, Technology and Environment

Food Industry Department, Thailand Institute of Science and Technological Research

Department of Fisheries, The Ministry of Agriculture and Agricultural Cooperatives

Department of Agriculture, The Ministry of Agriculture and Agricultural Cooperatives

Faculty of Agro-Industry and/or Department of Food Technology (Various Universities)

-Kasetsart University

-Chulalongkorn University

-Chiangmai University

-Prince of Songkhla University

-King Mongkut Institute of Technology North Bangkok

-King Mongkut Institute of Technology Ladkrabang

Institute of Food Research and Product Development, Kasetsart University

Nutrition Research Institute, Mahidol University

Agro-Industry Development Centre for Export, Prince of Songkhla University

Institute for Science and Technology Research and Development, Chiangmai University

National Center for Genetic Engineering and Biotechnology, National Science and Technology Development Agency

National Food Institute

Industrial Finance Corporation of Thailand

Small Scale Industry Finance Corporation

Credit Guarantee for Small-scale Industry Corporation

Thailand Productivity Institute

Thai Food Processors' Association

Thai Frozen Food Association

Appendix 4.2

Questionnaire for Related Agencies

1. What are the roles and responsibilities of your organisation with regard to the development of the food industry?

2. What are the contributions of your organisation with regard to the creation of technological capability of the food industrial firms?

( ) The test and analysis of product quality

( ) R&D activities (please specify the nature of research)

( ) Human resource development (please specify the characteristics of activities and the type of programme)

( ) Information services (please specify the type of information)

( ) Advice (please specify the type and contents of the advice)

( ) Others (please specify) _____

3. Has your organisation had any cooporation with other agencies (government and/or private sectors) in order to enhance the technological capability of the food industry? If so, what are the activities?

4. Has your organisation ever faced any difficulties in the activities regarding to the creation of technological capability in the food industry?

5. What are your suggestions regarding the development of the food industry, especially regarding the enhancement of technological capability, in order to allow the industry to further play a crucial role in the development of the Thai economy (particularly both in terms of the growth and the competitiveness of the industry in the world market)?

Appendix 4.3.

The Role of Government and Related Agencies Concerning Various Activities

Agency	Activity							
	The analysis of product quality	R&D	Human resource development	Information service	Technical service	Raw material development	Financial service	Marketing and export
Ministry of Public Health								
1.Office of Food and Drug Administration	/	/	/	/	/			
2.Department of Medical Sciences	/	/	/	/	/			
Ministry of Industry								
1.Thai Industrial Standard Institute		/	/	/	/			
2.Department of Industrial Promotion				/	/			
3.Office of Industrial Economics				/				
Ministry of Science, Technology and Environment								
1.Department of Science Services	/	/	/		/			
2.Thailand Institute of Scientific and Technological Research	/	/	/		/			
3.Office of Technology Transfer and Promotion							/	
4.Office of Atomic Energy for Peace	/							

Appendix 4.3 (continued)

Agency	Activity							
	The analysis of product quality	R&D	Human resource development	Information service	Technical service	Raw material development	Financial service	Marketing and export
Ministry of Agriculture and Cooperatives								
1.Deparment of Fisheries	/	/	/	/	/	/		/
2.Department of Agricultural Extension						/		
3.Department of Agriculture	/					/		
Ministry of Commerce								
1.Department of Export Promotion								/
2.Department of Foreign Trade								/
Ministry of Finance								
1.Customs Department								/
Universities								
1.Faculties (various universities)	/	/	/		/			
2.Institute of Food Research and Product Development, KU	/	/	/	/	/			
3.Nutrition Research Institute, MU		/	/	/				
4.Agro-Industry Development Centre for Export, PSU	/	/	/	/	/			

Appendix 4.3 (continued)

Agency	Activity							
	The analysis of product quality	R&D	Human resource development	Information service	Technical service	Raw material development	Financial service	Marketing and export
Government-supported Agency								
1.National Centre for Genetic Engineering and Biotechnology		/	/	/				
2.National Food Institute	/	/	/	/	/			
3.Industrial Finance Corporation of Thailand							/	
4.Small Industry Finance Corporation							/	
5.Credit Guarantee for Small-scale Industry Corporation							/	
6.Thailand Productivity Institute			/					
7. Export-Import Bank							/	/
Trade/Industry Association								
1.Thai Food Processors' Association			/	/		/		/
2.Thai Frozen Food Association			/	/		/		/

Appendix 4.4

Summary of Investment Incentives

Guarantees

- Against nationalisation
- Against competition from new state enterprises
- Against State monopolisation of the sale of products similar to those produced by promoted project
- Against price controls
- Permission to export
- Against tax-exempt imports by government agencies or state enterprises

Promotion measures (subject to justification and needs)

- Imposition of surcharge on foreign products at a rate not exceeding 50% of the CIF value for a period of not more than one year at a time
- Import ban on competitive products
- Authority by the Chairman to order any assisting actions or tax relief measures for the benefit of promoted projects

Permission

- To bring in foreign nationals to undertake investment feasibility studies
- To bring in foreign technicians and experts to work on promoted projects
- To own land or remit abroad foreign currency

Tax incentives

- Exemption or 50% reduction of business taxes on imported machinery
- 50% duty reduction on machinery subject to import duty greater than or equal to 10%
- 75% import duty reduction on raw materials and necessary inputs used for production for the domestic market for five years. The raw materials must be those not sufficiently available within the country.
- Exemption from import duties on raw materials or necessary inputs used for export products for eight years, for projects with export representing at least 30% of total sales.
- Exemption from corporate income taxes for three to eight years with permission to carry forward losses and deduct them as expenses for up to five years
- Exclusion from taxable income of dividends derived from promoted enterprises during the income tax holiday

Additional incentives for enterprises in special investment zones

- The relaxation of corporation tax to 50% of the normal rate for five years from the date of corporation tax exemption for 10 years
- Double deduction from taxable income of water, electricity, and transportation costs
- The permission to deduct the cost of infrastructure installation (or construction cost) of 25% of total investment from net profit.

Additional incentives for export enterprises

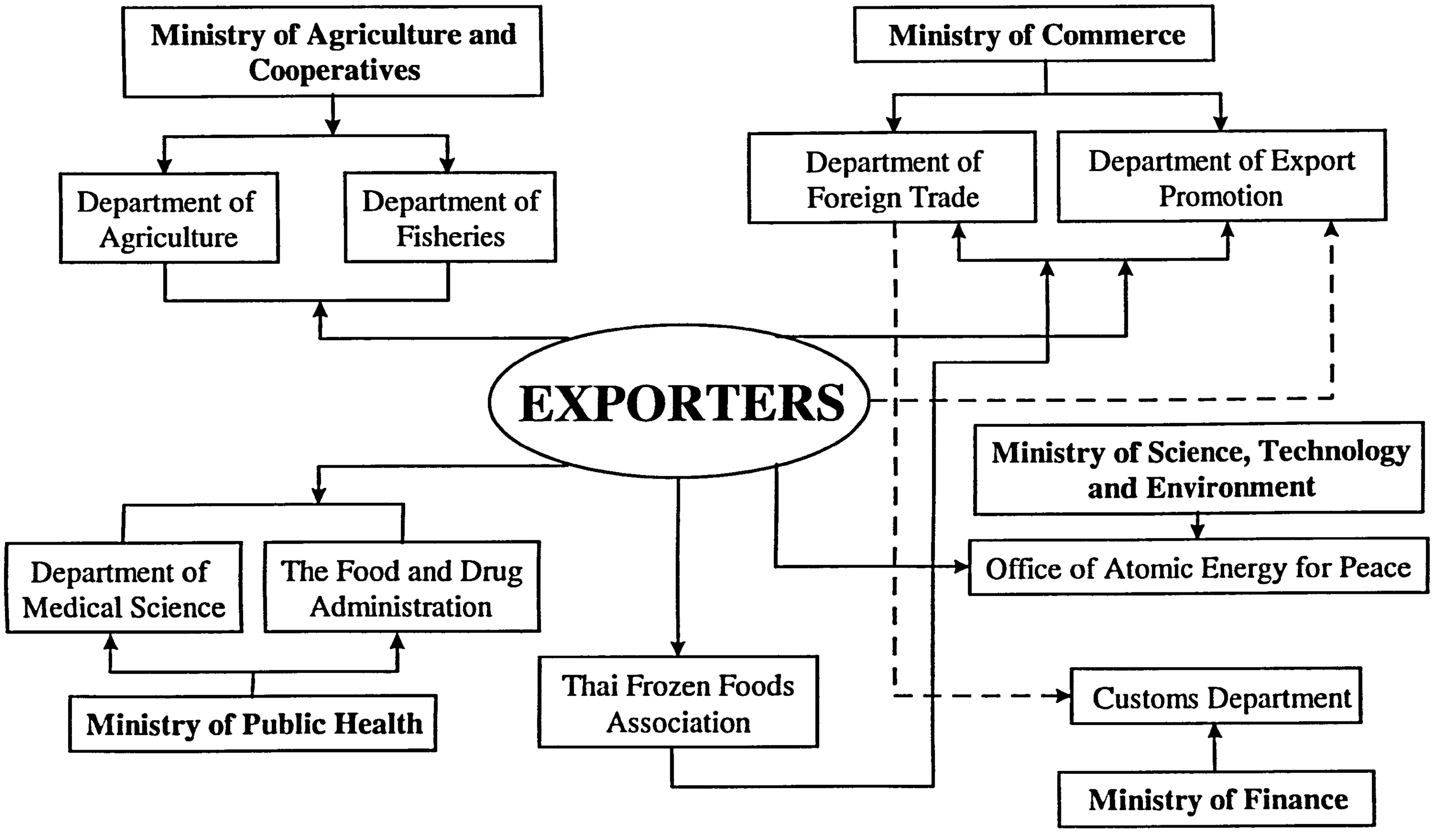
- Exemption of import duties on imported raw materials and components
- Exemption of import duties on re-exported items
- Exemption of export duties
- 5% reduction of the corporate income tax of an increase in income derived from exports over the previous year, excluding the cost of insurance and transportation

Additional incentives for R&D

- Exemption of corporate income tax for three more years
- Exemption on import duties on machinery and equipment used for R&D activities (for eight years)

Source: BOI (1997).

Appendix 4.5 The Flow Chart of Exportation Procedures



Source: Adapted from*Thai Frozen Food Association*,1997, p.33

Appendix 5.1 Data Included in the Regression Analyses Carried out Based on 62 Observations

Firm	ACTC	OPTC	ADTC	INTC	TCdnp	SIZE	OWN1	MARK1	PROM1	AGE	PROD1	PROD2	PROD3
1	2.8	2.57	3	0.57	3	280	1	0	0	5	1	0	0
2	2.6	2.29	2.4	1.42	4	500	1	1	1	9	1	0	0
3	1.8	2.21	2	1.29	4	450	1	1	1	9	1	0	0
4	2.6	2.21	1.8	0.29	3	300	1	1	0	5	1	0	0
5	3	2.43	2.8	3	5	425	0	1	1	3	1	0	0
6	2.5	2.34	1.8	1.14	4	550	1	1	1	11	1	0	0
7	2.1	2.07	2.2	2.14	5	1000	1	1	1	12	1	0	0
8	2.6	2.43	2	1.71	5	3000	1	1	1	26	1	0	0
9	2.4	2.5	1.2	1.57	4	1000	0	1	1	35	1	0	0
10	2	2	1.6	1.71	5	1000	1	1	1	18	1	0	0
11	2.8	2	1.6	1.43	4	250	0	1	0	4	0	0	0
12	2.6	2.43	2.4	0.14	2	35	1	1	0	5	0	0	0
13	2.4	2.29	2	1.86	4	400	1	1	1	8	0	0	0
14	2.1	1.57	1.8	0.14	1	30	1	1	0	13	0	0	0
15	2.8	2.21	2	1.57	3	160	0	1	1	7	0	0	0
16	2.6	2.5	2.2	2.57	6	1672	0	0	1	29	0	0	0
17	2.2	1.78	1.8	2.14	4	84	0	0	1	1	0	0	0
18	2.7	2.07	1.8	0.86	3	120	1	1	0	9	0	0	0
19	2.7	1.93	1.6	1.57	4	170	1	0	0	15	0	0	0
20	2.4	2	2	1.71	5	400	1	0	0	9	0	0	0
21	2.5	1.71	0.8	2.17	5	300	1	0	1	3	0	0	0
22	2.1	2.57	2.4	1.14	4	121	1	1	1	5	0	0	0
23	2.7	1.79	1.4	0.29	3	201	1	1	0	10	0	0	0
24	2.8	2.5	2.4	0.86	3	200	1	0	0	4	0	0	0

Appendix 5.1 (continued)

Firm	ACTC	OPTC	ADTC	INTC	TCdnp	SIZE	OWN1	MARK1	PROM1	AGE	PROD1	PROD2	PROD3
25	2.1	1.71	2.2	0.86	3	60	0	1	1	8	0	0	0
26	2.5	1.71	2.2	1.29	4	400	0	0	1	8	0	0	0
27	2.7	2	1.6	1.14	4	56	0	1	0	4	0	0	0
28	2.4	1.86	2.4	0.86	2	100	1	0	0	4	0	0	0
29	2.5	2.29	0.6	2	6	290	1	1	0	11	0	0	0
30	2.7	2.29	2.4	1.29	3	350	0	1	0	10	0	0	0
31	2	2	2	2.14	6	2500	0	1	1	11	0	0	0
32	2.2	2.14	2	0.86	3	915	0	1	1	7	0	1	0
33	3	2.57	2	2.43	6	1800	0	1	1	18	0	1	0
34	2.1	1.86	2	1	4	500	0	1	1	8	0	1	0
35	2.2	2.29	2.6	1.14	5	4400	1	1	1	20	0	1	0
36	2.7	1.71	1.6	0.57	3	900	1	1	0	8	0	1	0
37	2.1	2.43	1.8	1.29	5	860	0	1	1	19	0	1	0
38	1.8	2.07	1.2	0.86	4	728	1	0	1	11	0	1	0
39	2.4	2.07	2.2	1.14	3	182	1	1	1	8	0	1	0
40	2.5	2.5	1.6	1.86	6	3000	1	1	1	9	0	1	0
41	2.4	1.93	1.6	1.33	4	1283	1	1	1	11	0	1	0
42	2.1	2.43	1.6	1.14	4	350	1	1	1	17	0	1	0
43	2.2	1.86	2	1.43	6	1650	1	1	1	17	0	1	0
44	2.4	1.79	1.6	2.14	6	1220	1	1	1	10	0	1	0
45	2.1	2.21	2	1.33	5	560	1	1	1	15	0	1	0
46	2.2	2.14	1.8	2	6	850	1	0	1	18	0	1	0
47	2.3	2.14	1.6	1.57	5	3000	1	1	1	16	0	1	0
48	2.3	2.07	1.6	1.29	6	450	1	1	0	14	0	1	0

Appendix 5.1 (continued)

Firm	ACTC	OPTC	ADTC	INTC	TCdnp	SIZE	OWN1	MARK1	PROM1	AGE	PROD1	PROD2	PROD3
49	2.5	2.57	2	2.71	6	800	0	1	1	20	0	1	0
50	2.5	2.14	1.8	2	4	571	1	1	1	3	0	0	1
51	2.1	2.43	1.6	0.86	4	1500	1	1	1	9	0	0	1
52	2.2	2.14	1.6	1.86	4	781	1	1	1	8	0	0	1
53	2.4	2.43	1.6	1	4	346	1	1	0	11	0	0	1
54	2.5	2.43	2	1	4	354	0	1	0	6	0	0	1
55	2.3	2.21	2.4	2.43	5	665	0	1	1	15	0	0	1
56	1.9	2.29	1.8	1	4	700	1	1	1	7	0	0	1
57	2.7	2.14	1.22	1.71	5	950	1	0	1	11	0	0	1
58	2.6	2.64	2	2	6	3350	0	1	1	9	0	0	1
59	2.8	2.71	2.4	2.71	5	500	1	0	1	8	0	0	1
60	2.8	1.93	1.8	1.14	4	900	0	1	1	24	0	0	1
61	2.1	2.29	1.8	1	4	975	1	1	1	11	0	0	1
62	2.2	2.43	2.63	1.86	6	2000	1	1	1	14	0	0	1

Note: ACTC = acquisitive technological capability, OPTC = operative technological capability, ADTC = adaptive technological capability, INTC = innovative technological capability. (Scores used:1 - 3, Low, Medium and High levels, for estimating the respective values, see Chapter 5); TCdnp = the degree of firm's technological capability to develop new products (1 - 6 scale has been used, see Chapter 5); SIZE = size of firm, defined by number of workers; AGE = age of firm, defined by number of years since establishment.

OWN = ownership status:

OWN_1 = 1 if a wholly Thai-owned firm

= 0 otherwise

MARK = market orientation:

$MARK_1 = 1$ if an export-oriented firm, i.e. export ≥ 80% of total sales

$= 0$ otherwise

PROM = promotion status:

$PROM_1 = 1$ if a promoted firm

$= 0$ otherwise

PROD = main product

$PROD_1 = 1$ if a canned pineapple firm

$= 0$ otherwise

$PROD_2 = 1$ if a canned seafood firm

$= 0$ otherwise

$PROD_3 = 1$ if a frozen seafood firm

$= 0$ otherwise

$PROD_1 = 0$, $PROD_2 = 0$, and $PROD_3 = 0$ refer to other canned fruits and vegetable firm.

Appendix 6.1

Questionnaire for the Firms

Part I

1.1 Firm Profile

1.2 Technological Capability in Developing New Products

Part II

2.1 The Activities Regarding the Building of the Firm's Technological Capability

2.2 Factors Influencing the Enhancement of the Four Elements of Technological Capability

Part III

3.1 Policies, Strategies, and Management

3.2 Human Resource Development

3.3 Research and Development

3.4 Information and Linkage Systems

3.5 The Role of Foreign Partner(s) or Foreign Investor(s)

3.6 The Role of Government and Related Institutions

Part 1

1.1 Firm Profile

1.1.1 Year of establishment:_____

1.1.2 What are the products of your company?

Main product(s) _____
Others (please specify)_____

1.1.3 Type of ownership:

( ) Wholly Thai-owned
( ) Joint-venture: Thai _____ (%), Foreign (please specify) _____ (%)
( ) Wholly foreign-owned (please specify) _____

1.1.4 Did your firm receive promotion from The Board of Investment?

1) Start-up ( ) Yes ( ) No
2) Present ( ) Yes ( ) No

1.1.5 What is the market orientation of your products?

1) Domestic market _____ (%) of total sales
2) Foreign market _____ (%) of total sales

1.1.6 Personnel (person)

1) Total number of employees:_____
2) Number of unskilled labourers (full time/part time): _____

1.1.7 Is your company a member of a business group?

( ) No.
( ) Yes. (please specify) _____

1.1.8 Is your company a member of any trade/industry associations?

( ) No.
( ) Yes. (please specify) _____

1.2 Technological Capability in Developing New Products

According to the information in the table below, please specify the number that refers to the condition of your company (technologies refers to both machinery and equipment, and know-how used in the production).

Number: _____

Level of Technological Capability in Developing New Products
1 - The firm buys all technologies and performs only operation.
2 - The firm buys technologies, but it adapts its own products and packaging in order to use available raw materials.
3 - The firm produces similar products available in the market, but it develops and modifies its own products in order to meet market needs.
4 - The firm produces similar products available in the markets, but it improves production processes and performances through the efforts of its own and/or external R&D and related personnel.
5 - The firm produces similar products available in the markets, but it improves production processes and performances through the efforts of its own and/or external R&D and related personnel. Furthermore, the firm has introduced its own new products which are similar to other products in the markets.
6 - The firm designs and produces its own unique products, which are not imitations of other products in the markets.

Part II

2.1 The Activities Regarding the Building of the Firm's Technological Capability

Please read the following description before answering the questions listed below.

Minor improvement in acquired technologies refers to some improvements in machinery and equipment and/or know-how used in production so as to reduce cost of production and/or to improve efficiency.

Major improvement in acquired technologies refers to substantial improvements in machinery and equipment and/or know-how used in production to reduce cost of production and/or to improve efficiency.

Minor product modification refers to some modifications of product features so as to suit the needs of the market.

Radical product modification refers to the radical modification of the products, e.g. the introduction of new functional features of products, so as to respond to market needs.

Minor process modification refers to some modifications of process or minor changes in product lines so as to suit the needs of the market.

Radical process modification refers to the radical modification of the process, e.g. the introduction of new production lines by radically modifying the existing process, so as to respond to market needs.

2.1.1 Has your company ever undertaken the activities mentioned in the table below? If so, how were they undertaken? (External assistance refers to any assistance from those resources (e.g. personnel, know-how, and facilities) from outside your organisation and own business group and foreign partner(s) or foreign company.)

Activity	Yes	No	Dependence on external assistance		
			Complete	Partial	None
Duplication of machinery and equipment acquired					
Adaptation of machinery and equipment to suit raw materials and other factors					
Minor improvement in acquired technologies					
Major improvement in acquired technologies					
Minor product modification					
Major product modification					
Minor process modification					
Major process modification					
New product development					
New process development					
Commercialisation of benefits from using research results					

2.1.2 How does your company carry out the activities mentioned in the table below?

Activity	Dependence on external assistance		
	Complete	Partial	None
Search for sources of required technologies			
Negotiation of the terms of acquisition			
Assessment of the technologies offered			
Preparation of the specification to upgrade existing technological sources			
Decision-making on the mode of transfer of technology			
Installation and starting up of the production machinery and facilities			
Maintenance of plant and equipment			
Quality control in production			

2.1.3 Does your company use a computerised system for the activities mentioned in the table below? If so, to what extent?

Activity	Yes	No	Level of use	
			Partial	Extensive
Quality control activities				
Planning and coordination of production operation				
Design of products				

2.1.4 How does your company search for the required technologies?

-Sources of information

( ) Formal

( ) Informal

-Main sources of information

( ) Formal

( ) Informal

( ) Formal/Informal

2.1.5 To what extent is your company able to attain capacity utilisation and its planned production?

-Percentage of capital utilisation (please specify) _____

-Percentage of planned production (please specify) _____

- Rate of defects compared to industrial standard in the same industry

( ) More than double

( ) More than industry standard but less than double

( ) Equal or less than

2.1.6 How does your company maintain the plant and equipment?

( ) Ad-hoc maintenance programme

( ) Routine maintenance programme

( ) Preventive maintenance programme

( ) Other maintenance programmes (please specify)_____

2.1.7 Does your company have enough R&D facilities and personnel supporting R&D work for process/product development? If not, please state the present position.

( ) Yes

( ) No

-The present position _____

2.2 Factors Influencing the Enhancement of the Four Elements of Technological Capability

In this part, the questions are related to the influence of several factors on the enhancement of a company's technological capability, which is considered in terms of four components of capability, i.e. acquisitive capability, operative capability, adaptive capability, and innovative capability. Each Element of the capability includes the activities outlined in the table below.

Elements of Technological Capability	Activity
Acquisitive Capability	Searching for sources of required technologies, assessing technologies offered, negotiating the terms of acquisition, decision-making on the mode of transfer of technology, and preparing the specifications to upgrade existing technologies.
Operative Capability	Installing and starting up machinery and facilities, operating and controlling the plant and equipment, planning and controlling production activities, maintaining the plant and equipment, applying computerised systems for planning and coordination of production operation, undertaking quality control for production process, and applying computerised systems for quality control systems.
Adaptive Capability	Duplicating acquired machinery and equipment, adapting available machinery and equipment to raw materials and other factors, undertaking minor improvement in acquired technology, and undertaking minor product modification.
Innovative Capability	Undertaking major improvement in acquired technology, undertaking radical process modification, undertaking radical product modification, undertaking R&D work for product/process development (the sufficiency of facilities and personnel to conduct R&D), undertaking new product development, undertaking new production process development, deriving commercial benefits from research results.

In the following tables, the questions about the factors that may have an influence on the changes of product and production process, and the enhancement of various components of technological capability of your firm, are put forward in line with the above definitions.

2.2.1 How significantly have the following factors influenced your firm in terms of the changes of product and production process, and the enhancement of various elements of technological capability in the past?

9. Not applicable
1. No influence at all
2. Little influence
3. Some influence
4. Substantial influence
5. Very strong influence

Factor	Influence on the enhancement of technological capability					
1. Internal Factor						
1. 1 Policy and strategy						
-Acquisitive capability	9	1	2	3	4	5
-Operative capability	9	1	2	3	4	5
-Adaptive capability	9	1	2	3	4	5
-Innovative capability	9	1	2	3	4	5
1.2. Management and administration						
-Acquisitive capability	9	1	2	3	4	5
-Operative capability	9	1	2	3	4	5
-Adaptive capability	9	1	2	3	4	5
-Innovative capability	9	1	2	3	4	5
1.3. The accumulation of its own experience (e.g. leaning by doing)						
-Acquisitive capability	9	1	2	3	4	5
-Operative capability	9	1	2	3	4	5
-Adaptive capability	9	1	2	3	4	5
-Innovative capability	9	1	2	3	4	5
1.4 Staff training programmes						
-Acquisitive capability	9	1	2	3	4	5
-Operative capability	9	1	2	3	4	5
-Adaptive capability	9	1	2	3	4	5
-Innovative capability	9	1	2	3	4	5

Factor	Influence on the enhancement of the Four Elements of technological capability					
2. Government						
2.1 Government regulations						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
2.2 Government's tax and other incentives						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
2.3 Technical advice						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
2.4 Government technological information services						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
3 Customers						
3.1 Domestic customers						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
3.2 Overseas customers						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5

Factor	Influence on the enhancement of the Four Elements of technological capability					
4 Competitors						
4.1 Domestic competitors						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
4.2 Overseas market competitors						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
5 Suppliers						
5.1 Machinery and equipment suppliers						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
5.2 Fund suppliers						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
6. Universities						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
7. Trade/industry associations						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5

Factor	Influence on the enhancement of the Four Elements of technological capability					
8. Consulting agencies						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
9. Texts, journals, and reports						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5
10. Others (please specify)						
_____						
- Acquisitive capability	9	1	2	3	4	5
- Operative capability	9	1	2	3	4	5
- Adaptive capability	9	1	2	3	4	5
- Innovative capability	9	1	2	3	4	5

Part III

3.1 Policies, Strategies, and Management

3.1.1. What are the major characteristics of your successful products? (Please state the relative importance: 1 is the most important, 2 is the second most important, and so on)

Products' Characteristics	Order of importance
Product quality	
Low price	
Product differentiation (having more features)	
Having low market competition	
Having advantage from government support	
Using new technology	
Large size of market	
Others (please specify) _____	

3.1.2 What are the major sources of your firm's technology? (Please state the order of importance : 1 is the most important).

Source of firm's technology	Order of importance
Purchase of technology	
Foreign partner or parent company	
Company's parts and components suppliers	
Government agency	
Technical consulting service company	
Trade/industry exhibitions	
Product imitation or reverse engineering	
Company's own R&D activities	
Research papers, technical journals	
Others (please specify) _____	

3.1.3 What are the sources of the machinery, component, and equipment used in the production systems of your enterprise? (Please indicate the areas in the table below by giving √)

Item	Source of purchase		
	Domestic Producers	The Agencies of Foreign Producers Located in Thailand	Foreign Producers/suppliers (Direct Purchase)
Machinery			
Component/ equipment			

3.1.4 What are the technology development strategies of your company?

( ) Cooperation with foreign partner or suppliers
( ) Cooperation with local partner or supplier
( ) Imitation and reverse engineering
( ) Acquisition and adaptation of foreign technology
( ) Acquisition and adaptation of domestic technology
( ) Continuous accumulation of technology and human resource training
( ) R&D activities
( ) Others (please specify) _____

3.1.5 What are the elements of technology required by your company? If more than one, please state the priority: 1 is the highest.

( ) General production technology
( ) General design technology
( ) General production and design technology
( ) Some state-of-art production and design technology
( ) Much state-of-art production and design technology
( ) Others (please specify) _____

3.1.6 What is the major technological thrust of your company?

( ) To produce established products at low cost and of acceptable quality
( ) Modification and/or improvement of existing products
( ) Mainly to develop products for existing needs
( ) Developing new products for existing needs, and for new applications
( ) Others (please specify) _____

3.1.7 Who have been the key persons for introducing new technologies (machinery and know-how concerning production process and products) to your company?

3.1.8 Who have been the key persons to introduce market opportunities to your company?

3.1.9 Have the workers (ranking from basic operators to engineers/supervisors) ever contributed to the changes and improvements in production processes, products of the company? If so, what were their contributions?

3.1.10 How much involvement does your company's top management have in technology development activities?

( ) Assign and delegate responsibility for development to technical managers
( ) Give policy, direction and targets, and approve proposals
( ) Involved in major activities, such as: setting the organisation policy, participating in the technology acquisition process, and assessing technology choice
( ) Allocate budget for technological investment, and give full support to all technology development activities
( ) Others (please specify) _____

3.1.11 What are the characteristics of the top management values for your company?

( ) Emphasis on survival and expansion of existing business
( ) Emphasis on the understanding of market place and the proper use of resources
( ) Emphasis on the growth of current business and the exploration of new business
( ) Emphasis on various factors (such as R&D orientation, markets, production, finance, etc.) in dealing with a firm's external environments
( ) High emphasis on R&D orientation in dealing with a firm's external environments
( ) Others (please specify) _____

3.1.12 What is the characteristic(s) of your company's organisation structure?

( ) Formal and bureaucratic structure with usually poor communication among functional areas
( ) Formal structures but not very bureaucratic, with controlled communication among functional areas
( ) Informal structure with frequent and extensive communication among functional areas
( ) Others (please specify)_____

3.1.13 What is the characteristic(s) of manpower flows in your company?

( ) Low priority for manpower flows. Key roles are not identified.
( ) Flows take place mainly to coordinate marketing and production. Key roles are not easily identified.
( ) Flows encourage personnel to enhance product and to improve production process. Key roles played by specific individuals.
( ) Extensive flows to facilitate interaction between R&D, marketing and production. Key roles played by specific individuals
( ) Extensive flows to facilitate interaction between R&D, marketing and production. Key roles can be played by several individuals.
( ) Others (pleas specify) _____

3.2 Human Resource Development

3.2.1 Could you please describe your company's human resource development programmes? (purposes, short/long term)

3.2.2 What are the manpower development activities which your company provides for employees?

( ) Training in-house for low level personnel
( ) Training overseas for the senior personnel
( ) Sending personnel to participate in seminars/workshops organised by other agencies
( ) Periodic invitation of experts from overseas to meet with highly experienced technologists in the firm
( ) Providing information on technology and science through domestic and overseas subscriptions to journals
( ) Getting the staff to meet unofficially with government officers (including university staff) to exchange knowledge
( ) Sending staff to observe similar operations in the foreign parent firm
( ) Undertaking quality control activity within the firm
( ) Know-how internalisation
( ) Learning (e.g. learning by searching for new know-how, and by using production equipment)
( ) Others (please specify) _____

3.2.3 Could you please describe the company's promotion and reward systems for the employees?

3.2.4 Is financial support for undertaking human resource development activities sufficient? If not, how can your company resolve the problem?

3.3 Research and Development

3.3.1 Does your company have a separate R&D unit or any R&D activities at all? Please state briefly.

3.3.2 What is the main objective of the policy of your company regarding research and development?

3.3.3 What are the characteristics of the R&D activities of your company? If more than one, please state the priority: 1 is the highest.

Characteristics of the firm's R&D activities	Order of priority
Minor adaptation of products and processes	_____
The analysis of product quality	_____
The improvement of product quality	_____
The development of new products	_____
The development of new processes	_____
Applied and development research	_____
Basic, applied and development research	_____
Packaging design and development	_____
Others (please specify) _____	_____

3.3.4 Is financial support for undertaking R&D activities sufficient? If not, how can your company resolve the problem?

3.4 Information and Linkage Systems

3.4.1 What is the nature of information flow in your company?

- Establishment of information flows

  ( ) Within company
  ( ) With external sources

- Aspects of information needed

  ( ) Market development
  ( ) Marketing development
  ( ) Technologies
  ( ) Others (please specify) _____

3.4.2 Are there any internal links between related departments (such as marketing, R&D, production departments) regarding technology development within your company? If so, what are they?

3.4.3 Are there any links between your company and technology sources outside (such as universities, professional communities) and quality technology suppliers? If so, what are they?

3.5 The Role of Foreign Partner(s) or Foreign Investor(s)

3.5.1 If your organisation is a joint-venture or foreign firm, what are the major factors motivating your foreign partner(s) (investor) to invest in Thailand? (If there are more than one factor, please specify the order of relative importance)

Investment motivation	Order of importance
Low labour costs	_____
Qualified labour	_____
Good infrastructure	_____
To benefit from the investment promotion schemes provided by the Thai government	_____
To receive special customs' privileges (e.g. GSP) from the importing countries	_____
Others (please specify) _____	_____

3.5.2 If your organisation is a joint-venture firm, what is the major role of the foreign partner(s) involved in your enterprise? (If there are more than one activity, please specify the order of importance)

Relative activities	Order of importance
Market and marketing	_____
Technology development	_____
Human resource development	_____
Finance	_____
Others (please specify)_____	_____

3.6 The Role of Government and Related Institutions

3.6.1 Government

3.6.1.1 What are the government agencies that are of concern to your company? What are the activities that your company has to deal with?

3.6.1.2 What do you think about the present government regulations? Do they support the food industry properly and adequately?

3.6.1.3 What do you expect the government to do in the enhancement of the technological capability of the food industry?

3.6.2 Trade/industry associations and business group

3.6.2.1 If your company is a member of any trade/industry associations, what are the activities that your company deals with?

3.6.2.2 If your company is member of a business group, what are the activities that your company deals with?

3.6.3 Consulting firms

3.6.3.1 Has your company cooperated with consulting firms in activities regarding the enhancement of technological capability? If so, what are the activities?

3.6.4 Universities

3.6.4.1 Has your company cooperated with universities in activities regarding the enhancement of technological capability? If so, what are the activities? Please also describe briefly the type of co-operation extended.

3.6.5 Technology suppliers

3.6.5.1 Has your company cooperated with technology suppliers in activities regarding the enhancement of technological capability? If so, what are the activities?

3.6.6 Other agencies

3.6.6.1 Has your company cooperated with other agencies (please specify) _____ in activities regarding the enhancement of technological capability? If so, what are the activities?

Appendix 7.1

Acquisitive Technological Capability

$$ACTC_i = \beta_0 + \beta_1 \ln SIZE_i + \beta_2 AGE_i + \beta_3 OWN_i + \beta_4 MARK_i + \beta_5 PROM_i + \beta_6 PROD_{1i} + \beta_7 PROD_{2i} + \beta_8 PROD_{3i} + u_i$$

$ACTC_i$	= 2.5299 +	0.0569$lnSIZE_i$	- 0.0036AGE_i	- 0.1902OWN_i	- 0.1089$MARK_i$	- 0.3081$PROM_i$	+ 0.0863$PROD_{1i}$	- 0.0579$PROD_{2i}$	+ 0.0015$PROD_{3i}$
se	= (0.2422)	(0.0464)	(0.0062)	(0.0772)	(0.0881)	(0.0916)	(0.1207)	(0.1136)	(0.1162)
t	= (10.4457)	(1.2259)	(- 0.5861)	(- 2.4651)	(- 1.2359)	(- 3.3615)	(0.7156)	(- 0.5096)	(0.0127)
sig.	= (0.000)	(0.226)	(0.560)	(0.017)	(0.222)	(0.001)	(0.477)	(0.612)	(0.990)

$R^2 = 0.2761$ $\quad \bar{R}^2 = 0.1668$ $\quad F(8, 53) = 2.2526$ ($sig. = 0.021$) $\quad d = 2.2145$

Diagnostic Tests

Test statistics	LM Version		F Version	
A: Serial Correlation	CHSQ = 0.80217	(0.370)	F (1, 52) = 0.68161	(0.413)
B: Functional Form	CHSQ = 0.02494	(0.875)	F (1, 52) = 0.020930	(0.886)
C: Normality	CHSQ = 0.33142	(0.847)	Not applicable	
D: Heteroscedasticity	CHSQ = 0.37266	(0.542)	F (1, 60) = 0.36282	(0.549)

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

Appendix 7.2

Operative Technological Capability

$$OPTC_i = \gamma_0 + \gamma_1 \ln SIZE_i + \gamma_2 AGE_i + \gamma_3 OWN_i + \gamma_4 MARK_i + \gamma_5 PROM_i + \gamma_6 PROD_{1i} + \gamma_7 PROD_{2i} + \gamma_8 PROD_{3i} + u_i$$

$$OPTC_i = 1.8307 + 0.0452 lnSIZE_i + 0.0039 AGE_i - 0.0443 OWN_i + 0.0036 MARK_i - 0.0486 PROM_i + 0.2008 PROD_{1i} + 0.0319 PROD_{2i} + 0.2167 PROD_{3i}$$

se	= (0.2415)	(0.0463)	(0.0061)	(0.0770)	(0.0879)	(0.0914)	(0.1203)	(0.1133)	(0.1159)
t	= (7.5785)	(0.9763)	(0.6360)	(- 0.5754)	(0.0404)	(- 0.5315)	(1.6687)	(0.2811)	(1.8693)
sig.	= (0.000)	(0.333)	(0.528)	(0.567)	(0.968)	(0.597)	(0.101)	(0.780)	(0.067)

$R^2 = 0.2034$ $\quad \bar{R}^2 = 0.0832$ $\quad F(8, 53) = 1.6923$ ($sig. = 0.122$) $\quad d = 2.6507$

Diagnostic Tests

Test statistics	LM Version		F Version	
A: Serial Correlation	CHSQ = 7.3609	(0.007)	F (1, 52) = 7.0054	(0.011)
B: Functional Form	CHSQ = 0.000758	(0.993)	F (1, 52) = 0.000636	(0.994)
C: Normality	CHSQ = 1.0616	(0.588)	Not applicable	
D: Heteroscedasticity	CHSQ = 4.3242	(0.038)	F (1, 60) = 4.4985	(0.038)

A Lagrange multiplier test of residual serial correlation

B Ramsey's RESET test using the square of the fitted values

C Based on a test of skewness and kurtosis of residuals

D Based on the regression of squared residuals on squared fitted values

Appendix 7.3

Adaptive Technological Capability

$$ADTC_i = \delta_0 + \delta_1 \ln SIZE_i + \delta_2 \ln AGE_i + \delta_3 OWN_i + \delta_4 MARK_i + \delta_5 PROM_i + \delta_6 PROD_{1i} + \delta_7 PROD_{2i} + \delta_8 PROD_{3i} + u_i$$

$ADTC_i$	= 2.2944	- 0.0277 ln$SIZE_i$	- 0.0737 lnAGE_i	- 0.1745OWN_i	- 0.0657$MARK_i$	+ 0.0454$PROM_i$	+ 0.2991$PROD_{1i}$	+ 0.0505$PROD_{2i}$	+ 0.0913$PROD_{3i}$
se	= (0.4037)	(0.0795)	(0.1109)	(0.1288)	(0.1506)	(0.1549)	(0.2029)	(0.1920)	(0.1953)
t	= (5.6837)	(- 0.3477)	(- 0.6645)	(- 1.3549)	(- 0.4367)	(0.2929)	(1.4740)	(0.2629)	(0.4673)
sig.	= (0.000)	(0.729)	(0.509)	(0.181)	(0.664)	(0.771)	(0.146)	(0.794)	(0.642)

$R^2 = 0.0897$ $\quad \bar{R}^2 = -0.0476$ $\quad F(8, 53) = 0.6532$ ($sig. = 0.730$) $\quad d = 2.3580$

Diagnostic Tests

Test statistics	LM Version		F Version	
A: Serial Correlation	CHSQ = 4.1748	(0.041)	F (1, 52) = 3.7542	(0.058)
B: Functional Form	CHSQ = 0.31609	(0.574)	F (1, 52) = 0.26646	(0.608)
C: Normality	CHSQ = 2.5360	(0.281)	Not applicable	
D: Heteroscedasticity	CHSQ = 0.02550	(0.873)	F (1, 60) = 0.02469	(0.876)

A. Lagrange multiplier test of residual serial correlation

B. Ramsey's RESET test using the square of the fitted values

C Based on a test of skewness and kurtosis of residuals

D Based on the regression of squared residuals on squared fitted values

Appendix 7.4

Innovative Technological Capability

$$INTC_i = \lambda_0 + \lambda_1 \ln SIZE_i + \lambda_2 \ln AGE_i + \lambda_3 OWN_i + \lambda_4 MARK_i + \lambda_5 PROM_i + \lambda_6 PROD_{1i} + \lambda_7 PROD_{2i} + \lambda_8 PROD_{3i} + u_i$$

$INTC_i$	= 0.3195 +	0.2499$lnSIZE_i$	- 0.0877$lnAGE_i$	- 0.2884OWN_i	- 0.2998$MARK_i$	+ 0.5138$PROM_i$	- 0.1596$PROD_{1i}$	- 0.3448$PROD_{2i}$	- 0.2051$PROD_{3i}$
se	= (0.4752)	(0.0937)	(0.1306)	(0.1516)	(0.1772)	(0.1823)	(0.2388)	(0.2260)	(0.2299)
t	= (0.6723)	(2.6677)	(- 0.6719)	(- 1.9013)	(-1.6916)	(2.8181)	(- 0.6684)	(- 1.5259)	(- 0.8923)
sig.	= (0.504)	(0.010)	(0.505)	(0.063)	(0.097)	(0.007)	(0.507)	(0.133)	(0.376)

$R^2 = 0.4228$ $\quad \bar{R}^2 = 0.3357$ $\quad F(8, 53) = 4.8525$ ($sig. = 0.000$) $\quad d = 2.0936$

Diagnostic Tests

Test statistics	LM Version		F Version	
A: Serial Correlation	0.21778	(0.641)	F (1, 52) = 0.18330	(0.698)
B: Functional Form	0.31815	(0.573)	F (1, 52) = 0.26821	(0.607)
C: Normality	1.9064	(0.386)	Not applicable	
D: Heteroscedasticity	0.73685	(0.391)	F (1, 60) = 0.72166	(0.399)

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

Appendix 7.5

The Statistical Values Concerning the Test of Multicollinearity

Indicator	Statistical value
Partial correlation between independent variables	0.007 ≤ correlation ≤ 0.548
Tolerance value	0.443 ≤ tolerance ≤ 0.875
Variance Inflation Factors (VIF)	1.143 ≤ VIF ≤ 2.256
Eigenvalue	≥ 0.008722
Condition Index	≤ 26.115

Therefore, according to the statistics presented in Appendix 7.5, the level of multicollearity in the models could be tolerated.[1]

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[1] According to Gujarati (1995), the statistical values concerning the indicator of the problem of multicollinearity are pointed out as follows:

Indicator	Statistical value	The level of multicollinearity
R^2 between independent variables	> 0.80	high
VIF	≥ 10	high
Condition index	10 - 30	moderate to strong

SPSS Inc (1996a) also indicates that the condition index greater than 15 indicates a possible problem and index greater than 30 suggests a serious problem with collinearity. Concerning 'Tolerance value', SPSS Inc (1993) indicates that the tolerance value less than 0.001 is unacceptable and is not permitted to enter the analysis.

Appendix 8.1

Technological Capability in Developing New Products

$$TCdnp_i = \alpha_0 + \alpha_1 \ln SIZE_i + \alpha_2 AGE_i + \alpha_3 OWN_i + \alpha_4 MARK_i + \alpha_5 PROM_i + \alpha_6 PROD_{1i} + \alpha_7 PROD_{2i} + \alpha_8 PROD_{3i} + u_i$$

$TCdnp_i$	= - 0.0269	+ 0.7325$lnSIZE_i$	+ 0.0090AGE_i	- 0.1400OWN_i	- 0.2736$MARK_i$	+ 0.2513$PROM_i$	- 0.4796$PROD_{1i}$	- 0.1758$PROD_{2i}$	- 0.3474$PROD_{3i}$
se	= (0.7855)	(0.1505)	(0.0200)	(0.2503)	(0.2858)	(0.2972)	(0.3914)	(0.3686)	(0.3769)
t	= (-0.0343)	(4.8662)	(0.4527)	(- 0.5594)	(- 0.9570)	(0.8453)	(- 1.2254)	(- 0.4768)	(- 0.9216)
sig.	= (0.973)	(0.000)	(0.653)	(0.578)	(0.343)	(0.402)	(0.226)	(0.635)	(0.361)

$R^2 = 0.5307$ $\quad \bar{R}^2 = 0.45.99$ $\quad F(8, 53) = 7.4923$ ($sig. = 0.000$) $\quad d = 2.1832$

Diagnostic Tests

Test statistics	LM Version		F Version	
A: Serial Correlation	CHSQ = 0.70387	(0.401)	F (1, 52) = 0.59712	(0.443)
B: Functional Form	CHSQ = 0.85759	(0.354)	F (1, 52) = 0.72936	(0.397)
C: Normality	CHSQ = 0.84650	(0.655)	Not applicable	
D: Heteroscedasticity	CHSQ = 0.26788	(0.605)	F (1, 60) = 0.26037	(0.612)

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

Appendix 8.2A Internal Factors of Selected Canned Pineapple Firms

Internal Factor	CP3 (low TCdnp)	CP5 (high TCdnp)
Policy, Strategy and Management		
The major characteristics of successful products (in priority)	1. product quality 2. the use of new technology 3. low price	1. product quality, and product differentiation 2. the use of new technology 3. low price
Major sources of the firm's technology (in priority)	1. machinery and component suppliers, and product imitation or reverse engineering	1. product imitation 2. foreign partner or foreign company 3. machinery and component suppliers
Technology development strategy	1. the acquisition and adaptation of technology from overseas sources	1. R&D activities 2. the continuous accumulation of technology and human resource development 3. the acquisition and adaptation of technology from domestic sources
The elements of technology required	1. much state-of-the-art production technology	1.some state-of-the-art production and design technology
The major technological thrust	1.the production of established product at low costs and of acceptable quality 2. the production of products for existing needs (market demand)	1. the development of products for existing needs 2. the development of new products for existing market.
The key persons introducing new technologies to the firm	1. machinery and parts producers/suppliers	1. the advice of the firm's executive
The key persons introducing market opportunities to the firm	1. customers	1. foreign partners 2. foreign customers
The contribution of workers regarding the changes and improvements of products and production process of the firms	1. the improvement of machinery efficiency	1.in terms of management and administration (daily meeting in the factory concerning the solution of problems which emerge, weekly discussion on related projects, monthly company meeting

Appendix 8.2A (continued)

Internal Factor	CP3 (low TCdnp)	CP5 (high TCdnp)
The involvement of the firm's top management in technological development activities	1. being involved in major activities, such as setting the organisation policy, participating in the technology acquisition process, assessing technology choice 2. allocate budget for technological investment, and give full support to all technology development activities	same as CP3
The top management values	1. the understanding of market place and the proper use of resources 2. the growth of current business and the exploration of new business	1. the survival and expansion of existing business 2. the growth of current business and the exploration of new business 3. various factors (e.g. R&D orientation, markets, production, finance) in dealing with the firm's external environments
The firm's organisational structure	formal structures but are not very bureaucratic with controlled communication among functional areas	same as CP3
Manpower flows	mainly to coordinate activities between marketing and production departments, but key roles cannot be identified	low manpower flows, but the responsibilities can be substituted by each other
Human Resource Management		
Human resource development activities	see Table 8.2B	see Table 8.2B
Financial support for HRD activities	sufficient	sufficient (can also obtain funds from foreign partner)

Appendix 8.2A (continued)

Internal Factor	CP3 (low TCdnp)	CP5 (high TCdnp)
The promotion and reward systems	salary and bonus	salary, special allowance, grading workers into various groups (e.g. A, B, C) at the end of the year, holding a competition to recognise the good performance between workers, controlling food prices at the factory canteen, promoting the establishment of a co-operative shop within the firm, providing lockers, arranging study tour for workers
Research and Development		
R&D unit	not separated from other departments	separated from other departments
R&D activities (in priority)	1. the analysis and improvement of product quality 2. the modification of products to respond to market demand	1. the analysis and improvement of product quality 2. the development of new products 3. minor adaptation of products and production processes 4. the development of new production processes 5. Basic, applied and development research
Financial support	sufficient	sufficient (also receive funds from foreign partner)
Information and linkage systems		
Information flows	internal information flows (information: marketing)	internal and external information flows (information: market and marketing)
Internal links	internal links between related departments	internal links between related departments

Source: Study Survey, 1997.

Appendix 8.2B Human Resource Development Activities of Selected Canned Pineapple Firms

Activities	CP3 (low TCdnp)	CP5 (high TCdnp)
1. Training in-house for every level of personnel	/	/
2. Training overseas for the high level of personnel		/
3. Sending personnel to participate in seminars/workshops organised by other agencies	/	/
4. Periodic invitation of experts from overseas to meet with highly experienced technologists of the firm		/
5. Providing information on technology and science through domestic and overseas subscriptions to journals	/	/
6. Getting the staff to meet unofficially with government officers (including university staff) to exchange knowledge		/
7. Sending staff to observe similar operations in the foreign parent firm		/
8. Internal information flows	/	/
9. Undertaking QC activities	/	/

Source: Study Survey, 1997.

Appendix 8.3A Internal Factors of Selected Other Canned Fruit and Vegetable Firms

Internal Factor	**CFV8** (low TCdnp)	**CFV12** (high TCdnp)	**CFV3** (low TCdnp)	**CFV19** (high TCdnp)
Policy, Strategy and Management The major characteristics of successful products (in priority)	1. product quality 2. low price	1. product quality 2. low prices 3. the use of new technology	1 product quality 2. product differentiation 3. large size of market 4. low price	product quality, the use of new technology, large size of market, follow-on to the problems with customers. (All of them share the same level of importance).
Major sources of the firm' technology (in priority)	1. Machinery and component suppliers 2. product imitation	1. Machinery and component suppliers 2. product imitation or reverse engineering 3. own R&D activities 4 the purchase of technology 5. trade/industry exhibitions 6. related documents 7. government agencies	1. Machinery and component suppliers 2. trade/industry exhibitions	own R&D activities, the purchase of technology, the accumulation of its own experience (All of them share the same level of importance).
Technology development strategy	1. the acquisition and adaptation of technology from domestic sources	1 cooperate with the domestic suppliers 2. the acquisition and adaptation of technology from domestic sources	1. product imitation or reverse engineering 2. the acquisition and adaptation of technology from domestic sources	1. R&D activities 2. the continuous accumulation of technology 3. human resource development

Appendix 8.3A (continued)

Internal Factor	CFV8 (low TCdnp)	CFV12 (high TCdnp)	CFV3 (low TCdnp)	CFV19 (high TCdnp)
The elements of technology required	general production technology	1. general production technology 2. some state-of-the-art design and production technology	1. general production technology	1. general production technology 2. some state-of-the-art production and design technology
Major technological thrust	1.the production of established product at low costs and of acceptable quality	1. the production of established product at low costs and of acceptable quality 2.the production of products for existing needs (market demand)	1. the production of established product at low costs and of acceptable quality	1.modification and improvement of existing products 2. the development of new products for market demand
The key persons introducing new technologies to the firm	1 domestic machinery and parts producers/suppliers	1 domestic machinery and parts producers/suppliers 2. customers	1.technology suppliers 2.the Thai Industries Federation (for environment management)	1. customers 2. the firm's teamwork
The key persons introducing market opportunities to the firm	1. overseas customers or brokers	1. own efforts (about 70%) 2. trading agencies (about 30%)	customers	1.firm's personnel 2.customers

Appendix 8.3A (continued)

Internal Factor	CFV8 (low TCdnp)	CFV12 (high TCdnp)	CFV3 (low TCdnp)	CFV19 (high TCdnp)
The contribution of workers regarding the changes and improvements of products and production process of the firms	the improvement of productivity and in maintaining the quality of product	the improvement of production process and machinery and equipment	none	the improvement of machinery and equipment to increase productivity and efficiency This firm emphasises a 'teamwork strategy' in carrying out various activities.
The involvement of the top management in technological development activities	1. assign and delegate responsibility to the technical manager 2. being involved in major related activities	1. allocate a budget for technological investment and give full support to all related activities	1. assign and delegate responsibility to the technical manager 2. give policy, direction and targets, and approve the proposal	1. give policy, direction and targets, and approve the proposal
Top management values	1.the survival and expansion of existing business	1.the survival and expansion of existing business 2.the growth of current business and the exploration of new business	1.the survival and expansion of existing business	1. the survival and expansion of existing business 2.the growth of current business and the exploration of new business 3.various factors (e.g. R&D, markets, production, and finance in dealing with a firm's external environment
Organisational structure	formal and bureaucratic structure with usually poor communication among functional areas	informal structure with frequent and extensive communication among functional areas	informal structure with frequent and extensive communication among functional areas	formal structure but not very bureaucratic, with controlled communication among functional areas

Appendix 8.3A (continued)

Internal Factor	CFV8 (low TCdnp)	CFV12 (high TCdnp)	CFV3 (low TCdnp)	CFV19 (high TCdnp)
Manpower flows	low manpower flows, and key roles of individuals cannot be identified	extensive manpower flows to facilitate the interaction between R&D, marketing, and production Key roles can be played by several individuals	low manpower flows, and key roles of individuals cannot be identified	extensive manpower flows to facilitate the interaction between marketing and production departments Key roles of individuals can be identified
Human Resource Management Human resource development activities	see Table 8.3B	see Table 8.3B	see Table 8.3B	see Table 8.3B
Incentive systems	special allowances and bonus	special allowances and bonus, provide rewards to selected employees each year	special allowances	raising wages occasionally, annual bonus, overseas travelling, study tours
Financial support for undertaking HRD	insufficient	sufficient	insufficient	sufficient
Research and Development R&D unit	not separated from other departments	separated from other departments	separated from other departments	separated from other departments

Appendix 8.3A (continued)

Internal Factor	CFV8 (low TCdnp)	CFV12 (high TCdnp)	CFV3 (low TCdnp)	CFV19 (high TCdnp)
R&D activities (in priority)	1.the analysis of product quality 2.the improvement of product quality 3.minor adaptation of product and production process 4.the development of new product	1.the development of new production process 2.the improvement of product quality 3.the analysis of product quality 4.minor adaptation of product and production process 5.the development of new product	1.the improvement of product quality 2.the development of new product	the development of new products, the improvement of product quality, the development of new production process, the analysis of product quality, the modification of product/production process (All activities share the same importance).
Financial support for undertaking HRD	insufficient	sufficient	insufficient	sufficient
Information and linkage system				
Information flows	internal information flows (information: market, production and quality control)	internal information flows (information: market and marketing, technology development, production)	internal information flows (information: technology development)	Internal information flows external information flows (customers) (information: market demands)
Internal links	focus on the improvement of productivity	emphasis on the interaction between management - R&D-sale and marketing - production)	exchange of information between departments	exchange of information between departments (set joint target between the department concerned, employ a teamwork strategy)

Source: Study Survey, 1997

Appendix 8.3B Human Resource Development Activities of Selected Other Canned Fruit and Vegetable Firms

Activities	Firm			
	CFV3 (low TC/exp)	CFV19 (high TC/exp)	CFV8 (low TC/exp)	CFV12 (high TC/exp)
1. Training in-house for every level of personnel	/	/	/	/
2. Training overseas for high level personnel	/			
3. Sending personnel to participate in seminars/workshops organised by other agencies	/	/	/	/
4. Periodic invitation of experts from overseas to meet with highly experienced technologists of the firm				
5. Providing information on technology and science through domestic and overseas subscriptions to journals	/	/	/	/
6. Getting the staff to meet unofficially with government officers (including university staff) to exchange knowledge	/	/	/	/
7. Sending staff to observe similar operations in the foreign parent firm				
8. Internal information flows	/	/	/	/
9. Undertaking QC activities	/	/	/	/

Source: Study Survey, 1997

Appendix 8.4A Internal Factors of Selected Canned Seafood Firms

Internal Factor	**CS1** (low TCdnp)	**CS2** (high TCdnp)	**CS4** (low TCdnp)	**CS9** (high TCdnp)	**CS5** (low TCdnp)	**CS18** (high TCdnp)
Policy, Strategy and Management The major characteristics of successful products (in priority)	1.product quality 2.low price 3.a large size of market 4.product differentiation 5. the use of new technology 6.having low market competition 7.having advantage from government support	1.product quality 2.product differentiation 3.the use of new technology 4.a large size of market 5. having low market competition 6.low price 7. having advantage from government support	1.product quality 2.product differentiation 3.low price 4.a large size of market 5.the use of new technology 5.having advantage from government support 6.having low market competition	1.product quality 2.product differentiation 3.the use of new technology 4.a large size of market 5.having low market competition 6.low price 7.having advantage from government support	1.product quality 2.product differentiation 3. a large size of market 4.low price 5. having low market competition	1.product quality 2.product differentiation 3.the use of new technology
Major sources of the firm' technology (in priority)	1.product imitation or reverse engineering 2.firm's own R&D activities 3.foreign partners 4.machinery and equipment suppliers 5.documentary sources 6.Trade/industry exhibitions 7.the purchase of technology 8.government agencies	1.firm's own R&D activities 2.documentary sources 3.machinery and component suppliers 4.the purchase of technology 5.product imitation 6.trade/industry exhibitions 7.government agencies	1.machinery and component suppliers 2.firm's own R&D activities 3.product imitation 4.trade/industry exhibitions 5.documentary sources 6.the purchase of technology 7.foreign business partners	1.firm's own R&D activities 2.product imitation 3.the purchase of technology 4..machinery and component suppliers 5.documentary sources 6.government agencies 7.exhibitions 8.foreign partners	1.product imitation 2.government agencies 3.machinery and component suppliers 4.documentary sources 5.firm's own R&D activities	1 firm's own R&D activities 2.the purchase of technology 3.product imitation

Appendix 8.4A (continued)

Internal Factor	**CS1** (low TCdnp)	**CS2** (high TCdnp)	**CS4** (low TCdnp)	**CS9** (high TCdnp)	**CS5** (low TCdnp)	**CS18** (high TCdnp)
Technology development strategy	1.product imitation and reverse engineering 2.the acquisition and adaptation of technology from abroad 3.R&D activities	1.R&D activities 2.the continuous accumulation of technology and human resource development	1.cooperation with foreign/domestic suppliers/partners 2.the acquisition and adaptation of technology from domestic sources R&D activities 3..the continuous accumulation of technology and human resource development	1.R&D activities 2.the continuous accumulation of technology and human resource development 3.imitation and reverse engineering 4 the acquisition and adaptation of technology from domestic sources	1.the acquisition and adaptation of technology from domestic/overseas2 sources 2.the continuous accumulation of technology and human resource development	1.R&D activities 2. the acquisition and adaptation of technology from domestic sources 3.the continuous accumulation of technology and human resource development
The elements of technology required	some state-of-the-art production technology	some state-of-the-art design and production technology	general production technology	general and some state-of-the-art design and production technology	general production technology	some state-of-the-art design and production technology
Major technological thrust	for developing products for existing needs	for developing new products for existing needs, and for new applications	for developing new products for existing needs, and for new applications	for modifying and/or improving new products for existing needs, and for new applications	for producing established products at low cost and acceptable quality	for developing new products for existing needs, and for new applications
Key persons introduce new technologies to the firm	domestic/overseas technology suppliers, exhibitions	the firm's staff from various departments and finally decided by plant mangers	overseas technology suppliers, and new staff who gain experience from other firms	foreign customers and senior managers	technology suppliers, government agencies, foreign food authorities	foreign customers, foreign partners, technology suppliers

Appendix 8.4A (continued)

Internal Factor	**CS1** (low TCdnp)	**CS2** (high TCdnp)	**CS4** (low TCdnp)	**CS9** (high TCdnp)	**CS5** (low TCdnp)	**CS18** (high TCdnp)
Key persons introduce market opportunities to the firm	marketing manager	marketing staff, and trading agencies (agents)	agents	foreign customers, and agents	marketing manager	foreign customers, agents, the industry association, and its staff
The contribution of workers regarding the changes and improvement of products and production processes	improvement of production process, product development	exchanging ideas between executives and workers, and giving of some suggestions by the employees	the development of equipment for speeding the production	exchanging opinion/idea expression and practical experiment	the improvement of production process	the improvement of production process
Top management involvement in technology development activities	assign and delegate responsibility to technical/production manager	allocate budget for technological investment; give full support to all technological development activities	involve in major activities, e.g. setting the firm's policy, participating in the technology acquisition process, and assessing technology choice	assign and delegate responsibility to technical manager	assign and delegate responsibility to technical/production manager; involve in major activities, e.g. setting the firm's policy, participating in the technology acquisition process, and assessing technology choice	involve in major activities, e.g. setting the firm's policy, participating in the technology acquisition process, and assessing technology choice; allocate budget for technological investment; give full support to all technological development activities
Top management values	the understanding of market place and proper use of resources	the growth of current business and the exploration of new business, the understanding of market place and proper use of resources ; R&D orientation in dealing with the firm's external environment	various factors (e.g. R&D orientation, markets, production, finance) in dealing with the firm's external factors	various factors (e.g. R&D orientation, markets, production, finance) in dealing with the firm's external factors	the survival and expansion of existing business	the growth of current business and the exploration of new business

Appendix 8.4A (continued)

Internal Factor	**CS1** (low TCdnp)	**CS2** (high TCdnp)	**CS4** (low TCdnp)	**CS9** (high TCdnp)	**CS5** (low TCdnp)	**CS18** (high TCdnp)
Organisational structure	informal structure with frequent and extensive communication among functional areas	informal structure with frequent and extensive communication among functional areas	informal structure with frequent and extensive communication among functional areas	formal structure but is not very bureaucratic with controlled communication among functional areas	informal structure but is not very bureaucratic with controlled communication among functional areas	informal structure but is not very bureaucratic with controlled communication among functional areas
Manpower flows	extensive flows to facilitate the interaction between R&D, marketing, and production. Key roles can be played by several individuals	extensive flows to facilitate the interaction between R&D, marketing, and production. Key roles can be played by several individuals	extensive flows to facilitate the interaction between R&D, marketing, and production. Key roles can be played by several individuals	extensive flows to facilitate the interaction between R&D, marketing, and production. Key roles of individuals can be specified	low flows Key roles of individuals cannot be identified	low flows Key roles of can be played by several individuals
Human Resource Management						
Human resource development activities	see Table 8.4B	see Table 8.4B	see Table 8.4B	see Table 8.4B	see Table 8.4B	see Table 8.4B.
Financial support for human resource development activities	insufficient	sufficient	sufficient	sufficient	insufficient	sufficient
Research and development (R&D)						
R&D unit	separated from other departments	separated from other departments	separated from other departments	separated from other departments	separated from other departments	separated from other departments

Appendix 8.4A (continued)

Internal Factor	**CS1** (low TCdnp)	**CS2** (high TCdnp)	**CS4** (low TCdnp)	**CS9** (high TCdnp)	**CS5** (low TCdnp)	**CS18** (high TCdnp)
R&D activities (in priority)	1.the analysis of product quality 2.the improvement of product quality 3.minor adaptation of products and process 4.the development of new production processes 5.the development of new products	1.the analysis of product quality 2.the development of new products 3.the development of new production process 4.applied and development research 5.the analysis of product quality 6.basic research	1.the development of new products 2.the development of new production processes 3.the analysis of product quality 4.packaging design and development 5.basic, applied and development research	1.the development of new products 2.the development of new production processes 3.basic, applied and development research 4.minor adaptation of products and process 5.the improvement of product quality 6.the analysis of product quality 7.packaging design and development	1.the improvement of product quality 2.the development of new products 3.the analysis of product quality	1.the improvement of product quality 2.the development of new products 3.the development of new production processes 4.packaging design and development
Financial support R&D activities	insufficient	sufficient	sufficient	sufficient	insufficient	sufficient
Information and linkage systems Information flows	internal information flows (information: marketing)	internal information flows (information: technology, market, marketing)	internal/external information flows (information: technology, marketing)	internal/external information flows (information: technology development, market, administration - productivity)	internal information flows (information: the quality of product and production)	internal/external information flows (information: technology development, marketing, finance, administration)

Appendix 8.4A (continued)

Internal Factor	**CS1** (low TCdnp)	**CS2** (high TCdnp)	**CS4** (low TCdnp)	**CS9** (high TCdnp)	**CS5** (low TCdnp)	**CS18** (high TCdnp)
Promotion and reward systems	bonus	bonus; extra bonus promote workers who have quality and potential	rewards; special allowances, extra allowances, special bonus	job evaluation twice a year, special allowance	bonus	Incentive compensation, special allowances, bonus, and sending promoted employees to attend training courses and ; supporting employees to continue the study
Internal links between related departments regarding technology development	Internal links (information on consumers' demands)	internal links (daily meeting between the senior staff of planning and production departments, weekly meeting between marketing, R&D, production departments)	internal links (weekly meeting to transfer information between related departments)	internal links, and use a network computerised system in the quality control activities	lack internal links	internal links (for the development of new products, the introduction of new products in the markets and/or market feasibility)

Source: Study Survey, 1997

Appendix 8.4B Human Resource Development Activities of Selected Canned Seafood Firms

Activities	Firm					
	CS1 (low TCdnp)	**CS2** (high TCdnp)	**CS4** (low TCdnp)	**CS9** (high TCdnp)	**CS5** (low TCdnp)	**CS18** (high TCdnp)
1. Training in-house for every level of personnel	/	/	/	/	/	/
2. Training overseas for the high level personnel	/	/	/	/	/	/
3. Sending personnel to participate in seminars/workshops organised by other agencies	/	/	/	/	/	/
4. Periodic invitation of experts from overseas to meet with highly experienced technologists of the firm		/	/	/	/	/
5. Providing information on technology and science through domestic and overseas subscriptions to journals	/	/	/	/	/	/
6. Getting the staff to meet unofficially with government officers (including university staff) to exchange knowledge	/	/	/	/	/	/
7. Sending staff to observe similar operations in the foreign parent firm		/				
8. Internal information flows	/	/	/	/	/	/
9. Undertaking QC activities	/	/	/	/	/	/

Source: Study Survey, 1997

Appendix 8.5A Internal Factors of Selected Frozen Seafood Firms

Internal Factor	FS2 (low TCdnp)	FS9 (high TCdnp)	FS11 (low TCdnp)	FS10 (high TCdnp)
Policy, Strategy and Management				
The major characteristics of successful products (in priority)	1.product quality 2.a large size of market	1.product quality 2.product differentiation 3.a large size of market 4.the use of new technology 5.low market competition 6. having advantage from government support 7.low price	1.product quality 2.large size of market 3.having advantage from government support	1.product quality 2.product differentiation 3.a large size of market 4.the use of new technology
Major sources of the firm's technology (in priority)	1.company's machinery and component suppliers	1.foreign partner 2.firm's own R&D activities 3.company's machinery and component suppliers 4.documentary sources 5.imitation or reverse engineering 6.government agencies 7.the purchase of technology 8.trade/industry exhibitions	1.foreign partner 2.company's machinery and component suppliers 3.government agencies 4.firm's own R&D activities 5.trade/industry exhibitions 6.documentary sources 7.imitation 8.the purchase of technology	1.new staff who gained experience from other firms 2.company's machinery and component suppliers 3.firm's own R&D activities 4.product imitation 5 trade/industry exhibitions
Technology development strategy	1.the acquisition and adaptation of technology from domestic sources	1.the continuous accumulation of technology and human resources development 2. the acquisition and adaptation of technology of domestic sources 3. the acquisition and adaptation of technology of overseas sources	1 the continuous accumulation of technology and human resources development	1.R&D activities 2.the continuous accumulation of technology and human resources development 3.imitation 4.the acquisition and adaptation of technology from domestic sources

Appendix 8.5A (continued)

Internal Factor	FS2 (low TCdnp)	FS9 (high TCdnp)	FS11 (low TCdnp)	FS10 (high TCdnp)
		4.cooperation with local partners or suppliers 5.imitation 6.cooperation with foreign partners or suppliers		
The elements of technology required	general production technology	general design and production technology	general production technology	general production and design technology
Major technological thrust	the developing new products for existing needs	the developing new products for existing needs, and for new applications	the developing new products for existing needs	the developing new products for existing needs, and for new applications
The key persons introducing new technologies to the firm	firm's executives	customers technology suppliers	the participation of firm's personnel	the participation of firm's personnel
The key persons introducing market opportunities to the firm	1. firm's executives 2. marketing department	1.customers 2.government agencies (MOC)	foreign partner	marketing department
The contribution of workers regarding the changes and improvement of products and production processes	the improvement of production process	the improvement of production process (There are always the exchanges of ideas between top managers and lower-level employees.)	the improvement of production process	the improvement of production process The managers and workers always exchange their ideas. Sometimes the ideas of workers and supervisors are accepted for changing something in the production line.

Appendix 8.5A (continued)

Internal Factor	FS2 (low TCdnp)	FS9 (high TCdnp)	FS11 (low TCdnp)	FS10 (high TCdnp)
Top management involvement	Involved in major activities, e.g. setting the organisation policy, participating in technology acquisition process, and assessing technology choices.	Assign and delegate responsibility to technical manager; give policy, direction and targets, and improving proposals; allocate a budget for technological improvement, and giving full support to all technological development activities	Involve in major activities, e.g. setting the organisation policy, participating in technology acquisition process, and assessing technology choices.	Give policy, direction and targets, and improving proposals
Top management values	1.the survival and expansion of existing business 2.the understanding of market place and the proper use of resources	1.the survival and expansion of existing business 2.the understanding of market place and the proper use of resources 3.the growth of current business and the exploration of new business 4.various factors (e.g. R&D orientation, markets, production and finance)in dealing with the firm's external environments	1.the survival and expansion of existing business	1 the growth of current business and the exploration of new business 2 various factors (e.g. R&D orientation, markets, production and finance)in dealing with the firm's external environments
Organisational structure	formal structure but not very bureaucratic, with controlled communication among functional areas	formal structure but not very bureaucratic, with controlled communication among functional areas	informal structure with frequent and extensive communication among functional areas	formal structure but not very bureaucratic, with controlled communication among functional areas
Manpower flows	flows to coordinate activities between marketing and production. Key roles of individuals can be identified	no emphasis on manpower flows	flows to suit the personnel abilities and the organisation's benefit	no flows between executive and/or manager levels, but extensive flows at lower levels. Key roles can be played by specific individuals

Appendix 8.5A (continued)

Internal Factor	FS2 (low TCdnp)	FS9 (high TCdnp)	FS11 (low TCdnp)	FS10 (high TCdnp)
Human Resource Management				
Human resource development activities	see Table 8.5B	see Table 8.5B	see Table 8.5B	see Table 8.5B
Promotion and reward systems	incentive payments	bonus, study promotion rewards for good attendance and special work	special allowances for good attention	special allowances, position promotion
Financial support for HRD	sufficient	sufficient	sufficient	sufficient
Research and Development (R&D)				
R&D unit	separated from other departments	separated from other departments	not separated	separated from other departments
R&D activities (in priority)	1.the improvement of product quality 2.the analysis of product quality	1.the development of new products 2.the improvement of product quality 3.the development of new production processes	1.the improvement of product quality 2.the analysis of product quality	1. the development of new products; applied and development research 2.the improvement of product quality 3. the analysis of product quality 4.minor adaptation of products and processes
Financial support	sufficient	sufficient	sufficient	sufficient (also mobilised from other firms in the business group)
Information and Linkage Systems				
Information flows	internal flows (information: marketing and production)	internal and external flows (information: marketing, technology))	internal flows (raw material sources)	internal flows (technology development, market, marketing, R&D)
Internal links	internal links	internal links (marketing, R&D, and production)	no internal links	internal links (marketing and R&D)

Source: Study Survey, 1997

Appendix 8.5B Human Resource Development Activities of Selected Frozen Seafood Firms

Activities	Firm			
	FS2 (low TCdnp)	FS9 (low TCdnp)	FS10 (high TCdnp)	FS11 (low TCdnp)
1. Training in-house for every level of personnel	/	/	/	/
2. Training overseas for the high level personnel		/	/	
3. Sending personnel to participate in seminars/workshops organised by other agencies	/	/	/	/
4. Periodic invitation of experts from overseas to meet with highly experienced technologists of the firm		/	/	
5. Providing information on technology and science through domestic and overseas subscriptions to journals			/	
6. Getting the staff to meet unofficially with government officers (including university staff) to exchange knowledge	/	/	/	/
7. Sending staff to observe similar operations in the foreign parent firm		/		
8. Internal information flows	/	/	/	/
9. Undertaking QC activities	/	/	/	/

Source: Study Survey, 1997

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