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Technical efficiency performance of Thai listed manufacturing enterprises

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TECHNICAL EFFICIENCY PERFORMANCE OF THAI LISTED MANUFACTURING ENTERPRISES

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THESIS CERTIFICATION

I, Yot AMORNKITVIKAI, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Economics, Faculty of Commerce, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other academic institution.

Yot AMORNKITVIKAI

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ABBREVIATIONS

AE	Allocative Efficiency
AGM	Annual General Meeting
BOI	Board of Investment of Thailand
BOT	Bank of Thailand
CD	Convertible Debenture
CEO	Chief Executive Officer
CES	Constant Elasticity of Substitution
CIT	Corporate Income Tax
CRS	Constant Returns to Scale
DBD	Department of Business Development
DEA	Data Envelopment Analysis
DEAP	Data Envelopment Analysis Program
DEP	Department of Export Promotion
DRS	Decreasing Returns to Scale
ESOP	Employee Stock Option Program
EXIM Bank	Export and Import Bank of Thailand
FBA	Foreign Business Act B.E. 2542
FDI	Foreign Direct Investment
FeTCO	Federation of Thai Capital Market Organization
FRONTIER	A Computer Program for Stochastic Frontier Production and Cost Production Estimation
FTA	Free Trade Agreement
GDP	Gross Domestic Product
GLS	Generalized Least Squares
IAS	International Accounting Standards
IASC	International Accounting Standards Committee
ICAAT	Institute of Certified Accountants and Auditors of Thailand
IOD	Thai Institute of Directors Association
IRS	Increasing Returns to Scale
LIMDEP	Limited Dependent Variable Models
LR	Likelihood Ratio

MAI	Market for Alternative Investment
MLE	Maximum Likelihood Estimation
NIRS	Non-Increasing Returns to Scale
NTA	Net Tangible Assets
NVDRs	Non-Voting Depository Receipts (NVDRs)
R&D	Research and Development
RD	Revenue Department
SE	Scale Efficiency
SEC	Securities and Exchange Commission
SET	Stock Exchange of Thailand
SFA	Stochastic Frontier Analysis
SIPF	Securities Investor Protection Fund
SMEs	Small and Medium Sized Enterprises
TAS	Thai Accounting Standards
TE	Technical Efficiency
TFP	Total Factor Productivity
TIA	Thai Investors Association
TPO	Trade Promotion Organization
VRS	Variable Returns to Scale
WTO	World Trade Organization

LIST OF PAPERS AND PRESENTATIONS

Refereed Journal Paper:

1. Amornkitvikai, Yot and Harvie, Charles 2011, 'Finance, Ownership, Executive Remuneration and Technical Efficiency: A Stochastic Frontier Analysis of Thai Listed Manufacturing Enterprises' *the Australasian Accounting Business and Finance Journal*, Vol. 5, No. 1, pp33-55. (ERA Rank B)

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2. Amornkitvikai, Yot and Harvie, Charles 2010, 'Identifying and Measuring Technical Inefficiency Factors: Evidence from Unbalanced Panel Data for Thai Listed Manufacturing Enterprises', paper presented to the Korea and the World Economy, IX Conference, Incheon, Korea, 25-26 June 2010.

3. Amornkitvikai, Yot, Harvie, Charles, and Charoenrate, Teerawat 2010, 'Measuring Technical Inefficiency: The Case of Thai Manufacturing and Exporting Small and Medium Size Enterprises (SMEs)', paper presented to The 7th SMEs In A Global Economy Conference 2010, Kuching, Sarawak, Malaysia, 15-17 October 2010.

4. Charoenrat, Teerawat, Harvie, Charles, and Amornkitvikai, Yot 2010, 'Technical Efficiency in Thai Manufacturing SMEs: Evidence from a Firm-Level Industrial Census', presented to The 7th SMEs In A Global Economy Conference 2010, Kuching, Sarawak, Malaysia, 15-17 October 2010.

Refereed Working Paper:

1. Amornkitvikai, Yot and Harvie, Charles 2010, 'Identify and Measuring Technical Inefficiency Factors: Evidence from Unbalanced Panel Data for Thai Listed Manufacturing Enterprises', Working Paper No. 10-05, School of Economics, University of Wollongong, Wollongong.

Seminar Presentations:

1. Amornkitvikai, Yot 'Measuring Technical Inefficiency: The Case of Thai Manufacturing and Exporting Small and Medium Size Enterprises (SMEs)' seminar presentation at the Centre for Small Business and Regional Research, Faculty of Commerce, University of Wollongong, Australia, 17 September 2010.

2. Amornkitvikai, Yot 'Measuring Technical Inefficiency: The Case of Thai Manufacturing and Exporting Small and Medium Size Enterprises (SMEs)' seminar presentation at the School of Economics Seminar, Faculty of Commerce, University of Wollongong, Australia, 30 September 2010.

ABSTRACT

This thesis aims to measure the technical efficiency performance of Thai listed manufacturing enterprises over the period 2000 to 2008. It also aims to identify and measure firm-specific and business environment factors which significantly impact on the technical efficiency performance of Thai listed manufacturing enterprises. Unbalanced panel data for 178 Thai listed manufacturing enterprises over the period 2000 to 2008 is compiled and used to conduct an empirical analysis employing both parametric (Stochastic Frontier Analysis (SFA)) and non-parametric (Data Envelopment Analysis (DEA)) approaches. This provides a robust check of the empirical results to analyse technical efficiency performance as well as significant factors influencing the efficiency of Thai listed manufacturing enterprises, including sub-manufacturing sectors.

The empirical results of this study reveal that the mean technical efficiency scores of Thai listed manufacturing enterprises obtained from the SFA and DEA approaches are found to be quite consistent, given by 0.812 and 0.887 respectively, indicating that they operated at a high level of technical efficiency. Even though their technical efficiency performance is high, the empirical evidence from both estimation approaches confirm that they had operated under decreasing returns to scale over the period 2000 to 2008. More specifically, the SFA approach reveals the existence of decreasing returns to scale for Thai listed manufacturing enterprises. Similarly, the DEA approach suggests that approximately 86 percent of Thai listed manufacturing enterprises, on average, operate under decreasing returns to scale. The empirical results from the SFA approach also highlight that the production of Thai listed manufacturing enterprises is mainly contributed by intermediate inputs and labour input, but capital is found to be the least important input. Similarly, the empirical evidence from an estimated Translog production function confirm the existence of labour-using and capital-saving technical progress for Thai listed manufacturing enterprises, indicating that their technical progress relied on labour input over the period 2000 to 2008. Moreover, the rate of technical progress is found to be 0.0205 for Thai listed manufacturing enterprises, indicating that the rate of technical change only increased by 2.05 percent per year. As a result they must attain a higher production frontier to enhance their future technical efficiency performance.

The empirical evidence from both the SFA and DEA approaches also reveal that financial constraints (leverage) have a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises. To confirm this empirical evidence the empirical results from both estimation approaches reveal that liquidity has a significant and positive impact on their technical efficiency performance. In addition, the empirical evidence from both estimation approaches indicate that both external and internal financing are found to have a negative association with the technical efficiency performance of Thai listed manufacturing enterprises, but only the empirical evidence from the SFA approach is found to be statistically significant. External financing, however, does not exert a significant impact on their technical efficiency due to the very small magnitude of the estimated coefficients. The empirical results from both estimation approaches also reveal that research and development (R&D) has a significant and negative association with the

technical efficiency of Thai listed manufacturing enterprises. The empirical results from both estimation approaches, however, reveal that controlling ownership has a positive association with the technical efficiency performance of Thai listed manufacturing enterprises, but only the SFA approach produces a significant result. There is strong evidence from both estimation approaches that managerial ownership has a significant and positive impact on the technical efficiency of Thai listed manufacturing enterprises. Both estimation approaches also strongly confirm that executive remuneration has a significant and positive influence on their technical efficiency performance. Focusing on different types of firm ownership there is strong evidence from both estimation approaches that foreign and family ownership exerts a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises. According to the magnitude of the estimated coefficients of each type of firm ownership, there is strong evidence from both estimation approaches that foreign-owned firms perform best, followed by family-owned firms, hybrid-owned firms and domestic-owned firms, given joint-owned firms as the base category. There is strong evidence of a learning-by-exporting hypothesis from both estimation approaches, indicating exporting exerts a significant and positive effect on the technical efficiency performance of Thai listed manufacturing enterprises. Vice versa, there is evidence of the self-selection hypothesis that a firm's technical efficiency predicted by the SFA approach has a significant and positive impact on the export participation of Thai listed manufacturing enterprises. A positive result is also found from the DEA approach, but is not statistically significant.

Finally, the robust results from this study can be used to provide empirically based policy implications and recommendations which are useful to both policy-makers and entrepreneurs to enhance the long-term efficiency and competitiveness of Thai listed manufacturing enterprises.

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CHAPTER 1

INTRODUCTION

1.1 Background to the study

In recent years, Thailand has faced a real challenge of sustaining its growth and escaping from its middle income trap[1] (World Bank Office -Thailand, 2008). For Thailand to transition to higher income and growth in the long term, measures to improve productivity and competitiveness over the long term in all sectors (agriculture, industry, and services) are urgently needed. According to Thailand's Industry Master Plan (2010-2014) Thai manufacturing firms remain heavily dependent for their comparative advantage upon cheap labour and foreign direct investment, without enhancing their productivity. Therefore, a low level of productivity has been observed in this sector, since they lack (i) new technology, (ii) product and process innovation, (iii) financial access, (iv) skilled labour, (v) raw materials, (vi) high-value added production, and (vii) managerial skills (Ministry of Industry, 2009).

In particular, measures to increase the efficiency performance and competitiveness of firms in the manufacturing sector, as the main sector in Thailand accounting for 38 percent of Thai GDP in 1992 and 40.1 percent of Thai GDP in 2008 (Bank of Thailand, 2009b: Ministry of Industry, 2009), are very important. The manufacturing sector has been one of the most important sectors in the East and Southeast Asian countries. A significant contribution to economic growth in this region since the early 1980s has arisen from the rapid expansion in manufacturing exports (Jongwanich, 2007). In the case of Thailand a significant contribution to

[1] Thailand moved rapidly from a low-income country to a middle-income country during the period between the 1970s to mid-1990s. This resulted from the rapid growth in per capita income during that period. In recent years, real GDP growth has slowed and is now lower than that of other developing countries in East Asia. Despite intensifying global competition and higher commodity prices Thailand remains a heavily labour-intensive country, relying on unskilled labour and low value adding activities. These problems cause a real challenge for Thailand in sustaining its growth and to it becoming a higher income country (World Bank Office-Thailand, 2008, p2).

economic growth has also been generated from export-oriented large enterprises (Ministry of Industry, 2009).

Thailand's economic expansion before the Asian financial crisis was also underpinned by rapid growth in exports[2] (Athukorala and Suphachalasai, 2004). The major exported goods were mainly agricultural and processed food during the period 1981 to 1985, which accounted for almost 50 percent of total annual average export value (see Table 2.11, Chapter 2). However, a substantial shift from traditional agricultural exports[3] towards manufactured exports emerged during the period 1991 to 1995. After 1996 the upward trend of Thailand's manufactured exports also continued, accounting for 87 percent of total export value (see Figure 2.12, Chapter 2). Thailand is in a difficult competitive position as it cannot continue to depend on cheap labour for its competitiveness, and, therefore, must move up the technology spectrum and improve the efficiency and productivity of its enterprises. Fried et al. (2008, p11) also suggested that macro performance depends on micro performance, and, therefore, the same reasoning also applies to the study of economic growth. It is also necessary, therefore, to conduct a firm level analysis to analyse how best to increase Thailand's efficiency performance and competitiveness, since firms are the engines of economic growth. Thai listed enterprises make a significant contribution to the Thai economy. The average market capitalization of Thai listed enterprises accounted for approximately 55 percent of Thai GDP at current price over the period 2000 to 2008. More specifically, the average revenue of Thai listed manufacturing enterprises[4], accounted for approximately 12.9 percent of GDP at current price over the period 2000 to 2008 (Bank of Thailand, 2009; The Stock Exchange of Thailand, 2009).

Moreover, measuring efficiency and sources affecting firm inefficiency can be used to identify and separate controllable and uncontrollable sources of

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[2] A number of empirical studies of the region, however, fail to find a statistically significant relationship between trade/export and economic growth (Sinha, 1999; Ekanayake, 1999).

[3] Even though manufacturing contributed most to this development, agricultural products still accounted for a fairly important share of exports, but its relative importance was diminishing significantly (Lombaerde, 2008, p250).

[4] The resources sector has the highest average revenue, over the period 2000 to 2008, followed by the manufacturing sector, the services sector, the financial sector, and other sectors (see Table 2.4, Chapter 2).

performance variation, and, therefore, assist in the design of appropriate government policies and recommendations (Fried et al., 2008). For most firms the ultimate measure used to evaluate their business performance is a financial variable, but, in fact, it is just the bottom-line performance indicator as it is influenced by the efficiency and productivity performance of firms and price changes (e.g., input and product prices) (Fried et al., 2008). Therefore, a firm's efficiency and productivity performance is at the core of its financial achievement. Kalirajan and Shand (1999, p 149) suggest that the quantification of an efficiency measurement is useful in three ways: (i) measuring efficiency facilitates comparisons across similar economic units, (ii) where measurement indicates variations in efficiencies among economic units, further analysis can be conducted to identify the sources causing such variations, and (iii) the results of such analyses can be used for policy aimed at improving efficiency. Measuring the efficiency and inefficiency sources of firms will be emphasised in the context of this study as it is important to examine how firms can enhance their efficiency performance which has a direct impact on the overall growth of the economy. This is the fundamental objective of this thesis for the case of Thailand.

The major problems causing firm-level inefficiency could be obviously observed from the 1997 Asian Financial Crisis. The Crisis highlighted problems of lack of transparency in corporate governance and a corrupt and mismanaged banking system (e.g., excessive lending to non-productive assets, lack of adequate debt monitoring) among the crisis-affected countries in South East Asia as well as Thailand. The problem of weak corporate governance was related to, for example, the dominance of controlling shareholders, the separation of voting and cash flow rights (or the disparity between control and ownership), and the limited protection of minority rights (Claessens et al., 2000; East Asia Analytical Unit, 2000). Moreover

Not only did these inefficient business environment factors cause manufacturing inefficiency in Thailand, but firm-specific factors (i.e., inadequate firm size, lack of business experience, lack of research and development (R&D) investment, inefficient managerial skills, lack of internal competition, and lack of external competition or lack of learning-by-exporting experience) also affected the inefficiency performance of Thai listed manufacturing firms. After the 1997 Asian financial crisis the Thai corporate governance system has been strengthened through (i) enhancing the institutional framework for best accounting and auditing practices and improving the disclosure practice of listed companies, (ii) encouraging best practices for directors of listed companies, and (iii) relaxing foreign ownership controls[5] (East Asia Analytical Unit, 2000; Talerngsri and Vonkhorporn, 2005; Sally, 2007). Minority shareholders' rights through protection measures (e.g., market regulation and enforcement, trading and settlement system reliability, information disclosure, quality accessibility, and securities investor production funds (SIPF)) have also been addressed. According to World Bank (2005), even though corporate governance in Thailand has made a significant improvement since the 1997 Asian financial crisis, further enhancing Thailand's corporate governance is still needed to be it into line with international standards (see Section 2.6, Chapter 2).

However, the relative significance of business environment and firm-specific factors affecting firm inefficiency have not been empirically examined for listed manufacturing enterprises in Thailand after the 1997 financial crisis. In this context, this thesis conducts a quantitative analysis to measure the technical efficiency performance, and factors affecting technical efficiency, of Thai listed manufacturing enterprises. The key factors of this thesis cover (i) financial factors (e.g., financial constraints, sources of financing), (ii) research and development (R&D), (iii) ownership structure (e.g., controlling (concentrated) ownership, managerial ownership, types of owned firms (e.g., family and foreign owned firms), (iv) executive remuneration, and (v) exporting (learning by exporting and self-selection hypotheses). In addition, other firm-specific and business environment factors (e.g., firm age, firm size, government assistance, and foreign cooperation) are also included in this thesis.

Eight unique hypotheses covering the key factors mentioned above are developed from a review of the literature in Chapter 3. These have not been empirically examined before for the case of Thai listed manufacturing enterprises and are measured by employing the Stochastic Frontier Analysis (SFA) and Data

[5] After the 1997 crisis the 1999 Foreign Business Act B.E. 2542 (FBA) was enacted, allowing foreign ownership of up to 100 percent in most manufacturing activities, subject to specific requirements from the Board of Investment of Thailand (BOI).

Envelopment Analysis (DEA) approaches. More importantly, most of these hypotheses provide a significant contribution to the existing finance literature (see Section 1.3). This thesis also constructs a comprehensive firm-level data series[6] for Thai listed manufacturing enterprises using raw data (electronic reports) obtained from the Stock Exchange of Thailand (SET), covering the period 2000 to 2008. This ensures the unique contribution of this thesis (see Section 1.3). Empirically based policy implications and recommendations are also provided for policy makers and entrepreneurs of Thai listed manufacturing enterprises.

1.2 Research objectives and research questions

This thesis aims to examine the performance of Thai listed manufacturing enterprises, covering the period 2000 to 2008. The specific purposes of the thesis are as follows:

(i) To measure the technical efficiency of Thai listed manufacturing enterprises;

(ii) To identify and measure firm-specific and business environment factors which significantly affect the inefficiency performance[7] of Thai listed manufacturing firms; and

(iii) To provide evidence based policy implications and recommendations to enhance the efficiency and competitiveness of Thai listed manufacturing enterprises.

The following research questions are addressed subject to the above objectives. These questions also link to the key hypotheses to be addressed in this thesis.

[6] Firm-level survey data for Thai listed enterprises is not available.

[7] The term, "technical inefficiency" is used here due to the specific characteristic of an inefficiency effects model obtained from the Battese and Coelli (1995) model as analysed by FRONTIER 4.1.This thesis also alternatively uses the term, "technical efficiency" for simplification purposes, but the interpretation of this term will be in the opposite direction.

Main research questions

(i) How do Thai listed manufacturing enterprises perform in terms of technical efficiency?

(ii) Which factors significantly contribute to the technical efficiency performance of Thai listed manufacturing enterprises?

(iii) How can the overall technical efficiency performance of Thai listed manufacturing enterprises be enhanced?

From the main research questions above, a number of sub-research questions can be derived from the literature on this issue as follows:

(1) How do "*financial constraints (leverage) and liquidity*" impact on the technical efficiency of Thai listed manufacturing enterprises?

(2) Which types of *"source of finance"* (internal or external financing) significantly affect the technical efficiency of Thai listed manufacturing enterprises?

(3) How does "*research and development"* (R&D) affect the technical efficiency of Thai listed manufacturing enterprises?

(4) How does "*controlling ownership"* (concentrated ownership) influence the technical efficiency of Thai listed manufacturing enterprises?

(5) How does "*managerial ownership*" impact on the technical efficiency of Thai listed manufacturing enterprises?

(6) What is the impact of "*executive remuneration*" on the technical efficiency of Thai listed manufacturing enterprises?

(7) Which "*types of owned firms"* (types of ownership) are more technically efficient?

(8) How does "*exporting*" influence the technical efficiency performance of Thai listed manufacturing enterprises?

(9) What is the impact of "*technical efficiency*" on the export participation of Thai listed manufacturing enterprises?

(10) How do other firm-specific variables such as (i) government assistance, (ii) firm size, (iii) firm age, and (iv) foreign cooperation[8] influence the technical efficiency of Thai listed manufacturing enterprises?

(11) How can policies initiated by the Stock Exchange of Thailand (SET) and the government, directly or via other government agencies, be made to improve the efficiency and competitiveness of Thai listed manufacturing enterprises?

1.3 Contribution and significance of the research

According to the research objectives and research questions presented above, this thesis will make a significant contribution in several areas as follows:

First, this thesis is the first to identify and measure firm-specific and business environment factors that significantly impact on the technical efficiency performance of Thai listed manufacturing enterprises, covering the period 2000 to 2008. Focusing on the measurement of listed firm performance, most previous studies have measured firm performance by a firm's profitability and financial ratios (McConnell and Servaes, 1990; Smith, 1990; Cho, 1998; Xu and Wang, 1999; Claessens et al., 2000; Dewenter and Malatesta, 2001; Joh, 2003; Chang and Shin, 2007; Lee, 2008). In Thailand, some empirical studies have also measured firm performance based on the

[8] This includes (i) technical assistance from foreign partners and (ii) assistance from foreign partners in exporting to new foreign markets.

profitability and financial ratios of Thai listed enterprises (Wiwattanakantang, 2001; Yammeesri and Lodh, 2003). None of these empirical studies, however, have measured the performance of Thai listed manufacturing enterprises in terms of technical efficiency. For most firms, especially listed enterprises, financial indicators (e.g., return on assets and return on equity) are used to evaluate their financial performance, but, in fact, the root of their financial performance growth is their efficiency and productivity improvement and price variations (e.g., input and product prices) (Fried et al., 2008, p11). Therefore, efficiency and productivity[9] measures are key indicators of the development of firm performance, as suggested by Fried (2008).

A firm's technical efficiency measures the ability to produce the maximum output from a given set of inputs and production technology (Coelli et al., 2005, p51). Technical efficiency is a relative concept, since a firm's production performance is compared to a best-practice input-output association (Alauddin et al., 1993). In other words, the efficiency of a firm refers to a comparison between observed and optimal values of its output and input (e.g., a comparison of observed output to maximum output obtainable from the input, or a comparison between observed and optimal values of its input required to produce the output, or some combination of the two) (Fried et al., 2008). The "optimum" term refers to a production frontier (or best-practice performance) where a firm is technically efficient.

More importantly, this thesis indentifies firm-specific and business environment factors and measures their impact on technical efficiency, which has not been previously addressed for the case of Thai listed manufacturing enterprises. More specifically, eight unique hypotheses are developed from a review of the literature (Chapter 3). Hypotheses 1, 2, 4, 5, 6, and 7 provide a significant contribution to the literature, since the measurement of a firm's performance in the literature has extensively been based on its profitability and financial ratios (financial performance). The following hypotheses are identified and examined in this thesis as follows:

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[9] The concept of productivity and efficiency are different (see Sections 3.2.2 and 3.2.3, Chapter 3).

Hypothesis 1: *Financial constraints (leverage) have a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises. Vice versa, the more liquidity the lower is the technical efficiency of Thai listed manufacturing enterprises.*

Several empirical studies have investigated the impact of financial constraints (leverage) on a firm's performance as measured by accounting or financial ratios (see Section 3.4.2, Chapter 3). Few empirical studies, however, have examined the effect of financial constraints (leverage) on a firm's technical efficiency (Dilling-Hansen et al., 2003; Sena, 2006; Mok et al., 2007; Weill, 2008). No empirical study conducted for other countries has investigated the effects of both leverage and liquidity on a firm's technical efficiency. More importantly, this hypothesis has not been examined for the case of Thailand using either the SFA or two-stage DEA approach, or even applying both estimation approaches.

Hypothesis 2: *External financing has a significant and positive relationship with a firm's technical efficiency for Thai listed manufacturing enterprises. Vice versa, internal financing has a significant and negative effect on a firm's technical efficiency for Thai listed manufacturing enterprises.*

This hypothesis aims to examine the effects of external and internal financing on a firm's technical efficiency as discussed in the literature review (see Section 3.4.3, Chapter 3). More importantly, from the perspective of this study, this hypothesis has not been examined in any empirical studies focusing on Thailand, especially for Thai listed manufacturing enterprises using either the SFA or two-stage DEA approach, or even applying both estimation approaches.

Hypothesis 3: *Research and development (R&D) has a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises.*

As discussed in the literature review in Section 3.6 of Chapter 3, a number of empirical studies have investigated the effect of research and development (R&D) on a firm's technical efficiency (Aw and Batra, 1998; Dilling-Hansen et al., 2003; Kim, 2003; Sheu and Yang, 2005). This hypothesis, however, has not been investigated before for Thai listed manufacturing enterprises using either the SFA or two-stage DEA approach, or even applying both estimation approaches.

Hypothesis 4: *Controlling ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

As discussed in Section 3.5.1 of Chapter 3, several empirical studies have investigated the effect of controlling ownership (concentrated ownership) on a firm's performance based on accounting or financial measures (Demsetz and Lehn, 1985; McConnell and Servaes, 1990; Leech and Leahy, 1991; Wiwattanakantang, 2001; Yammeesri and Lodh, 2003; Zeitun and Tian, 2007). None of these empirical studies conducted for other countries have examined this hypothesis, and especially in applying both the SFA and two-stage DEA approaches. More importantly, this hypothesis has not been examined before for Thai listed manufacturing enterprises using either of these estimation approaches.

Hypothesis 5: *Managerial ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

According to Section 3.5.3 of Chapter 3, empirical studies have studied the effect of managerial ownership on firm performance, as measured by financial profitability (McConnell and John, 1990; Morck et al., 1988; Wiwattanakantang, 2001; Yammeesri and Lodh, 2003). Very few empirical studies, however, have examined the effect of managerial ownership on a firm's technical efficiency (Liao et al., 2010). None of these empirical studies conducted for other countries have used both the SFA and the two-stage DEA approaches to test this hypothesis. More importantly, this hypothesis has not been examined before for Thai listed manufacturing enterprises.

Hypothesis 6: *Executive remuneration has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

Several empirical studies in the finance and accounting literature have examined the effect of executive remuneration on a firm's performance based on accounting or financial measures (see Section 3.7, Chapter 3). None of the empirical studies conducted for other countries have employed both estimation techniques, especially for the case of listed manufacturing firms. This hypothesis, however, has not been investigated before for Thai listed manufacturing firms using either the SFA or two-stage DEA approach, or even applying both estimation approaches.

Hypothesis 7: *Foreign and family ownership*[10] *have a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises; foreign-owned firms perform best in terms of technical efficiency relative to other ownership types for Thai listed manufacturing enterprises.*

Many empirical studies have investigated the effect of foreign ownership on a firm's performance, as measured by accounting or financial measures (Zhang et al., 2001; Takii, 2004; Choi and Yoo, 2006; Aydin et al., 2007; Kimura and Kiyota, 2007; Greenaway et al., 2008) (See Section 3.5.2, Chapter 3). Similarly, a number of empirical studies have also examined the relationship between foreign ownership and a firm's technical efficiency (Fukuyama et al., 1999; Goldar et al., 2003; Bottasso and Sembenelli, 2004). While information on family ownership has been extensively discussed in the finance literature (see Section 3.5.2, Chapter 3), few studies have linked family ownership with a firm's technical efficiency (Lauterbach and Vaninsky, 1999). In the case of Thailand, Wiwattanakantang (2001) and Yammeesri and Lodh (2003) studied the effect of family ownership on a firm's performance based on accounting or financial measures. This hypothesis, therefore, has not been examined for Thai listed manufacturing enterprises as well as listed manufacturing enterprises in other countries, using either the SFA or two-stage DEA approach, or even applying both estimation approaches.

Hypothesis 8: *A firm's exports have a significant and positive association with its technical efficiency (the learning by exporting hypothesis exists); A firm's technical efficiency has a significant and positive effect on the export participation (the self selection hypothesis exists) of Thai listed manufacturing enterprises.*

[10] This refers to majority foreign and family ownership using a cut-off shareholding level of 25 percent.

Several empirical studies have examined the effect of a firm's export performance on its productivity (see Table 3.3, Section 3.8, Chapter 3). Few empirical studies have investigated the learning-by-exporting hypothesis in which a firm's performance is measured by technical efficiency (Dilling-Hansen et al., 2003; Kim, 2003; Granér and Isaksson, 2007). Very few studies have examined the self-selection hypothesis using technical efficiency as the measurement of firm performance (see Table 3.3, Section 3.8, Chapter 3). More importantly, this hypothesis examines the existence of both learning-by-exporting and the self-selection hypotheses on the technical efficiency of Thai listed manufacturing enterprises. This has not been previously conducted using either the SFA or two-stage DEA approach, or even applying both estimation approaches.

Second, this thesis is the first to employ both parametric (Stochastic and Frontier Analysis (SFA) and non-parametric (two-stage Data Envelopment Analysis (DEA)) approaches for a robustness checking, as suggested by a number of contributions in the efficiency literature (Bauer et al., 1998; Stone, 2002; Jacobs et al., 2006; Miranda et al., 2010). This thesis also predicts a firm's technical efficiency (scores)[11], and then examines the effects of firm-specific and business environment variables, which have been previously discussed, on a firm's technical inefficiency. In Thailand, Sirasoontorn (2004) applied both approaches in estimating the technical efficiency of Thai electricity generation under public ownership However, none of these empirical studies have conducted an empirical analysis employing either the Stochastic Frontier Analysis (SFA), or the Data Envelopment Analysis (DEA) approach, or even applied both estimation approaches for the case of Thai listed manufacturing enterprises. These two approaches[12] can be specifically used to evaluate firm performance based on technical efficiency, and investigate the sources affecting the technical inefficiency of Thai listed manufacturing enterprises. More importantly, applying both SFA and DEA approaches can facilitate a comparison of the empirical evidence obtained in this thesis.

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[11] For the two-stage DEA approach technical efficiency scores predicted by DEAP Version 2.1 are changed to technical inefficiency scores by subtracting them from "unity" so as to be consistent with an inefficiency effects model used for the SFA approach, which focuses on factors affecting firm technical inefficiency (see Sirasoontorn, 2004).
[12] The programs, FRONTIER 4.1 and DEAP 2.1 are used to conduct the empirical analysis for the SFA and DEA approaches, respectively (see Chapters 4 and 6).

Third, this thesis does not utilise any firm-level survey data for Thai listed manufacturing enterprises[13], due to the unavailability of such data. A specific firm-level dataset focusing upon Thai listed manufacturing enterprises, however, has been compiled by the author using raw data (electronic reports) obtained from the Stock Exchange of Thailand (SET), covering the period 2000 to 2008[14], such as (i) consolidated financial reports, (ii) annual reports (Form 56-1), and (iii) the list of board of directors and major shareholders. This ensures the uniqueness of the thesis and the empirical results obtained. This thesis also provides empirically based policy recommendations to improve the efficiency and competitiveness of Thai listed manufacturing enterprises. The empirical evidence obtained from this thesis will be useful for both policy-makers and entrepreneurs of Thai listed manufacturing enterprises, aimed at enhancing their efficiency, competitiveness, and development. All of the policy implications and recommendations of this thesis are provided in more detail in Chapter 7.

In conclusion, this thesis provides a unique study of Thai listed manufacturing enterprises, and makes (i) a significant contribution to the existing finance and economic literature, and (ii) applies estimation techniques which have not been used before in the context of Thai listed manufacturing enterprises. More specifically, most hypotheses[15] also make a significant contribution to the study of listed manufacturing enterprises in other countries, especially employing both the SFA and DEA approaches for their analysis. Even though some hypotheses[16] have been previously examined for other countries, none of them has examined these hypotheses (e.g., (i) the effects of external and internal financing on firm technical efficiency (see hypothesis 2), and (ii) the existence of learning by exporting and self-selection hypotheses (see hypothesis 8)) by adopting both estimation approaches. Focusing on the estimation techniques in measuring technical efficiency and the

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[13]The 1997 and 2007 Thai Industry Censuses, including Thai Industry Surveys, are also available, which can be used to measure the technical efficiency performance of Thai manufacturing firms. However, the 1997 and 2007 Thai Industry Censuses, including Thai Industry Surveys have been used to study the technical efficiency of Thai manufacturing enterprises (see Arunsawadiwong, 2007) and Thai small and medium sized enterprises (see Charoenrat and Harvie, 2011). The use of these Thai census and survey data have limitation in analyzing firm-level panel data. However, this thesis uses firm-level panel data over the period 2000 to 2008, which leads to the uniqueness of the study.

[14] See Section 8.3, Chapter 8 for the data limitation.

[15] See hypotheses 1, 4, 5, 6, and 7 in Chapter 5 for more details.

[16] See hypotheses 2 and 8 in Chapter 5 for more details.

factors causing firm inefficiency, this thesis also makes a significant contribution by applying both the SFA and DEA estimation techniques to cross check the results for each hypothesis. This has not been conducted for other empirical studies focusing upon other countries, particularly listed manufacturing enterprises.

1.4 Methodology

To achieve the above objectives this thesis will employ different methodologies, and consists of five steps. The first step (chapter 2) is to (1) provide a country overview which consists of four main parts. The first part provides an economic overview of Thailand, including a discussion of the 1997 financial crisis. The second part provides an overview of financial markets in Thailand, including their structure and development. In the second part, Thai listed enterprises' performance and their ownership structure is also provided. The third part focuses on an overview of information on corporate governance in Thailand, including directors' rules and responsibilities, accounting standards, and shareholder protection. Thailand's export performance as well as manufacturing exports and its output capacity, and net flow of foreign direct investment (FDI), are also provided in the last part.

The second step (chapter 3) is to conduct a literature review focusing on different measurements of firm performance. A review of the literature regarding firm-specific and business environment factors that can significantly affect the listed enterprises' performance is also provided. These factors include, for example, (i) financial factors (e.g., financial leverage, sources of financing), (ii) ownership structure (e.g., types of ownership, controlling ownership, and managerial ownership), (iii) research and development (R&D), and (iv) executive remuneration. A review of the literature focusing upon other factors (e.g., government assistance, networking, foreign cooperation, geographical diversification, firm size, and firm age) is also provided.

The third step (chapter 4) is to survey the theoretical and empirical issues related to firm efficiency measurement concepts. The survey also covers different estimation approaches which can be used to predict the technical efficiency of Thai listed manufacturing firms, and also measure the factors causing their technical inefficiency. More specifically, two competing approaches the parametric (Stochastic Frontier Analysis) and non-parametric (Data Envelopment Analysis) efficiency methods are reviewed. The survey also indicates specific software used to conduct the empirical analysis for both estimation techniques. These two estimation approaches are also compared in terms of their advantages and disadvantages. It suggests that there is no reason to favour one estimation approach over the other, and it is reasonable to cross check the results from both estimation approaches (see Chapter 4).

The fourth step (Chapters 5 and 6) is to identify the hypotheses and variables to be used to conduct the empirical analysis, using the Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) approaches. For the SFA approach the Battese and Coelli (1995) model is applied to (i) predict the technical efficiency of all Thai listed manufacturing enterprises including its sub manufacturing sectors through an estimated stochastic frontier production function, and (ii) to measure the inefficiency effects model which examines the significant factors impacting on the technical inefficiency of Thai listed manufacturing enterprises simultaneously.

For the DEA approach the two-stage DEA model is applied. In the first step, technical inefficiency scores[17] are predicted by applying variable returns to scale (VRS) linear programming as analysed by DEAP Version 2.1. In the second stage the maximum likelihood Tobit model is used, in which technical inefficiency scores are regressed with firm-specific and business environment variables. In addition, the maximum likelihood Probit model is also applied when examining the self-selection hypothesis as part of hypothesis 8. The empirical results obtained from both estimation approaches are interpreted, discussed, and compared for a robustness checking of these results.

The final step (Chapter 7) is to provide policy implications and recommendations based on the empirical results obtained in Chapter 6. These policy implications and recommendations are developed to enhance the performance and competitiveness of Thai listed manufacturing enterprises. In conclusion, different

[17] See footnote 11.

methodologies, as previously described, are conducted to ensure that the research objectives and research questions of this thesis are adequately addressed. By collecting all available data sources (e.g., financial reports, annual reports, and the list of board of directors and shareholders), conducting a comprehensive dataset for Thai listed manufacturing enterprises, covering the period 2000 to 2008, and applying both parametric SFA and non-parametric DEA approaches, this thesis provides robust results leading to significant evidence based policy implications and recommendations.

1.5 Research scope

This thesis mainly examines the significant firm-specific and business environment factors influencing the technical efficiency performance of Thai listed manufacturing enterprises, covering the period 2000 to 2008. However, the SET classifies listed enterprises into eight industrial sectors based upon their core business operations, such as (i) Agro and Food Industry, (ii) Consumer Products, (iii) Financials, (iv) Industrials, (v) Property and Construction, (vi) Resources, (vii) Services, and (viii) Technology. By employing the International Standard Industrial Classification (ISIC), some listed enterprises which are not classified as manufacturing enterprises are excluded from the study. As a result 178 listed manufacturing firms over the period 2000 to 2008 are used to conduct the empirical analysis of this thesis (see Section 5.3.2, Chapter 5).

Moreover, non-listed manufacturing enterprises are not considered in this thesis. This thesis also uses available data sources (electronic reports) obtained from the Stock Exchange of Thailand (SET) as discussed in Section 1.3. Finally, figures which are related to the hypotheses and variables discussed in Chapter 5 (Hypothesis and Data Description) are selected from these data sources in order to form a new firm-level data set used for the empirical analysis (Chapter 6).

1.6 Organization of the thesis

The structure of this thesis consists of eight chapters which are briefly outlined as follows: Chapter 2 provides an overview of (i) the economy of Thailand, (ii) financial markets in Thailand focusing on the economic significance and development of the Thai equity (capital) market, (iii) the business performance and ownership structure of listed manufacturing firms in the Stock Exchange of Thailand (SET), (iv) corporate governance in Thailand, which includes directors' rules and responsibilities, accounting standards, and shareholder protections, and (v) economic integration of Thailand including Thailand's export performance as well as manufacturing exports and its output capacity, and the flow of foreign direct investment (FDI).

Chapter 3 reviews the literature starting with different measurements of firm performance, and then focusing on key firm-specific and business environment factors which significantly affect the performance of publicly listed firms. These include, for example, (i) financial factors (e.g., financial leverage, sources of financing), (ii) ownership structure (e.g., types of ownership (e.g., family owned firms and foreign owned firms), controlling ownership (concentrated ownership), and managerial ownership), (iii) research and development (R&D), and (iv) executive remuneration. In addition, the literature review also focuses upon other factors that may affect technical efficiency such as government assistance, networking, foreign cooperation, geographical diversification, firm size and firm age.

Chapter 4 presents a review of firm efficiency measurement concepts, which includes (i) technical efficiency, (ii) allocative efficiency, (iii) scale efficiency, and (iv) cost and revenue efficiencies. This chapter also explains two competing approaches, "Stochastic Frontier Analysis (SFA)" and "Data Envelopment Analysis (DEA)", which can be used to estimate firm technical efficiency and investigate factors that affect it. For SFA the development stages of the stochastic production frontier is also provided starting from (i) the deterministic parametric frontier, (ii) the stochastic production frontier, and (iii) the stochastic production frontier with panel data, respectively. The selected stochastic frontier production function including its estimation is also explained in Chapter 6. Focusing on DEA, a description of the DEA approach including its estimation used in the conduct of an empirical analysis in Chapter 6 is also provided. The problem of "slacks" when dealing with the DEA approach is also discussed, and the methods which can be used to solve this problem are also discussed and selected. More importantly, this chapter also discusses the strengths and weaknesses of these two estimation approaches.

Chapter 5 identifies the hypotheses and variables used to conduct the empirical analysis in Chapter 6. More specifically, there are eight hypotheses focusing upon factors impacting upon the technical efficiency of Thai listed manufacturing enterprises, such as (i) finance (leverage and liquidity; internal financing and external financing), (ii) research and development (R&D), (iii) ownership structure (controlling and managerial ownership), (iv) executive remuneration, (v) types of owned-firms (foreign and family-owned firms), and (vi) exporting (learning by exporting and self-selection hypotheses). Other variables such as (i) firm size, (ii) firm age, (iii) government assistance, and (iv) foreign cooperation are also identified. This chapter discusses possible input and output variables to be used in predicting technical inefficiency (scores) through the selected stochastic frontier production function for the SFA, and also the first step of the two-stage DEA. Firm-specific and business environment variables, which are related to each hypothesis, are also explained and used in the conduct of an inefficiency effects model for the SFA approach, and also in the second step of the two-stage DEA approach.

Chapter 6 conducts an empirical analysis related to the hypotheses discussed in Chapter 5. This chapter also employs both the SFA and DEA approaches for 178 Thai listed manufacturing enterprises, covering the period 2000 to 2008. There is no obvious reason to favour one estimation technique over the other due to perceived advantages and disadvantages as discussed in Chapter 4. For the SFA approach the Battese and Coelli (1995) model is applied by estimating a stochastic frontier production function and inefficiency effects model simultaneously using FRONTIER Version 4.1. In addition, a number of null hypotheses such as (i) the validation of the Cobb-Douglas production function, (ii) the absence of technical progress, (iii) the absence of neutral technical progress, (iv) the absence of inefficiency effects, (v) the absence of stochastic frontier inefficiency effects, and (vi) the insignificance of joint inefficiency variables are also conducted. For the DEA approach the two-stage DEA approach is applied for this study. The first stage is to predict technical inefficiency scores applying variable returns to scale (VRS) linear programming as analysed by DEAP Version 2.1. In the second stage the maximum likelihood Tobit model is used, in which technical inefficiency scores are regressed with firm-specific and business environment variables. As part of hypothesis 8 the self-selection hypothesis is tested by employing the maximum likelihood Probit model. The empirical results obtained from both estimation approaches are compared for a robustness checking.

Chapter 7 provides evidence-based policy implications and recommendations to enhance the efficiency performance and competitiveness of Thai listed manufacturing enterprises. Policy implications and recommendations are addressed based upon the empirical evidence of each hypothesis, including the empirical results of other selected firm-specific and business environment variables. Focusing upon the empirical evidence for each hypothesis and how these could be improved, this chapter also addresses measures which have been currently implemented for Thai listed manufacturing enterprises and how these could be improved. This chapter also makes recommendations on current measures and policies, and further suggests policies to enhance the technical efficiency performance of Thai listed manufacturing enterprises.

Chapter 8 provides a summary and conclusions from the thesis. Finally, the limitations of this study are also outlined and future research possibilities are suggested at the end of this chapter.

1.7 Conclusions

This chapter has overviewed the overall thesis background to enlighten and prepare for the subsequent chapters of this thesis. It firstly provided the background of the study including research problems, outlined the main research objectives of the thesis, and described research questions and sub-research questions to be examined in this thesis. It also highlighted the contributions of the thesis to the existing literature and empirical studies related to the factors affecting firm performance. The chapter also illustrated a number of methodologies necessarily used to accomplish the research objectives of this thesis. Furthermore, the research scope of this thesis was discussed at the end of this chapter. Issues identified in this chapter will be discussed in more detail in the following chapters.

CHAPTER 2

Financial Markets, Business Performance and Ownership Structure, Corporate Governance, and Economic Integration in Thailand

2.1 Introduction

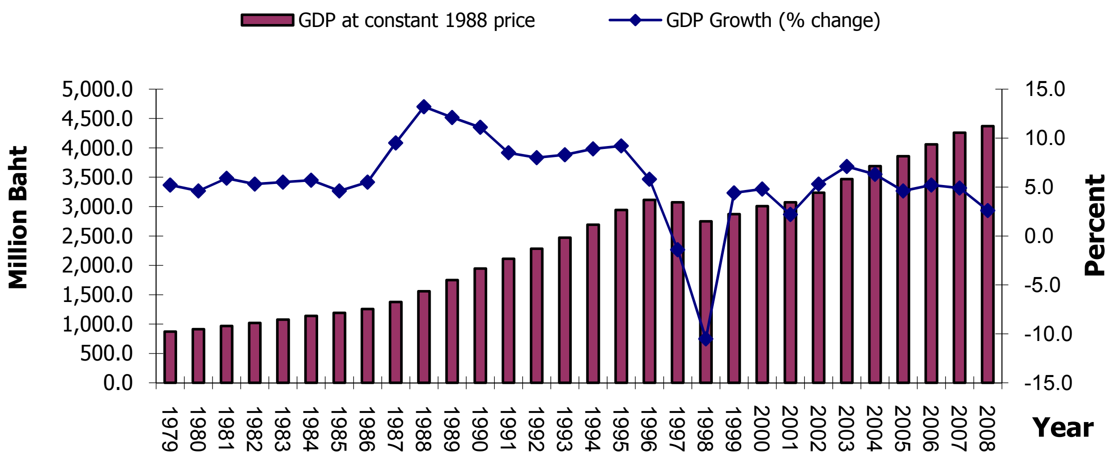
This chapter aims to provide background knowledge which is very important for laying the foundation for subsequent chapters in this thesis. The following information such as (i) financial markets in Thailand focusing on the equity (capital) market, (ii) business performance and ownership structure of listed enterprises in the Stock Exchange of Thailand (SET), and (iii) corporate governance in Thailand are necessary and useful, since this thesis focuses on the technical efficiency performance of Thai listed manufacturing enterprises as well as the effects of business environment and firm-specific factors which significantly impact on their technical efficiency performance. In addition, the following issues, such as (i) economic integration of Thailand, (ii) the export performance, and (iii) the flow of FDI, have become increasingly important for Thailand's economic growth, since Thailand has moved towards an open economy. Economic integration has become an important factor in promoting the productivity of factors among cooperative countries. Thailand's export performance and foreign direct investment are also worthy of being discussed, since exporting enterprises benefit from their learning-by-exporting experience. Thai firms also gain benefits, such as new technology and access to finance from foreign investors or companies. These factors, therefore, are very crucial for the enhancement of Thailand's economic growth, including the efficiency and competitiveness of Thai manufacturing enterprises.

This chapter, therefore, consists of eight sections as follows: Section 2.2 provides an economic overview of Thailand, including the 1997 financial crisis. Section 2.3 provides an overview of the financial sector in Thailand including its structure and development. Section 2.4 provides an overview of the capital market in Thailand, emphasising its economic significance and development (e.g., the establishment of the Stock Exchange of Thailand (SET) and Securities Exchange Commission (SEC)). Section 2.5 provides an overview of business performance and ownership structure of corporate enterprises listed in the SET. Section 2.6 provides an overview of information on corporate governance in Thailand, which includes directors' rules and responsibilities, accounting standards, and shareholder protection. Section 2.7 provides information on economic integration in Thailand, which includes the country's export performance as well as manufacturing exports and its investment promotion and trade policy regimes, and net flow of foreign direct investment (FDI). Finally, section 2.8 provides the major conclusions from this chapter.

2.2 An economic overview of Thailand

From the 1970s to the mid 1990s, Thailand rapidly moved from a low-income country to a middle-income country (World Bank-Thailand, 2008). In recent years, Thailand, however, has confronted the problem in maintaining its growth and escaping from its "*middle income trap*". Therefore, measures to enhance Thailand's productivity and competitiveness in all sectors (agriculture, industry, and services) are urgently required to transit the country to a higher income and sustain its growth over the long run (World Bank-Thailand, 2008). Figure 2.1 demonstrates that the Thai economy experienced steady growth in the first half of the 1980s, but a more rapid increase in the second half of the 1980s.

Figure 2.1: Thailand's GDP growth (constant 1988 prices), 1979-2008



Source: The Bank of Thailand (2009c)

GDP growth reached an historical maximum of 13.2 percent in 1988. From 1987 to 1995 GDP growth averaged 9.9 percent annually, but started to slow down from 5.9 percent at the beginning of 1996 to its historical minimum of -10.5 percent in 1998. The causes of such a dramatic slowdown of GDP growth were due to a decline in export growth, tight monetary policy, and political and financial instabilities (Lombaerde, 2008). In 1999, GDP growth recovered to 4.45 percent, and achieved an annual average rate of 5 percent during 1999 to 2007. In 2008 GDP growth slowed to 2.6 percent, much lower than that of other developing countries in the region such as China (9 percent), Indonesia (6.1 percent), Malaysia (4.6 percent), and the Philippines (4.6 percent) (Bank of Thailand, 2009b). The reduction in Thai economic growth in 2008 was mainly due to high oil and food prices, and particularly in the fourth quarter, internal political unrest and the global economic downturn adversely affecting Thai export demand, manufacturing production, and tourism (World Bank-Thailand, 2008; Bank of Thailand, 2009d). The main sectors contributing to Thai GDP in 2008 were the manufacturing sector (40.10 percent) and other services including the financial sector, education, hotels, and restaurants (37.2 percent) (Bank of Thailand, 2009b).

The 1997 financial crisis

The Asian financial crisis saw the largest financial bailout packages offered by the IMF in history, and the sharpest financial shock to hit developing countries since the 1982 debt crisis (Radelet and Sachs, 1999). Thailand and Indonesia were the two hardest hit economies by the crisis (Rosengard, 2004). The main reasons for this crisis were due to the corrupt and mismanaged banking systems, investment in non productive assets, exchange rate policy (e.g., the maintenance of pegged exchange rate regimes for too long), lack of transparency in corporate governance, macroeconomic mismanagement, an excessive reliance on short term debt and shortcomings of state-managed capitalism (Fischer, 1998; Radelet and Sachs, 1998; Radelet and Sachs, 1999). Interestingly, there was little sign of deterioration before the crisis since the conventional macroeconomic fundamentals within Asian economies had been outstanding for decades, but signs of excess debt and rising current account deficits had emerged (Radelet and Sachs, 1998).

Thailand had enjoyed high economic growth for a decade under the framework of a fixed exchange rate regime, and had embarked on a liberalization of financial markets since 1990 that brought greater competition among financial institutions, but lacked appropriate supervisory and regulatory measures. The first (1990-1992) and second (1993-1995) three-year financial system development plans announced and implemented by the Thai government, substantially liberalized financial capital flows and foreign exchange transactions. Thailand agreed to adopt Article 8 of the IMF's Articles of Agreement in 1990, removing foreign exchange restrictions on current-account-related transactions (Kawai and Takayasu, 1999). The Bangkok International Banking Facility (BIBF) was established in 1993 as part of the second financial system development plan (1993-1995), aimed at playing an essential role in expanding international bank loans. The BIBF contributed to a dramatic expansion of foreign loans, particularly short-term loans into Thailand. The foreign liabilities of banks and financial institutions in Thailand increased from 5 percent of GDP in 1990 to 28 percent of GDP in 1995 (Radelet and Sachs, 1999). However, a resilient financial system focused on cautious management of assets and liabilities, trustworthy information disclosure, generally accepted accounting standards, and effective supervision and prudential regulation was not established in conjunction with this development (Kawai and Takayasu, 1999).

The Thai economy started to experience major economic difficulties by mid 1996. Thailand's export growth, one of the key driving forces for the country's economic growth, decreased by 1.3 percent in 1996, and the current account deficit increased to 7.9 percent of nominal GDP (Kawai and Takayasu, 1999). During the first half of 1997, an unsustainable current account deficit, a significant appreciation of the real effective exchange rate, a rise in short-term foreign liabilities, a deterioration of the fiscal balance and rapidly visible financial sector shortcomings emerged (Lindgren et al., 1999). After the Baht devaluation on 2nd July 1997, the Thai economy declined further. Corporate borrowers' repayment liabilities to banks in foreign currency expanded rapidly. In order to protect capital flight a high-interest rate policy was proposed to secure the value of the Baht, leading to a slow down of the Thai economy, further decline in the real estate and stock markets, and a contagion effect to other regional economies (Kawai and Takayasu, 1999).

Furthermore, the IMF initially viewed the 1997 crisis as a serious and traditional balance of payments crisis. An early stage policy of the Thai government, suggested by the IMF to deal with the crisis, therefore, focused upon an austerity approach, such as implementing tight fiscal and monetary policies and the rapid closing of 56 nonviable financial institutions in 1997 (Kawai and Takayasu, 1999; Radelet and Sachs, 1999; Jansen, 2001). The panic of investors, depositors, and creditors, however, increased dramatically, deepening the Thai economic contraction. International creditor banks started to cut lending and refused to roll over their cross-border loans, which threatened financial market stability. The exchange rate and the stock market collapsed, most financial institutions were closed down, and the recapitalisation of all financial institutions emerged (Menkhoff and Suwnaporn, 2007). These domino effects led to a credit crunch and the economy's GDP experienced a sharp contraction by 10.5 percent in 1998. From early 1998 several financial remedies were addressed, including the consolidation of nonviable finance companies and banks with viable ones (Kawai and Takayasu, 1999; Bank of Thailand, 2002). After the 1997 crisis, Thailand sustained its prudent fiscal policies, maintaining relatively small budget deficits and managing its debt burden effectively (Rosengard, 2004). Financial institutions and entrepreneurs in Thailand have monitored their external vulnerabilities and limited exposure to contingent liabilities. In other words, they have become more risk averse after the crisis. More importantly, Thailand's corporate governance has improved after the crisis (see Section 2.6).

By mid 2000, restructuring in the banking and corporate sectors included the introduction of more competition, including from foreigners. The government explicitly encouraged foreign banks to takeover local banks in stabilizing the Thai financial sector, and also promoting technological upgrading (Okuda and Rungsomboon, 2005). An emergency Decree was issued to amend the Commercial Banking Act B.E. 2505 (1962) (No. 2). This helped relax restrictions on the foreign ownership of commercial banks by allowing foreign investors to own the shares of Thai commercial banks up to 100%, subject to certain conditions (Bank of Thailand, 2000). The Thai economy started to recover strongly in mid 2000. At this time it could be seen that fiscal expenditure and exports were expanding. Furthermore, strengthening institutions, enhancing human resources, and tackling infrastructure weaknesses became essential to increasing Thailand's long term growth (East Asia Analytical Unit, 2000).

2.3 The financial sector in Thailand

The financial market is an important part of the Thai economic system, where potential borrowers (issuers) can meet lenders (investors) to negotiate and conduct a number of financial agreements (Bank of Thailand, 2009a). The aim of financial market development is, therefore, to improve its capability in terms of allocation of financial resources as an intermediary. To promote the Thai financial market there should be a sizable demand for investment from different kinds of investors, a wide range of financial instruments, and diversified investors and issuers. A highly efficient financial market can accommodate large and varied issuance of financial instruments, with a minimum price effect enabling financial instruments to be promptly exchanged at reasonable cost (Bank of Thailand, 2009a).

2.3.1 Financial sector development in Thailand

Comprehensive liberalization of the Thai financial system was implemented according to two Financial System Development Plans (Kawai and Takayasu, 1999); (1) the first Financial System Development Plan (1990 to 1992) and (2) the second Financial System Development Plan (1993 to 1995). The aims of the first Financial System Development Plan were as follows: (1) To deregulate and liberalize interest rates, and foreign exchange transactions; (2) To develop new financial instruments and financial infrastructure; (3) To enhance supervision and examination of financial institutions; (4) To improve payment systems. Furthermore, the main objectives of the second Financial System Development Plan were as follows: (1) To improve financial market efficiency; (2) To establish the Bangkok International Banking Facility (BIBF) as an offshore banking centre; (3) To mobilize domestic savings through pension systems and other means (Kawai and Takayasu, 1999). Due to the second Financial System Development Plan the BIBF contributed to a dramatic expansion of foreign loans, particularly short term loans into Thailand, without adequate financial institution supervision (Kawai and Takayasu, 1999).

The Thai financial sector has been progressively changed since the 1997 Asian financial crisis. Risk management, improved customer service, and lending based on cash flow and credit analysis, have been progressively encouraged in the Thai financial sector (East Asia Analytical Unit, 2000). In 1998, the Thai government allowed foreigners to own up to 100 percent of the shares in banking, securities, and foreign companies. In addition, the Thai Cabinet approved an increase in foreign ownership in insurance companies from 25 to 49 percent. As a result, relaxing foreign ownership restrictions expanded these financial institutions' capital, management expertise, and technology (East Asia Analytical Unit, 2000). The Financial Sector Master Plan (FSMP), proposed by the Ministry of Finance and then approved by the Council of Ministers in January 2004, was implemented to establish the further development of the Thai financial sector. The FSMP has three important visions, as follows: (1) Vision 1: To provide financial services to all economically viable users; (2) Vision 2: To increase the efficiency of the Thai Financial Sector; (3) Vision 3: To set up measures to improve consumer protection (The Federation of Thai Capital Market Organization, 2006).

As part of the FSMP, for the capital market, the Federation of Thai Capital Market Organizations (FeTCO), and related government agencies, proposed a second phase master plan for the Thai capital market (2006 - 2010), and this was approved by the Ministry of Finance in 2006. This plan emphasised seven principal measures to strengthen the Thai capital market, including the equity, bond, and derivative markets (The Federation of Thai Capital Market Organization, 2006). As for the equity market the plan emphasised the need to increase market size and the supply of corporate equity, promoting SMEs to be listed in the Market for Alternative Investment (MAI), as well as increasing the proportion of institutional investors[18] from 10 percent to 20 percent of the total value of share trading. As for the bond market the plan focused upon encouraging its growth to the same volume as the money market. Derivative instruments and securitization have also been encouraged to develop as stated in this plan, since it can reduce the risk exposure of entrepreneurs and investors in the capital market. Furthermore, an increase in the number of listed companies has been encouraged aimed at improving their corporate governance and competitiveness. The plan also aims to increase financial literacy across the country, and the SEC and the SET would be promoted to develop and supervise the Thai capital market (The Federation of Thai Capital Market Organization, 2006). On 25 March 2008 the Government established the Thai Capital Market Development Supervisory Committee, chaired by the Minister of

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[18] "Institutional investors" means (i) institutional investors, as defined according to the SEC, (ii) foreign securities companies, and (iii) other juristic persons as prescribed by the SET.

Finance. They will be responsible for the formulation of a Capital Market Development Plan and allocated tasks from relevant authorities (Bank of Thailand, 2009a).

Consequently, the Thai financial market has developed at a steady pace after the 1997 Asian financial crisis. According to the Bank of Thailand (2009a) it can be seen that there have been several parties in the public and private sectors involved in the development of the Thai financial market, such as (i) the Public Debt Management Office (PDMO), (ii) the Fiscal Policy Office (FPO), (iii) the Revenue Department, (iv) the Office of Securities and Exchange Commission (SEC), (v) the Office of Insurance Commission (OIC), (vi) the Stock Exchange of Thailand (SET), (vii) the Thai Bond Market Association (ThaiBMA), (viii) the Thai Bankers' Association (TBA), (iv) the Foreign Banks' Association (FBA), (v) the Federation of Accounting Professionals (FAP), (vi) the Bank of Thailand (BOT), (vii) the Federation of Thai Capital Market Organization (FeTCO), (viii) Ministry of Finance (MOF) as well as academics and market professionals (Bank of Thailand, 2009a). The authorities, as mentioned above, have comprehensively established and improved financial market infrastructures in Thailand such as improving the clearing and settlement system, easing and introducing some supervisory regulations, encouraging new types of financial instruments, enhancing the tax system and accounting standards, preparing codes of conduct and market practices, setting up financial market associations to gather and disclose information to the public, and standardizing market practices (Bank of Thailand, 2009a).

2.3.2 Structure of the Thai financial market

The Thai financial market consists of (i) the foreign exchange market, (ii) the money market, (iii) the debt market, and (iv) the derivatives market. These markets are highly related to one another (Bank of Thailand, 2009a). The foreign exchange market is also known as an Over the Counter (OTC) market where commercial banks have authorization from the BOT in conducting FX transactions, and are the main traders (Bank of Thailand, 2009a). The money market is a market for short-term borrowing and lending (liquidity management), normally within a 1 year period (Bank of Thailand, 2009). Most transactions in the money market are in unsecured interbank borrowing (clean loan), trading of short-term papers (e.g., Treasury Bills, BOT securities, Promissory Notes, and Bills of Exchange), and Repurchase Agreements (Repo) and debt instruments are traded in the debt market (Bank of Thailand, 2009a). The bond market has become a significant market for alternative lending after the 1997 Asian financial crisis. This market helps reduce the dependence on domestic and foreign bank lending (East Asia Analytical Unit, 2000). Complex financial instruments whose value is derived from the value of underlying assets are also traded in the derivative market (Bank of Thailand, 2009a). The equity market (capital market) is a market for long-term funding for business units. Shareholders have the ownership power over the firms in which securities are issued. Shareholders will obtain a return in the form of a dividend and capital gain.

Table 2.1: Share of Thai financial markets from 2002-2007 as measured by transaction volume (%)

Financial Markets	2002	2003	2004	2005	2006	2007
FX Market	44.2	47.8	27.1	28.4	29.6	21.3
Money Market*	48.2	40.6	57.4	59.4	59.9	61.7
Bond Market	3.9	4.1	5.7	5.9	5.5	12.1
Derivatives Market	Nil	Nil	Nil	Nil	Nil	Nil
Equity Market (SET and MAI)	3.7	7.5	9.8	6.2	5.1	4.9
Total	**100**	**100**	**100**	**100**	**100**	**100**

Source: The Bank of Thailand (2009a)
Note: *Inclusive of Interbank Clean Loan, BOT Repo, Private Repo, Bilateral Repo (during 2004-2007), and Sell and Buy Back transactions

According to Table 2.1 the money market has been the most active market in the Thai financial market, with its share in the financial market rising from 48.2 percent in 2002 to 61.7 percent in 2007. The foreign exchange (FX) market has the second highest share of the financial market, but its share has decreased from 44.2 percent in 2002 to 21.3 percent in 2007. The bond market has experienced substantial growth since 2002. It contributed 12.1 percent of total shares to the Thai financial market in 2007. The equity market (SET and MAI), however, has the lowest ranking in the financial market, with a market share of only 4.9 percent.

2.4 Capital market in Thailand

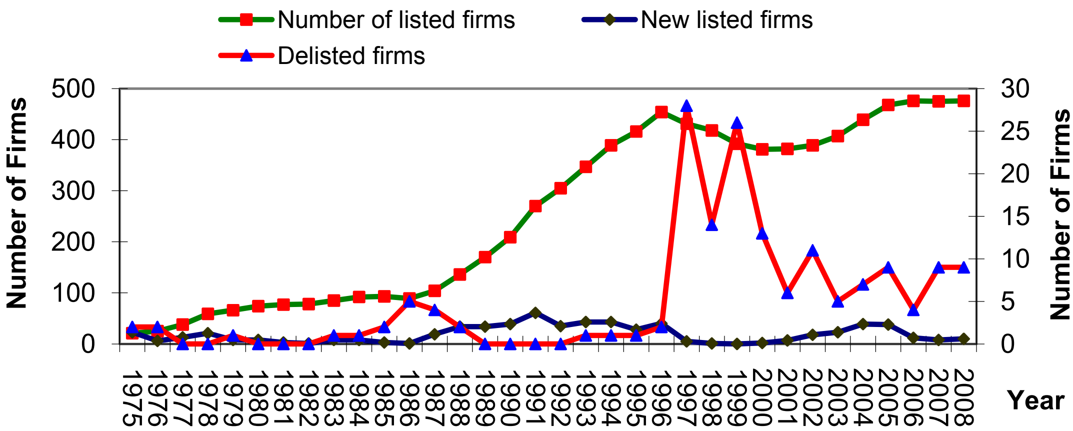
The equity market in Thailand is supervised by the Office of Securities and Exchange Commission (SEC) and operated by the Stock Exchange of Thailand (SET) under the Securities and Exchange Act B.E. 2535 (1992) (The Stock

Exchange of Thailand, 2009a). The securities can be traded through the Stock Exchange of Thailand (SET) and Market for Alternative Investment (MAI). Growth of the Thai capital market is considered to be a crucial source of funds for medium to long-term investment by firms. It assists enterprises or entrepreneurs who require substantial funds for their business operations in obtaining direct funds from the public by issuing and offering their securities (Securities and Exchange Commission, 2009). Issuing securities through the mechanism of the capital market allows enterprises to raise funds at lower cost compared with the conventional medium through loans from domestic and foreign financial institutions (Securities and Exchange Commission, 2009). The improvement of the Thai capital market, hence, plays an important role in developing, as well as strengthening, the stability of the Thai economic system.

2.4.1 Economic significance of the equity market (capital market)

An open capital market can reduce the cost of capital and increase market efficiency. The capital market plays a crucial role within an economy in providing large-scale direct finance to productive firms as well as facilitating a secondary market for equity holders to buy and sell securities (Naughton, 1999). The following figures indicate the importance of the Thai capital market to the Thai economy, as well as its importance relative to other Asian countries.

Figure 2.2: Number of listed firms, new listed firms, and delisted firms in Thailand (1975 – 2008)

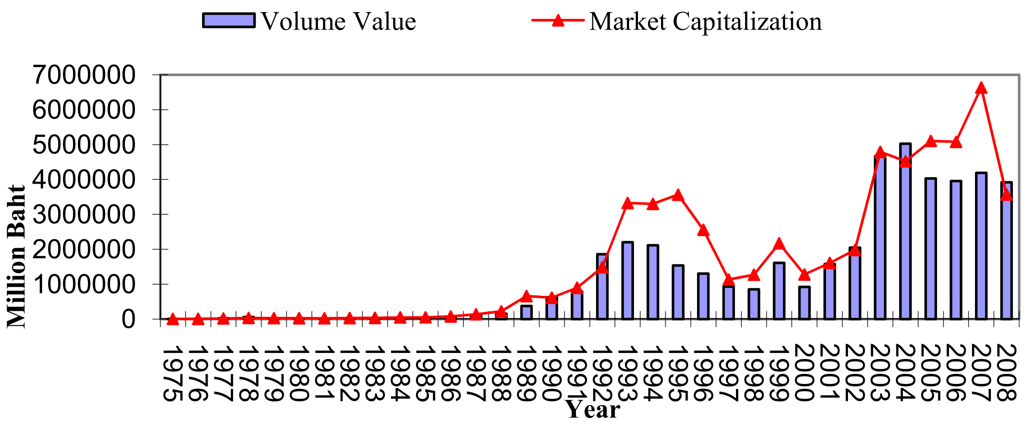


Source: The Stock Exchange of Thailand (2009g)

Note: Both vertical axes represent the number of firms. The total number of listed firms refers to the left vertical axis. The number of newly listed firms and delisted firms refers to the right vertical axis.

Figure 2.2 shows that the number of listed firms gradually increased from 21 in 1975 as its first trading year to 89 in 1986. There was a sharp increase in the number of listed firms from 104 in 1987 to 454 in 1996. The increasing number of new listed firms reached an historical maximum of 61 in 1991. In 1997, the Asian financial crisis began and adversely affected the growth of the Thai Economy. During this year, some 28 listed firms were delisted from the Exchange. There were, however, only 5 new firms listed in the Exchange at the end of 1997 compared with 40 new firms previously listed in 1996. The decrease in numbers of listed firms continued for four years during 1997 to 2000. In particular, 26 firms were delisted from the Exchange, with no new firms listed on the Exchange, from 1999. The number of listed firms started to increase again from 382 firms in 2001 to 468 firms in 2005. During the period 2005 to 2008, new listed firms annually averaged 10 firms.

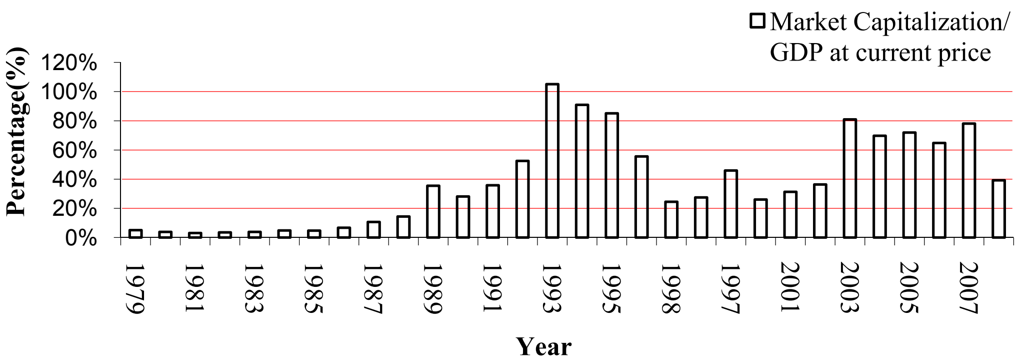
Figure 2.3: Market capitalization and the value of share trading in Thailand (1975 -2008)



Source: The Stock Exchange of Thailand (2009g)

From Figure 2.3 it can be seen that the size of Thai listed enterprises was quite small during the period 1975 to 1988, since market capitalization as a measure of corporate or economic size slowly increased from 5,394 million baht in 1975 to 223,645 million baht in 1988. Nevertheless, there was a substantial increase in market capitalization from 659,493 million baht in 1989 to 3,564,569 million baht in 1995. The trend of market capitalization had been downward starting from a 1995 value of 3,564,569 million baht to a 2000 value of 1,279,224 million baht. Subsequently, market capitalization recovered again after 2000, and reached an historical peak at 6,636,069 million baht in 2007. In 2008, market capitalization suddenly decreased by 46.23 percent relative to 2007 due to the global economic downturn and domestic political instability. Similarly, the value of share trading slowly increased from 559 million baht in 1975 to 156,445 million baht in 1988. It followed the same growth pattern as market capitalization during 1989 to 2004. The highest value of share trading was 5,024,399 million baht in 2004. The value of share trading, however, dropped from 5,024,399 million baht in 2004 to 4,031,240 million baht in 2005, and remained stable during 2005 to 2008 due to the global economic downturn as well as domestic political unrest.

Figure 2.4: The size of market capitalization relative to Thai GDP (%)

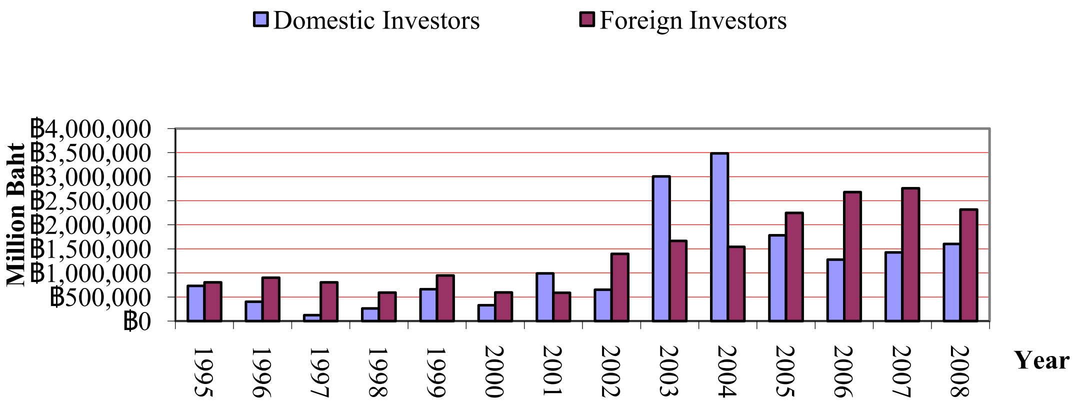


Source: The Bank of Thailand (2009c) and the Stock Exchange of Thailand (2009g)

The measurement of corporate size can be expressed by market capitalization, and also compared with GDP to measure its importance to the economy. From Figure 2.4 it can be seen that the size of market capitalization relative to GDP was relatively high after 1989. It substantially increased from 35.52 percent in 1989 to an historical peak of 105.06 percent in 1993. Nevertheless, it dramatically dropped after 1993, which could be seen from a downturn from 90.95 percent in 1994 to 24.50 percent in 1998. During 1999 to 2002 it gradually started to increase again, and went on a substantially increasing trend from 36.35 percent in 2002 to 78.13 percent in 2007. After 2007 there was a sudden drop, and remained at only 39.20 percent in 2008 due to the global economic downturn as well as domestic political unrest.

The value of share trading is the summation of both the selling and buying value of share trading. Figure 2.5 shows the value of share trading classified by type of investor, which are domestic and foreign investors. It can be seen that foreign investors are the major investors in the SET, since their share trading has exceeded that of domestic investors during most of the period from 1995 to 2008, with the exception of 2003 and 2004. The share trading value of domestic investors reached an historical maximum of 1,541,521 million baht in 2004.

Figure 2.5: Value of share trading by type of investor in the SET (1995 - 2008)



Source: the Stock Exchange of Thailand (2009g)

Nevertheless, foreign investors remained the most active investors during 2005 to 2008, with their share of total trading value being 55.78 percent in 2005, 67.75 percent in 2006, 65.90 percent in 2007, and 59.07 percent in 2008.

Table 2.2: The average value of share trading in Asian countries (1995-2008) (In million USD)

Stock Exchange	1995-1997	1998-2000	2001-2003	2004-2006	2007-2008	1995-2008
Tokyo SE	3,065,590	3,353,356	2,428,975	4,248,215	3,723,363	3,363,900
Hong Kong Exchanges	367,488	525,352	561,242	1,210,472	1,991,592	931,229
Korea Exchange	136,228	189,694	236,278	647,296	796,702	401,240
Taiwan SE Corp	234,000	294,868	311,081	504,038	510,213	370,840
Singapore Exchange	140,335	149,879	122,465	286,415	402,076	220,234
Bursa Malaysia	206,713	116,208	134,281	199,241	257,265	182,742
Thailand SE	97,560	40,171	66,791	126,479	150,129	96,226
Indonesia SE	63,204	37,645	35,908	97,855	155,227	77,968
Philippine SE	57,309	33,903	20,665	45,563	77,442	46,976
Colombo SE	1,989	1,454	1,908	5,715	5,920	3,397

Source: World Federation of Exchange (2009b)

Table 2.2 indicates that the average value of share trading in Thailand is relatively low compared with other Asian Exchanges, except the Indonesia Stock Exchange, the Philippine Stock Exchange, and Colombo Stock Exchange. The Tokyo Stock Exchange had the highest value of share trading in market capitalization on average over the period 1995 to 2008, followed by the Hong Kong Stock Exchanges and Clearing Limited, and the Korea Exchange, the Taiwan Stock Exchange Corporation, and the Singapore Exchange, Bursa Malaysia, the Stock Exchange of Thailand, the Indonesia Stock Exchange, the Philippine Stock Exchange, and Colombo Stock Exchange.

Table 2.3: The average market capitalization in Asian countries (1995 – 2008) (In million USD)

Stock Exchange	1995-1997	1998-2000	2001-2003	2004-2006	2007-2008	1995-2008
Tokyo SE	2,905,684	3,353,356	2,428,975	4,248,215	3,723,363	3,331,919
Hong Kong Exchanges	388,749	525,352	561,242	1,210,472	1,991,592	935,481
Korea Exchange	120,986	189,694	236,278	647,296	796,702	398,191
Taiwan SE Corp	249,598	294,868	311,081	504,038	510,213	373,960
Singapore Exchange	136,794	149,879	122,465	286,415	402,076	219,526
Bursa Malaysia	204,365	116,208	134,281	199,241	257,265	182,272
Thailand SE	84,822	40,171	66,791	126,479	150,129	93,678
Indonesia SE	62,120	37,645	35,908	97,855	155,227	77,751
Philippine SE	56,818	33,903	20,665	45,563	77,442	46,878
Colombo SE	1,986	1,454	1,908	5,715	5,920	3,397

Source: Word Federation of Exchanges (2009a)

In addition, Table 2.3 indicates that the size of the Thai capital market, expressed in terms of the average market capitalization, is still low compared to other stock exchanges in Asia. The Tokyo Stock Exchange had the highest value of market capitalization on average over the period 1995 to 2008, followed by the Hong Kong Exchanges and Clearing Limited, the Korea Exchange, the Taiwan Stock Exchange Corporation, the Singapore Exchange, Bursa Malaysia, the Stock Exchange of Thailand, the Indonesia Stock Exchange, the Philippine Stock Exchange, and Colombo Stock Exchange.

2.4.2 Development of the Thai capital market

The Thai Capital Market has been developing since the 1960s. The first five - year National Economic and Social Development Plan (1963-1966) was implemented in 1961 to support the development of the Thai economy and its stability, as well as the standard of living in Thailand. In addition, the Second National Economic and Social Development Plan (1967-1971) also mentioned the underdevelopment of the Thai capital market and measures required to facilitate its development as proposed in chapter five of this plan. The capital market was not successful in raising funds, since only 500 million baht was raised through the Stock Exchange during the period 1966 to 1971 (The National Economic and Social Development Board, 1967). Furthermore, inefficient securities trading, lack of regulated securities agencies, and a lack of investor confidence in the management of companies were seen to be the causes slowing down the development of the Thai capital market. In this regard, the establishment of an orderly securities market was, for the first time, suggested by the Second National Economic and Social Development Plan (1967-1971). The settlement of this market aimed at providing appropriate facilities and procedures for securities trading (The Stock Exchange of Thailand, 2009a). Hence, the development of the Thai capital market officially started in 1969 when the Thai government, with the support of the World Bank, initiated a study aimed at developing the capital market in Thailand and which resulted in the establishment of the Stock Exchange of Thailand (SET). Currently, the Second Capital Master Plan (2006 - 2010) is being implemented, focusing upon seven principal measures to strengthen the Thai capital market including the equity, bond, and derivative markets as mentioned in section 2.4.1 (The Federation of Thai Capital Market Organization, 2006).

Stages of development of the stock exchange in Thailand

There have been two stages in the development of the Thai Stock Exchange. Before establishing the Stock Exchange of Thailand (SET) in 1975 the Bangkok Stock Exchange (BSE), which was privately owned by a group of foreigners, began operation in 1963.

Establishment of the Bangkok stock exchange

Prior to the establishment of the SET the development of the Thai capital market was initiated by a private group (in the form of a mutual fund). They established an investment company called “IBEC” in 1960 (The Stock Exchange of Thailand, 2005). In July 1962, they established an organised stock exchange as a limited partnership, which was later transferred to a limited company. Its name was changed to the “Bangkok Stock Exchange Co., Ltd.”(BSE) in 1963 (The Stock Exchange of Thailand, 2009a). However, the operation of BSE was not successful and became rather inactive. Its annual turnover decreased from 160 million baht in 1968 to 114 million baht in 1969, and its trading volumes also continued to decrease dramatically thereafter from 46 million baht in 1970 to 28 million baht in 1971. In 1972, the turnover in debentures was valued at 87 million baht, but stocks started to perform poorly with a low turnover of only 26 million baht. Finally, the BSE stopped its operations in the early 1970s (The Stock Exchange of Thailand, 2009a). The failure of BSE’s operation was mainly due to the lack of official government support and insufficient investor knowledge of the equity market.

Establishment of the stock exchange of Thailand

Although the operation of BSE was not successful the Thai capital market was still supported by the Thai government, due to one of the objectives of the Second National Economic and Social Development Plan (1967-1971) being to promote the country’s capital market. Hence, the development of the Thai capital market was officially supported by the Government with the recommendation of the World Bank in 1969. In April 1970, a study conducted by Professor Sidney M. Robbins was presented to the Bank of Thailand suggesting that securities trading should be operated at only one place, so that investors would perceive the securities’ prices equally (The Stock Exchange of Thailand, 2009a). The report also suggested that the Government must initiate and support the restructuring of capital markets in Thailand. The Bank of Thailand, therefore, proposed to the Ministry of Finance the establishment of a working group on capital market development aimed at establishing a stock market in Thailand (The Stock Exchange of Thailand, 2009a).

In 1972, the "Announcement of the Executive Council No. 58 on the Control of Commercial Undertakings Affecting Public Safety and Welfare" was amended by the government. The operations of finance and securities institutions, therefore, was controlled under the government's regulation (The Stock Exchange of Thailand, 2009a). "The Securities Exchange of Thailand" (SET) was enacted and stated in the Special Degree No. 91 on 20th May 1974. The Revenue Code was revised at the end of 1974, which allowed the investment of savings in the capital market. "The Securities Exchange of Thailand" officially started trading on April 30, 1975. Its name was formally changed to "The Stock Exchange of Thailand" (SET) on January 1, 1991 (The Stock Exchange of Thailand, 2009a).

Establishment of the securities exchange commission (SEC)

The SEC has been established since 1992 under the promulgation of the Securities and Exchange Act B.E. 2535 (1992) or "the SEC Act" which was enacted on March 16th, 1992 (Securities and Exchange Commission, 2009). The SEC is an independent state agency, and has the responsibility to supervise and develop the Thai capital market under the direction and supervision of the Board of the SEC. The current strategic plan (2010 to 2012) of the SEC is to sustain orderly market, to ensure investor protection, to support business innovation, and to enhance competition (Securities and Exchange Commission, 2010). In addition, the Derivatives Act B.E. 2546 (2003) was declared on July 3rd, 2003 and came into force on January 6, 2004. This Derivatives Act provides a regulatory framework for the derivatives market and intermediaries, which allows the SEC to supervise the financial integrity of the market and control to impede adverse systemic effects (Securities and Exchange Commission, 2009).

2.5 Business performance and ownership structure of listed enterprises

Focusing on the growth rate of SET industrial sectors' performance, Table 2.4 indicates that the growth rate of listed firms' gross and net profits decreased by 27.49 percent and 4.75 percent, respectively, from the period 2003-2005 to 2006-2008.

Table 2.4: Business performance of listed firms by sector (2000-2008) (In million baht)

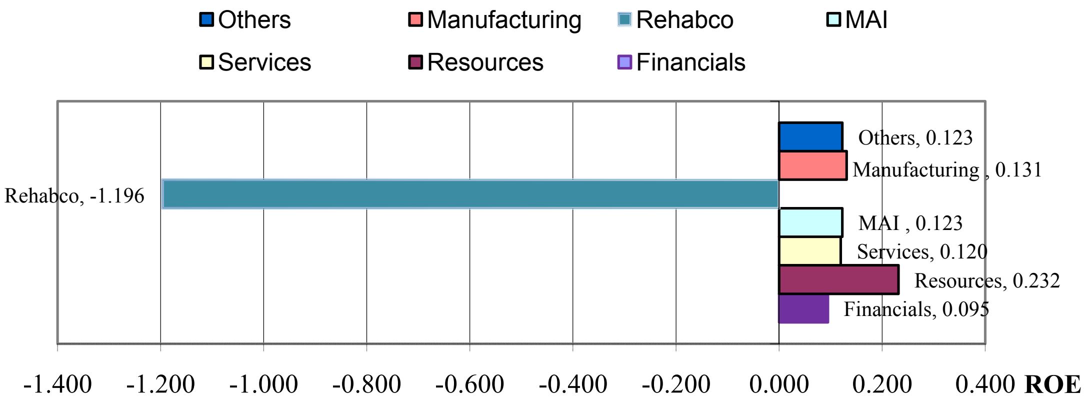
Sector	2000-2002			2003-2005			2006-2008			2000-2008		
	Sales	Gross Profits	Net Profits	Sales	Gross Profits	Net Profits	Sales	Gross Profits	Net Profits	Sales	Gross Profits	Net Profits
Financials	321,447	122,096	35,079	326,709	197,338	85,509	484,640	278,704	802,675	377,599	199,379	307,754
Resources	515,793	95,209	34,046	1,089,829	181,857	110,584	2,836,270	324,139	859,983	1,480,631	200,402	334,871
Services	341,870	94,297	19,218	532,985	124,886	45,707	727,277	134,510	403,357	534,044	117,898	156,094
MAI	2,477	488	95	16,540	3,784	1,071	44,308	9,609	17,406	21,108	4,627	6,191
Rehabco	112,185	15,497	- 19,847	197,663	29,720	35,583	22,040	3,607	- 15,492	110,629	16,275	81
Manufacturing1/	791,815	148,842	40,073	1,214,850	227,334	105,347	1,595,223	252,124	779,472	1,200,629	209,433	308,297
Others 2/	202,728	63,043	13,428	402,355	113,070	57,667	627,164	157,822	511,598	410,749	111,312	194,231
Total	**2,288,315**	**539,472**	**122,092**	**3,780,931**	**877,990**	**441,468**	**6,336,923**	**659,484**	**420,510**	**4,135,390**	**692,315**	**328,023**

Source: The Stock Exchange of Thailand (2009g) (compiled by the author)
1/ The manufacturing sector consists of all listed firms in the agro and food industry, industrials, and consumer products sectors, and some listed firms that are classified as manufacturing firms in property and construction and technology sectors. 2/ Includes some firms that are in sub-industrial sectors, which cannot be grouped in the manufacturing sector (e.g., property development, property fund, and information and communication technology).

With respect to individual industrial sectors the Market for Alternative Investment (MAI) has achieved the highest growth rate on its returns, since the growth rate of net profits increased by 153.92 percent for the period 2003-2005 to 2006 - 2008, followed by the resources sector (78.24 percent), the financials sector (42.23 percent), the other sectors (39.58 percent), the manufacturing sector (10.90 percent), and the services sector (7.71 percent).

In addition, the resources sector, which consists of energy, utilities and mining, has the highest sales revenue, with an average of 1,480,631 million baht during the period 2000 to 2008, followed by the manufacturing sector, whose sales revenue averaged 1,200,629 million baht during the period 2000 to 2008. Moreover, the resources sector achieved the highest net profits followed by the manufacturing, financials, services, others, MAI, and rehabco (rehabilitation companies) sectors, respectively. The size of the SET's manufacturing sector, as indicated by its averaged sales revue over the period 2000 to 2008, is approximately 17.88 percent of Thai GDP at current prices.

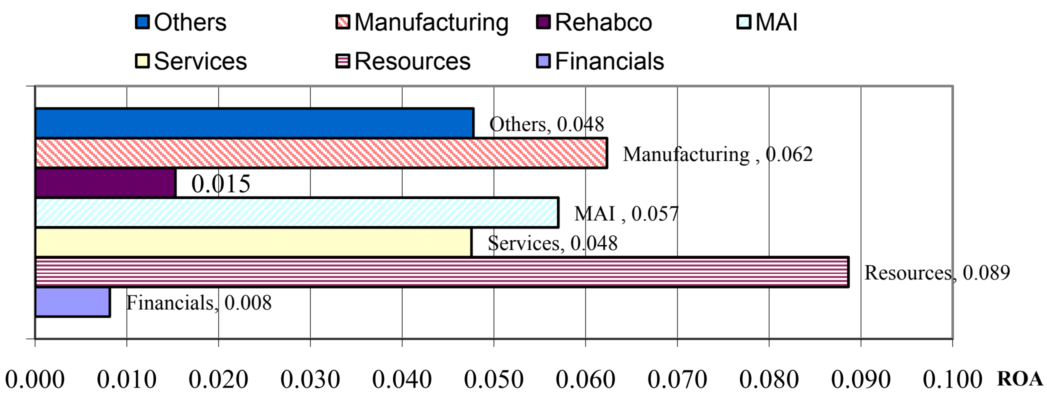
Figure 2.6: Return on equity ratio of listed firms by sector (2000-2008)



Source: The Stock Exchange of Thailand (2009g) (compiled by the author)

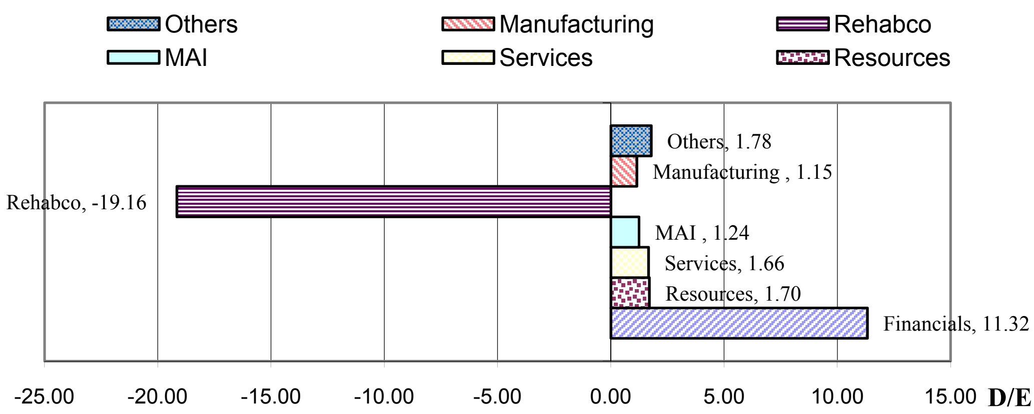
From Figures 2.6 and 2.7 it can be seen that the resources sector performed better than other sectors, as shown by the highest return on equity (ROE) and return on assets (ROA) ratios at 0.23 and 0.09, respectively, during the period 2000 to 2008, followed by the manufacturing sector at 0.13 and 0.06, respectively. The rehabco (rehabilitation companies) sector, however, showed a poor performance, as indicated by the negative return on equity (ROE) ratio at 1.20 during the period 2000 to 2008, and also gave the lowest return on assets (ROA) at 0.02 compared with the other sectors.

Figure 2.7: Return on assets ratio of listed firms by sector (2000-2008)



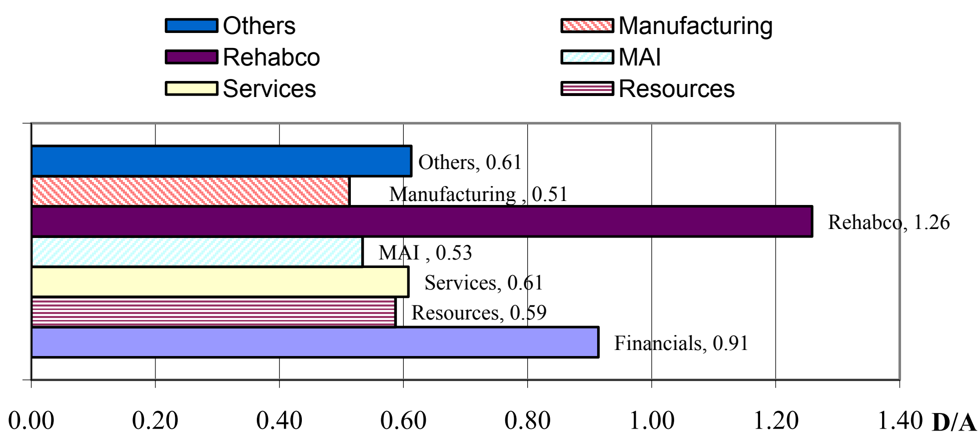
Source: The Stock Exchange of Thailand (2009g) (compiled by the author)

Figure 2.8: Debt to equity ratio of listed firms by sector (2000-2008)



Source: The Stock Exchange of Thailand (2009g) (compiled by the author)

Figure 2.9: Debt to asset ratio of listed firms by sector (2000-2008)



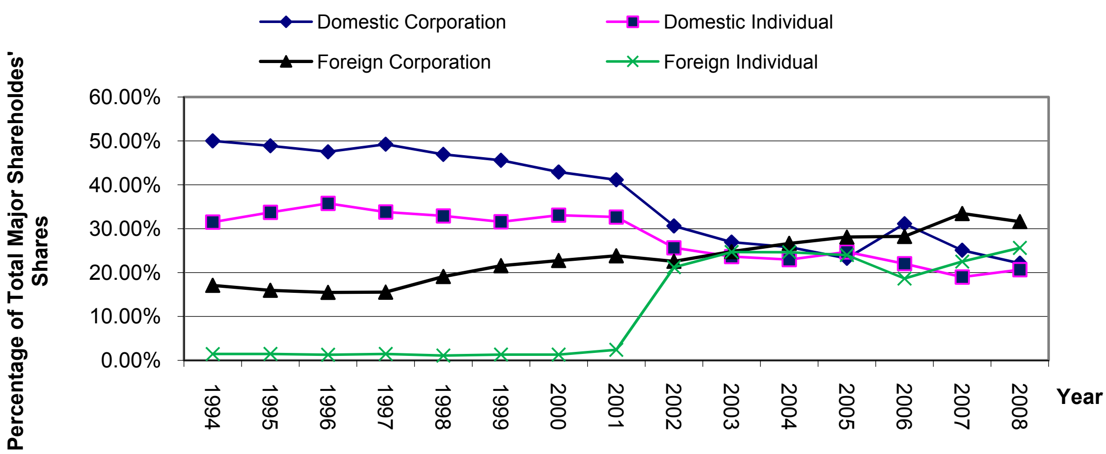
Source: The Stock Exchange of Thailand (2009g) (compiled by the author)

In addition, from Figures 2.8 and 2.9, it can be seen that the manufacturing sector has the lowest risk for investment as shown by its debt to equity ratio (D/E ratio) and debt to asset ratio (D/A ratio) at 1.15 and 0.51, respectively, followed by the Market for Alternative Investment (MAI) at 1.24 and 0.53, and the services sector at 1.66 and 0.61, and the resources sector at 1.70 and 0.59. The financials sector, however, showed the highest D/E ratio at 11.42 over the period 2000 to 2008. The higher D/E ratio of the financials sector compared with other sectors is not surprising, since the nature of each financial institution is to borrow funds from depositors, as indicated by the high level of its debt compared with listed firms in other sectors. It earns a profit margin from (i) the interest rate that it receives from borrowers minus (ii) the interest rate that it pays to depositors and the costs of its operation.

Ownership structure of listed firms

After the 1997 crisis the old 1972 Alien Business Law was replaced by the 1999 Foreign Business Act B.E. 2542 (FBA), allowing foreign investors to have ownership of up to 75 percent or 100 percent in most manufacturing activities subject to specific requirements from the Board of Investment (BOI) of Thailand (Talerngsri and Vonkhorporn, 2005; Sally, 2007). The services sector is highly restricted for foreign ownership compared with other sectors. In the financial sector, foreign investors can have ownership of up to 100 percent in banking and securities (East Asia Analytical Unit, 2000). The retail, transport, construction and health-care sectors, however, are tightly restricted (Sally, 2007).

Figure 2.10: Types of major shareholder of listed firms[1] (1994-2008)



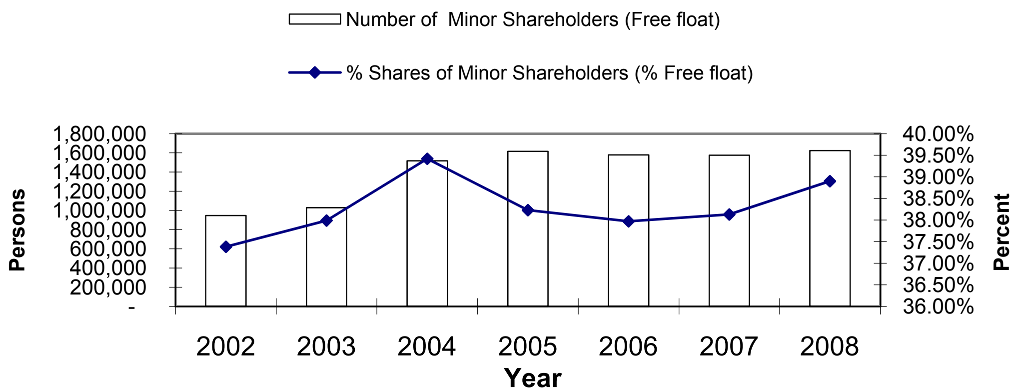
Source: The Stock Exchange of Thailand (2009g) (compiled by the author)

1/ Includes securities of all listed firms

From Figure 2.10 it can be seen that domestic corporations and individuals were the major shareholders of listed firms, accounting for 46.5 percent and 33.1 percent of total shares of listed firms respectively, during the period 1994 to 2001. Foreign individuals, however, became active shareholders in the SET after 2001 due to an increase in their ownership of listed securities from 2.4 percent in 2001 to 25.61

percent of total shares in 2008. Foreign corporations have also remained active major shareholders of securities listed in the SET, since their ownership has increased from 17.07 percent in 1994 to 31.61 percent of total shares in 2008. From 2002 to 2008 the ownership of foreign corporations and individuals averaged 50.94 percent for all securities of SET listed firms.

Figure 2.11: Minor shareholders (free float) of listed firms (2000-2008)



Source: The Stock Exchange of Thailand (2009g) (compiled by the author)

The increased number of minor shareholders is very crucial to a security, since it enables listed firms to raise funds successfully. Minor shareholders are defined to be ordinary shareholders of a firm not classified as "strategic shareholders", where "strategic shareholders" refer to persons with a controlling influence over a firm (The Stock Exchange of Thailand, 2009d). From Figure 2.11, the number of minor shareholders has increased from 946,057 shareholders (37.38 percent of total shares) in 2002 to 1,624,200 shareholders (38.90 percent of total shares) in 2008. The increased number of minor shareholders, therefore, increases the capability of listed firms in raising funds.

The top 10 best and least performing manufacturing firms, including sub-manufacturing sectors, in 2008 were identified by ranking their technical efficiency scores predicted by the SFA approach (see Appendices 1.1 and 1.2). The characteristics of selected firm-specific and business environment factors[19] for the

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[19] Firm-specific and business environment factors will be discussed more in Chapter 3 (Literature Review) and Chapter 5 (Hypotheses and Data Description).

top 10 best and least performing manufacturing enterprises, are (i) type of firm ownership[20], (ii) the percent of executive remuneration relative to total labour expenditure, (iii) the percentage of controlling ownership, (iv) the percentage of managerial ownership, (v) firm leverage and liquidity ratios, (vi) the percentage of firm exports, (vii) the percentage of foreign direct investment, were also provided for all Thai listed manufacturing firms as well as manufacturing sub-sectors.

Comparing the top 10 best and least performing manufacturing firms, executive remuneration relative to total labour expenditure for the top 10 best performing manufacturing firms was approximately 20.01 percent on average in 2008, but 15.57 percent on average in 2008 was found for the top 10 least performing manufacturing firms. Controlling and managerial ownership for the top 10 best performing manufacturing firms was found to be 68.86 percent and 23.38 percent on average in 2008, respectively, but was 60.50 percent and 16.81 percent on average in 2008 for the top 10 least performing manufacturing firms. In addition, foreign direct investment in 2008 was 22.13 percent on average for the top 10 best performing manufacturing firms, but was 16.81 percent on average in 2008 for the top 10 least performing manufacturing firms.

The leverage ratio (debt to asset ratio) in 2008 was 0.48 on average for the 10 best performing manufacturing firms, but 0.11 on average for the 10 least performing manufacturing firms. Both estimated ratios for the Thai manufacturing sector are relatively low compared with the debt to asset ratio in other industries. The higher value of the leverage ratio of the 10 best performing manufacturing firms may indicate that they engage in higher levels of investment compared with the 10 least performing manufacturing firms.

Finally, major shareholders of the 10 best and least performing manufacturing firms, including sub-manufacturing firms, are provided in Appendices 3.1, 3.2, 3.3, 3.4, and 3.5.

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[20] Types of firm ownership will be discussed more in Chapter 3 (Literature Review) and Chapter 5 (Hypothesis and Data Description).

2.6 Corporate governance in Thailand

Weakness in corporate governance and risk management in Thailand was one of the major causes of the 1997 financial crisis. Prior to the crisis most Thai companies were operated by family members or a single shareholder. Concentrated family ownership decreased the quality of the country's corporate governance (East Asia Analytical Unit, 2000). This problem slowed down improvement of corporate governance in Thailand. Moreover, cross shareholding among major shareholders and their affiliates also decreased transparency and increased illicit assets (East Asia Analytical Unit, 2000). Major improvement of corporate governance started after the 1997 financial crisis. The institutional framework for accounting and auditing practices has been strengthened to improve the quality and reliability of corporate financial and non-financial information, especially for SET listed firms. The rules and responsibilities of board of directors have also been strengthened.

The SET began a study of the roles of audit committees in 1995 prior to the crisis. After the 1997 financial crisis the SET announced, in early 1998, that all listed companies were required to obtain an audit committee before 1999 (The Stock Exchange of Thailand, 2009f). In 1999 the SET also issued a guideline for best practices for directors of listed companies, namely the "Code of Best Practices for Directors of Listed Companies". This guideline is currently applied to all directors of listed companies in the SET (The Stock Exchange of Thailand, 2009f). In 2001 the Good Corporate Governance Committee, which consists of representatives from different groups of professionals and organizations, disseminated a report on corporate governance.

This report aimed at enhancing good corporate governance systems and practices used by organizations in the Thai capital market. In 2002, the Thai Government established the National Corporate Governance Committee (NCGC). The SET also introduced fifteen principles of good corporate governance for listed enterprises to implement (The Stock Exchange of Thailand, 2009f). Listed companies are required to disclose their implementation of these principles to the public (by mentioning this in their annual registration statement (Form 56-1) and annual reports) since 2002.

Moreover, under the SEC's regulations any listed company is required to disclose the name of its top 10 shareholders. In a case where one of the top 10 shareholders of the listed company is itself a company which has related transactions with the listed company, the shareholders of that company must also be disclosed (World Bank, 2005, p3).

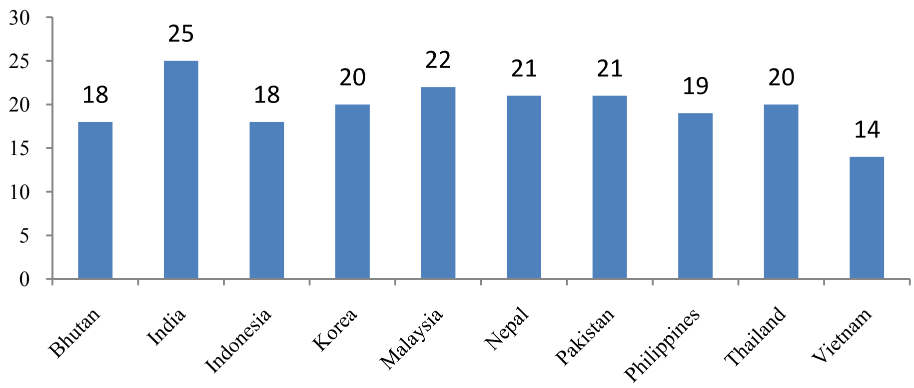
In July 2002 the Corporate Governance Centre was established by the SET to help listed companies develop their corporate governance system. This Centre provides consulting services regarding good corporate governance practices for directors and executives of listed companies, as well as for firms which are preparing to be listed in the Exchange (The Stock Exchange of Thailand, 2009f). In September 2008 securities companies have been required by the SEC to include the company's corporate governance performance according to the Corporate Governance Report (CGR) organised by the Thai Institute of Directors Association (IOD) in their securities analysis reports. Hence, good corporate governance will be more widely considered by investors. This requirement should encourage listed firms to enhance their corporate governance to attract long term investors, since it will be explicitly disclosed on their securities analysis reports (Thai Institute of Directors Association, 2008).

2.6.1 Directors' rules and responsibilities

As part of ongoing improvements to Thai corporate governance the SET issued a guideline for best practices for directors of listed companies, namely the "Code of Best Practices for Directors of Listed Companies" in 1999. The Code of Best Practice for the Directors of Listed Companies is not a legal requirement, but it is considered as a guideline for all board members concerning their behaviour while holding such appointments. The Code aims at enhancing the confidence of shareholders, investors and other related parties in the management of the listed companies (The Stock Exchange of Thailand, 2009h). In addition, the Thai Institute of Directors Association (IOD) has been established since 1999 with the support from the SEC, SET, BOT, and World Bank. The IOD has been promoting good governance practices in Thai companies by developing professional standards of directorship, and providing best practice guidelines for directors to perform their duties effectively (Thai Institute of Directors Association, 2008). Kouwenberg (2006) examined the effect of the voluntary adoption of a code of good governance practices on the value of 320 firms. He found that a one standard deviation increase in the firm-level code addition index led to a 10 percent increase in firm value during the period 2003 to 2005.

However, the World Bank (2005, p3) argued that even though the concepts of trustee duty, duty of care and duty of loyalty are embedded within the Public Limited Company Act (PCA), in practice directors have only a limited understanding of their roles and responsibilities. McGee (2009) compiled 10 reports for the World Bank on the Observance of Standards and Codes (ROSC) of corporate governance for 10 Asian countries, and summarized the findings using 5 categories, such as (i) rights of shareholders, (ii) equitable treatment of shareholders, (iii) role of stakeholders in corporate governance, (iv) disclosure and transparency, and (v) responsibility of the board of committee.

Figure 2.12: A comparative study of the responsibilities of the board of committee in Asia (30 points = the maximum score)



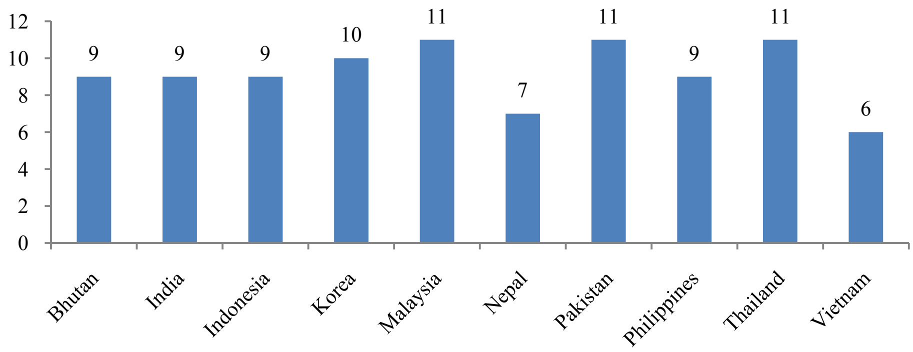
Source: McGee (2009, p139)

Figure 2.12 shows that India had the best score (25 points) regarding the board of committee's responsibilities, followed by Malaysia (22 points), Pakistan and Nepal (21 points), Korea and Thailand (20 points), the Philippines (19 points), Indonesia and Bhutan (18 points), and Vietnam (14 points).

2.6.2 Shareholder protection

According to World Bank (2005) basic shareholder protection has been strengthened in Thailand. For example, investors can freely transfer their shares and the registration of listed companies' shares has been securely improved. As part of recent corporate governance reforms the SET has initiated a number of protection measures through market regulation and enforcement, trading and settlement system reliability, information disclosure and equal accessibility. For instance, the SET has inspected and gathered evidence on suspicious securities trading practices to protect shareholders from controlling shareholder self-dealing, fraud, and insider trading (East Asia Analytical Unit, 2000). In addition, the SEC has allowed the SET to blacklist persons who have caused companies serious damage. In addition, the Securities Investor Protection Fund (SIPF) was established in October 2004 to enhance investor confidence and contribute to market growth (The Stock Exchange of Thailand, 2009e). However, the World Bank (2005, p3) argued that even though shareholders are able to receive all necessary information from Thai listed companies, and are eligible to attend and vote in annual general meetings (AGMs), they still find difficulty in proposing their own agenda at AGMs due to the concentrated control of Thai listed companies.

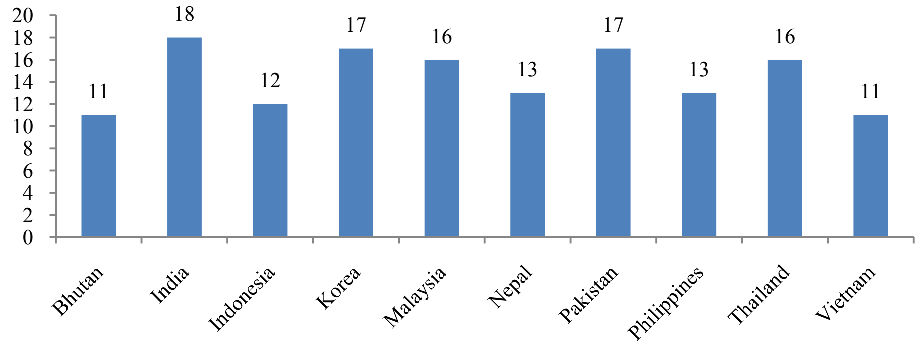
Figure 2.13: A comparative study of the equitable treatment of shareholders in Asia (15 points = the maximum score)



Source: McGee (2009, p137)

Figure 2.13 indicates that Malaysia, Pakistan, and Thailand had the highest score (11 points) in equitable treatment of shareholders, followed by Korea (10 points). Bhutan, India, Indonesia, and the Philippines were in a tie for third place (9 points), followed by Nepal (7 points), and Vietnam (6 points).

Figure 2.14: A comparative study of the role of shareholders in Asia (20 points = the maximum score)



Source: McGee (2009, p138)

Focusing on the role of shareholders in corporate governance for 10 Asian countries, as indicated in Figure 2.14, shows that India is in first place, followed by Korea and Pakistan (17 points), Malaysia and Thailand (16 points), Nepal and the Philippines (13 points) and Indonesia (12 points). Bhutan and Vietnam had the lowest score (11 points) for role of shareholders in corporate governance.

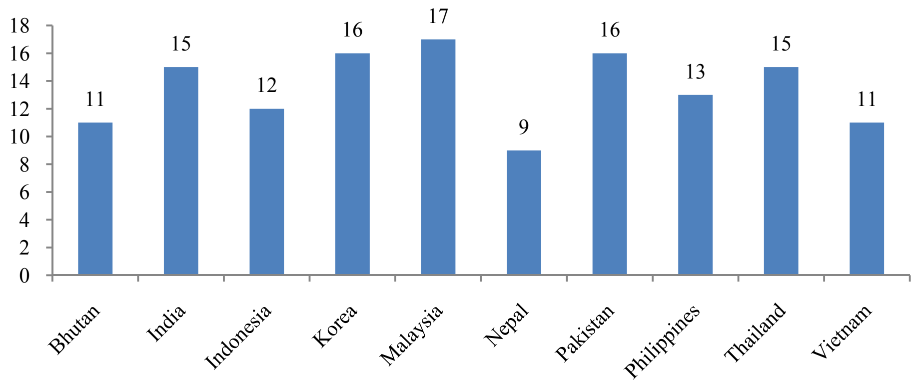
2.6.3 Accounting standards

Tower et al. (1999, p293) mention that accounting standards have economic outcomes that has a direct impact on share prices. Accounting standards can also cause the following impacts: (i) increasing volatility in the net income figure and (ii) changing financial ratios and possible violations of debt covenant agreements. The International Accounting Standards Committee (IASC) has played an important role in developing International Accounting Standards (IAS). Thai Accounting Standards (TAS) initially followed the UK and US standards. International Accounting Standards (IAS) has been used for TAS as its platform since 1997 (Ball et al., 2003; Deloitte Touche Tohmatsu, 2008).

Tower et al. (1999) also state that International Accounting Standards were adopted as the basis for the development of national accounting standards in Malaysia, Singapore and Thailand. Thai Accounting Standards (TAS) are influenced from a number of sources by the Accounting Professions Act B.E. 2547 (2004), International Financial Reporting Standards (IFRS), U.S. GAAP, and other regulatory agencies (e.g., the Thai revenue Department, Securities Exchange of Thailand (SEC), Bank of Thailand, the Office of Insurance Commission) (Deloitte Touche Tohmatsu, 2008). Furthermore, Thai Accounting Standards (TAS) are currently issued by the Federation of Accounting Professions (FAP). Before the establishment of the FAP, Thai Accounting Standards (TAS) were issued by the Institute of Certified Accountants and Auditors of Thailand (ICAAT) (Tower et al., 1999).

As for listed firms the SET has played a leading role in controlling the financial reporting quality of listed firms. As the crisis unfolded in 1998 and 1999 the SET strengthened corporate governance by raising requirements for listed firms to disclose complete and accurate information. The consolidated financial statements must reveal all external and off-balance sheet liabilities. By the end of 1998 the financial statements of listed firms had to meet TAS (East Asia Analytical Unit, 2000). In addition, auditors of the financial reports of listed firms must be approved by the SEC. However, according to the World Bank (2005, p3) Thai Accounting Standards (TAS) are not fully consistent with international accounting standards, and it is not certain that the Federation of Professional Accountants (FPA) can help improve the quality of auditors in Thailand.

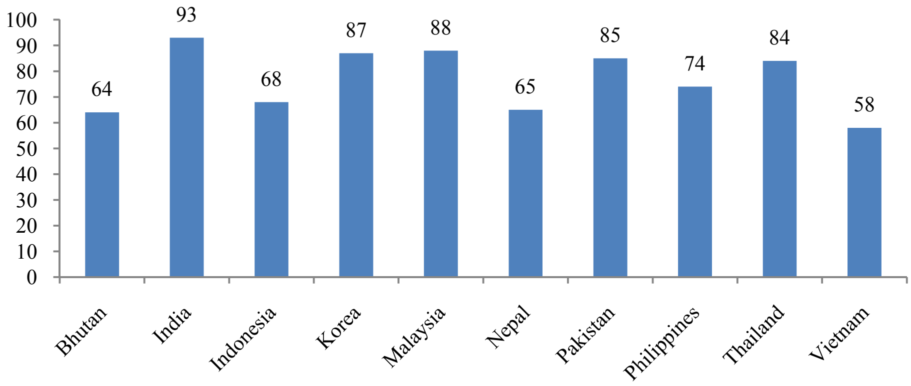
Figure 2.15: A comparative study of disclosure and transparency in Asia (20 points = the maximum score)



Source: McGee (2009, p138)

With regard to disclosure and transparency among 10 Asian countries, Figure 2.15 indicates that Malaysia performs the best (17 points), followed by Korea and Pakistan (16 points), India and Thailand (15 points), the Philippines (13 points), Indonesia (12 points), Bhutan and Vietnam (11 points), and Nepal (9 points).

Figure 2.16: A comparative study of the corporate governance performance in Asia (115 points = the maximum score)



Source: McGee (2009, p140)

Overall, Thailand has made a significant improvement in corporate governance, as discussed earlier. From Figure 2.16 it can be seen that the overall score of Thailand's corporate governance was 84 points out of 115 points. Among the 10 Asian countries in terms of corporate governance, Thailand ranked as the 5th best performing country.

The World Bank (2005, pp3-6) also proposed a number of policy recommendations for Thailand's corporate governance improvement, as follows: (i) strengthening the legislative and regulatory framework, such as strengthening minority shareholder rights by amending the Securities and Exchange Act (SEC) and the Public Company Act (PCA); (ii) increasing the accountability of directors and management and the clarity of the fiduciary duty of directors such as introducing board evaluation procedures and clarifying audit committees; (iii) improving the quality and reliability of financial information and disclosures provided by Thai listed companies, and (iv) establishing corporate governance enforcement priorities, such as strengthening the independence of the SEC and enhancing enforcement for violation of the law.

2.7 Thailand's economic integration, export performance, and foreign direct investment

Besides the reviews in earlier sections (e.g., financial markets in Thailand, business performance and ownership structure of the SET's listed companies, Thailand's corporate governance), this section illustrates the importance of economic integration, export performance, and foreign direct investment, as these factors can significantly impact on Thailand's economic development. Economic integration of Thailand has become increasingly important for its economic development, as this can lead to the productivity enhancement of factors among cooperative nations as suggested by Lloyd (2008). Exports also play an important role in promoting Thailand's economic growth, especially for the manufacturing sector, as exporting firms can benefit from their learning-by-exporting experience, leading to higher efficiency and competitiveness. Foreign direct investment, via the form of foreign ownership, has also become increasingly crucial, as it brings new technology, foreign network, know-how, financial support, and managerial expertise to local firms. As a result, it is very interesting to link these factors with the technical efficiency performance of Thai listed manufacturing enterprises, and, therefore, they are worthy of being discussed as follows:

2.7.1 Thailand's economic integration

The main idea of economic integration is to remove all forms of government measures which discriminate against foreign goods and services, foreign capital inflows, and foreign labour (Lloyd, 2008). Economic integration, therefore, is crucial, since it can increase the productivity of factors among cooperative countries, leading to an increase in the real income of these countries (Lloyd, 2008). The World Trade Organization (WTO) is a global multi-lateral trading group which aims to liberalize trade through tariff reductions in merchandise goods, covering other measures such as anti-dumping, non-tariff measures and trade in services (Hoa, 2008). The WTO, however, has a number of its own difficulties such as its slow negotiation progress in successive rounds in the past, in conjunction with rapid developments in the Asian economies (Hoa, 2008). Bilateral or multilateral free trade agreements (RTAs), therefore, have become an alternative trading platform. Regional Trading Agreements (RTAs) (e.g., the European Union (EU), North American Free Trade Agreement (NAFTA), the Closer Economic Relations (CER), the Common Market of the Southern Cone (MERCOSUR), ASEAN, ASEAN-China, ASEAN+3, ASEAN+6, and the Australia-US Free Trade Agreement (AUSFTA)), therefore, have become an important catalyst in promoting regional economic integration (see Table 2.5).

Moreover, regional economic integration has recently changed to become more outward oriented, to focus on “deep integration” arrangements (e.g., trade facilitation measures, investment and competitive policies, and intellectual property rights) besides intra-regional trade, to link both developed and developing countries together (e.g., NAFTA, the EU-Mexico FTA, and EU enlargement) (Harvie, 2008). Thailand’s trade policy also shifted from import-substitution to export-orientation in 1972 when the Industrial Promotion Act took place (Talerngsri and Vonkhorporn, 2005; Sally, 2007). This caused the Thai economy to become rapidly open and globally-integrated, characterised by strong unilateral liberalization in the 1980s and 1990s, especially in the manufacturing sector (Sally, 2007, p1594). In 1996, Thailand also started to implement a much more outward oriented trade policy (World Trade Organization, 1999).

Thailand has also decided to expand the scope of its bilateral, regional and multilateral economic arrangements as a vehicle of commercial policy, since bilateral or regional trade arrangements are complementary to the multilateral trade objectives towards free trade (Thanapornpun, 2008). According to the WTO trade policy review in 2008, Thailand’s trade policy not only focuses upon its immediate neighbours, but also the wider Asian region through free-trade agreements (FTAs) (World Trade Organization, 2008). Some of Thailand’s trading commitments with other trading partners include, for example, the Uruguay Round (UR) obligations, voluntary trade within APEC, regional liberalization within ASEAN, bilateral regional trading agreements (Talerngsri and Vonkhorporn, 2005). Regional integration through FTAs has notably increased for Thailand after the Asian financial crisis of 1997. For example, expanding Intra-ASEAN FTAs, participating in the Bangladesh-India-Myanmar-Sri Lanka-Thailand Economic Cooperation (BIMSTEC) FTAs, and joining in ASEAN agreements with third countries (e.g., ASEAN-Australia-New Zealand, ASEAN-Japan, and ASEAN-Korea) were successfully negotiated (see Table 2.10) (World Trade Organization, 2008).

Table 2.5: Thailand's trade agreements

Type of Cooperation	
Regional Trade Agreement	
APEC	Economic cooperation
ASEM	Economic cooperation
AFTA	Free trade area (in force from 1992)
ASEAN + 3	Free trade area (to be negotiated by 2012)
ASEAN + 6	Free trade area (under study CEPEA Phase II)
ASEAN-Australia-New Zealand	Free trade area (negotiation completed: 27 Feb 2009; in force: 12 March 2010 (Thailand))
ASEAN-CHINA	Free trade area (negotiation completed for all members: 29 November 2004; in force: 1 October 2003 (Thailand); Investment Agreement completed: 9 November 2009)
ASEAN-Japan	Comprehensive economic partnership (FTA) (negotiation completed : 11 April 2008; in force: 1 June 2009 (Thailand))
ASEAN-India	Free trade area (negotiation completed: 13 August 2009; in force: 1 January 2010 (Thailand))
ASEAN-Korea	Economic cooperation (negotiation completed: 27 February 2009; in force: 1 January 2010(Thailand))
BIMSTEC	Economic cooperation (Agreement on Trade in Goods was completed in 2006)
Greater Mekong Subregion (GMS)	Economic cooperation
Indonesia - Malaysia - Thailand Growth Triangle (IMT-GT)	Economic cooperation
Thailand-EU	Free trade area (under study: public rehearsal)
Thailand's Bilateral Trade Agreement	
Australia	Free trade agreement (in force : 1 Jan 2005)
Bahrain	Free trade agreement (negotiation is temporarily pending since 2005)
China	Free trade agreement (in force : 1 October 2003)
EFTA	Free trade agreement (under negotiation)
India	Free trade agreement (in force : 1 December 2004))
Japan	Free trade agreement (in force : 1 November 2007)
New Zealand	Free trade agreement (in force : 1 July 2005)
Peru	Free trade agreement (negotiation completed: 19 November 2005)
US	Free trade agreement (negotiation is temporarily pending since 2006)
Thailand's Bilateral Trade Agreement under Consideration	
Bangladesh	Free trade agreement
Chile	Free trade agreement
Mexico	Free trade agreement
Pakistan	Free trade agreement
South Africa	Free trade agreement
Sri Lanka	Free trade agreement

Source: Author (information obtained from Department of Trade Negotiations, Thailand, 2010)

In addition, Thailand has agreed on bilateral preferential trading arrangements with several trading partners (e.g., India and Peru) (Department of Trade Negotiations, 2009) (see Table 2.5). One of the most significant bilateral agreements is the Thailand - China FTA, which was concluded in October 2003. This will promote a zero rate of tariffs on general commodities in 2010, and sensitive items for the ASEAN-6 will be attained in 2015. The negotiation of an ASEAN-

China FTA has also inspired other ASEAN trading negotiations with other countries, which include ASEAN-Japan and ASEAN-India (Puntasen et al., 2008).

A number of empirical studies have also examined the effects of FTAs on Thai exporting firms as well as other exporting firms in Asia. Kohpaiboon and Jongwanich (2006) revealed that the overall FTA utilization rates in 2005 for the manufacturing sector in Australia, the Philippines, Malaysia, and Indonesia were relatively low, accounting for 38.7 percent on average. In addition, FTA export creation was not significant in the Thai manufacturing sector, since it was limited to a certain group of manufactured goods (e.g., completely-built-up (CBU) vehicles).

Wignaraja et al. (2010) conducted a survey of 221 exporters in 2008 for leading manufacturing sub-sectors (e.g., textile/garments, electronics, and automobiles/automotive parts). The results suggest that (i) 24.9 percent of exporting respondents utilized FTAs in 2007 and 2008; (2) 45.9 percent of exporting respondents claimed that their business plans were influenced by the provisions of Thailand's FTAs; (3) 62 percent of exporting respondents consulted with government and business associations regarding FTAs; (4) 26.2 percent of exporting respondents were concerned that dealing with multiple rules of origin caused by FTAs increased their business costs. Overall, the awareness of exporting respondents of FTAs and the use of government agencies (e.g., Ministry of Commerce, Ministry of Industry, Customs Department, and Department of Trade Negotiations) and business support institutions (e.g., Thai Chamber of Commerce, Thai Export Association, and Federation of Thai Industries) for their business adjustment to FTAs was low.

2.7.2 Thailand's export performance

Economic expansion in Thailand before the 1997 financial crisis was underpinned by rapid growth in exports. During 1981-1985 the major exported goods were mainly agricultural and processed food, accounting for almost 50 percent of the total average export value (Talerngsri and Vonkhorporn, 2005).

Table 2.6: Thailand's trade value by sectors (1979 - 2008) (In million baht)

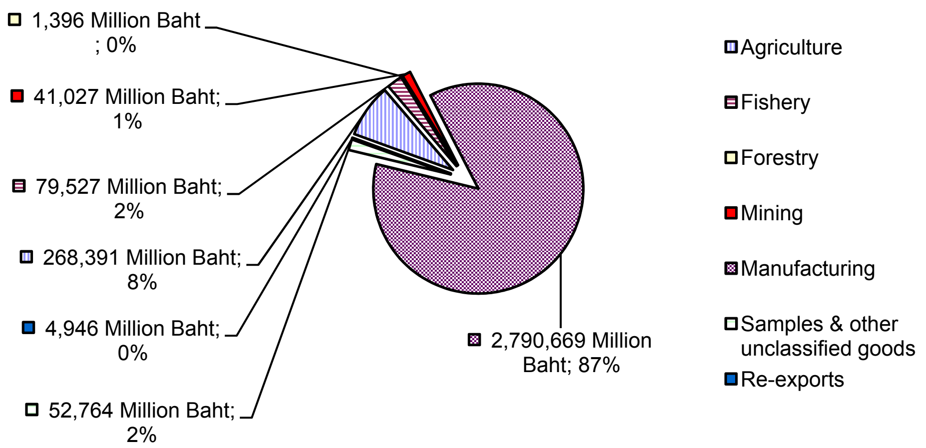
	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2001-2008
Exports	**165,561**	**408,587**	**1,006,009**	**2,091,228**	**3,489,331**	**5,344,321**
Food	82,645	137,664	221,626	348,812	454,852	617,692
Beverages and tobacco	1,912	1,735	3,897	6,219	8,563	13,550
Crude materials	17,326	30,424	51,068	88,923	168,571	295,892
Mineral fuel and lubricant	593	3,121	8,489	45,706	115,011	286,143
Animal and vegetable oils and fats	363	207	309	2,117	6,047	13,783
Chemicals	1,749	5,507	23,355	100,271	239,596	424,475
Manufactured goods	28,916	76,144	175,711	243,197	419,154	677,172
Machinery	10,650	69,375	306,654	843,963	1,517,561	2,347,832
Miscellaneous manufactured goods	16,696	79,176	203,151	345,485	470,763	569,354
Miscellaneous transactions and commodities	1752	4,018	9,756	61,851	83,198	93,966
Re-exports	2,958	1,215	1,993	4,683	6,015	4,461
Imports	**229,259**	**519,162**	**1,510,508**	**1,986,541**	**3,444,211**	**5,252,372**
Food	6,862	22,931	45,175	76,326	125,171	185,365
Beverages and tobacco	1,824	3,029	5,946	7,240	10,367	11,728
Crude materials	14,220	34,927	73,735	84,186	132,778	175,116
Mineral fuel and lubricant	59,400	50,705	92,948	193,472	480,239	1,036,588
Animal and vegetable oils and fats	749	421	1,155	2,141	3,343	4,858
Chemicals	30,052	62,624	124,074	212,240	374,009	564,488
Manufactured goods	37,038	110,853	266,786	351,484	609,870	975,776
Machinery	62,355	197,254	578,024	898,587	1,435,426	1,824,483
Miscellaneous manufactured goods	13,141	22,039	36,268	117,797	194,468	333,638
Miscellaneous transactions and commodities	3,592	12,392	27,441	28,681	33,746	29,851
Gold	26	1,986	6,707	14,386	44,793	110,480
Net Trade (Exports - Imports)	**- 63,699**	**- 110,575**	**- 252,249**	**104,686**	**45,121**	**91,949**

Source: Customs Department (compiled by Bank of Thailand (2009e)) and Talerngsri and Vonkhorporn (2005)

Moreover, the main imported items were mineral fuel and lubricants, and machinery, accounting for 25.9 percent and 27.2 percent of the total average import value respectively (see Table 2.6). A substantial shift from traditional agricultural exports towards manufactured exports emerged during 1991-1995. The manufacturing sector has been one of the most crucial sectors in the East and Southeast Asian countries. Economic growth in this region since the early 1980s has increased primarily from the rapid expansion in manufacturing exports[21] (Jongwanich, 2007). The trend of Thailand's manufactured exports after 1996 has also continued, accounting for 87 percent of total export value (see Figure 2.17). Although manufacturing contributes most to total exports, agricultural products still counted for a fairly important share of exports but its relative importance was diminishing significantly (Lombaerde, 2008).

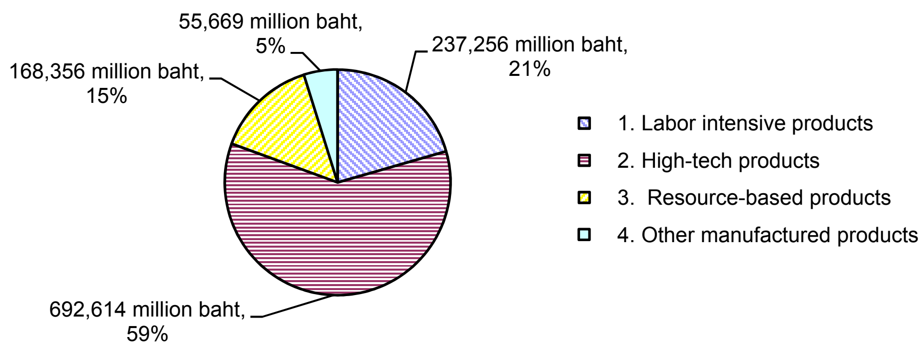
21 This statement might be controversial, as a number of empirical studies of the region have found no statistically significant association between trade/export and economic growth (Sinha, 1999; Ekanayake, 1999).

Figure 2.17: Exports by sector (1996 - 2008)



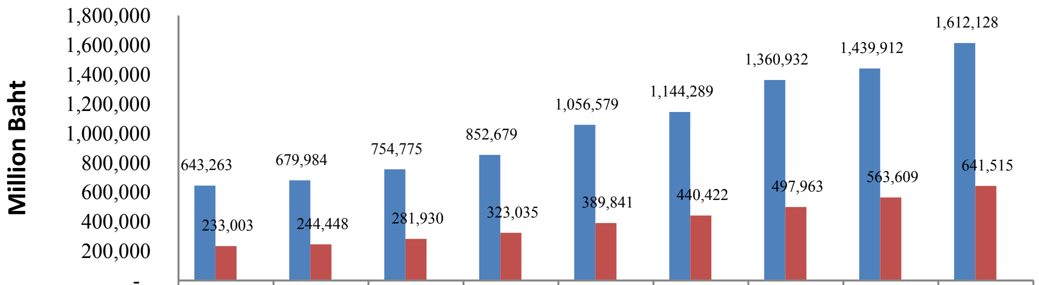
Source: Customs Department (Compiled by the Bank of Thailand (2009e))

Figure 2.18: Exports by manufactured products (1996 - 2008)



Source: Customs Department (compiled by the Bank of Thailand (2009e))

Figure 2.19: The export values of Thai listed manufacturing firms (2000-2008)



	2000	2001	2002	2003	2004	2005	2006	2007	2008
Sales Revenue	643,263	679,984	754,775	852,679	1,056,5	1,144,2	1,360,9	1,439,9	1,612,1
Exports Revenue	233,003	244,448	281,930	323,035	389,841	440,422	497,963	563,609	641,515
Exports/Sales (%)	36.22%	35.95%	37.35%	37.88%	36.90%	38.49%	36.59%	39.14%	39.79%

Source: Author's estimates (compiled from annual reports and financial reports of Thai listed manufacturing firms).

With regard to manufactured products, high-tech products were the most important exports, accounting for 692,614 million baht (or 59 percent of the total value of manufactured products) (see Figure 2.18). However, there were trade deficits during the period 1981-1985, 1986-1990, and 1991-1995, averaging 63,699, 110,575, and 252,249 million baht respectively, since the value of Thai imports grew faster than those of Thai exports (see Table 2.6). The pre-crisis export contraction in Thailand was mainly due to a sharp decline in international competitiveness as well as a deterioration in its terms of trade (Athukorala and Suphachalasai, 2004). This resulted from some of Thailand's macroeconomic factors such as (i) an appreciation of the real exchange rate due to large foreign capital inflows as well as strengthening of the US dollar to which the Baht was tied, (ii) capital market liberalization, and (iii) labour market tightening and real wage growth (Warr, 2000).

Terms of trade deterioration is also one of the factors contributing towards the pre-crisis export contraction. Furthermore, a series of tariff reductions were introduced in the early 1990s, along with an overvalued exchange rate and a relaxing of capital outflows and inflows (Jansen, 2001). As a result, very high rates of import growth appeared. The trade deficit during 1991 -1995 was almost fourfold larger than that for the 1981-1985 period, and more than double that for the 1986 -1990 period.

Focusing on Thai listed manufacturing enterprises' exports, Figure 2.19 also indicates that foreign markets have been a major source of revenue for Thai listed manufacturing enterprises, accounting for 36.22 percent on average in 2000 to 39.79 percent on average in 2008. According to the Ministry of Industry (2009) a significant contribution to Thai economic growth has arisen from export-oriented large enterprises, even though large enterprises account for only 1 percent of Thai business establishments. The increase in Thai listed manufacturing firms' exports has possibly resulted from regional integration through FTAs after the Asian financial crisis of 1997 (see Section 2.7.1).

According to the direction of trade, Thailand mainly exported to NAFTA (mainly to the United States), the European Union (EU), and Japan during the 1980s and the mid 1990s (Talerngsri and Vonkhorporn, 2005). Thailand also mostly imported goods from Japan during the period 1981 to 2008, followed by ASEAN, EU, and NAFTA (see Table 2.7).

Table 2.7: Thailand's merchandise trade value by countries (1981 - 2008) (In million baht)

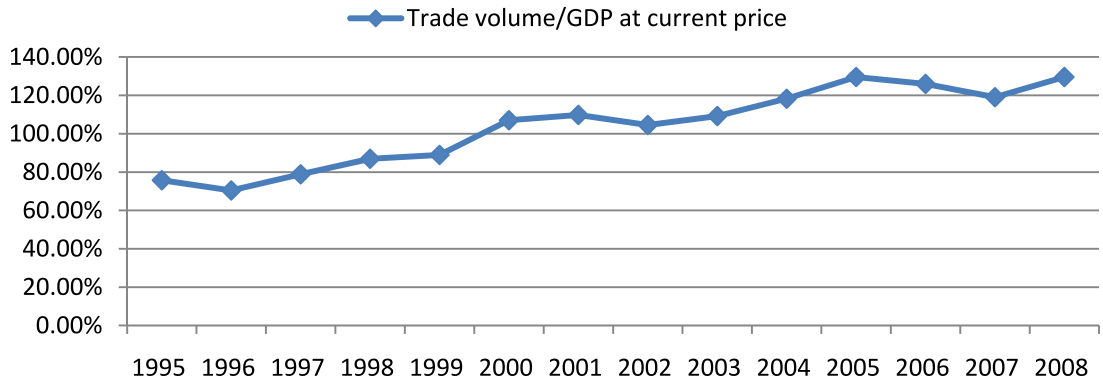
	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2008
Exports						
Japan	22,871	66,317	173,060	307,578	496,639	635,192
NAFTA	27,574	91,533	221,385	468,389	663,797	764,792
EU 1/	35,115	85,221	169,807	356,877	525,446	729,956
ASEAN 2/	25,650	51,682	163,516	410,831	730,646	1,155,885
Rest of the World	54,351	113,833	278,241	547,553	1,072,803	2,058,495
Total exports	**165,561**	**408,586**	**1,006,009**	**2,091,228**	**3,489,331**	**5,344,321**
Imports						
Japan	59,202	151,914	377,916	502,144	791,299	1,028,604
NAFTA	32,701	70,320	159,226	274,584	328,910	393,018
EU 1/	29,986	75,269	179,129	256,403	360,321	441,081
ASEAN 2/	34,036	70,160	161,475	295,267	589,061	925,730
Rest of the World	73,335	151,499	380,512	658,144	1,374,620	2,463,940
Total imports	**229,260**	**519,162**	**1,258,258**	**1,986,541**	**3,444,211**	**5,252,372**

Source: Customs Department (compiled by the Bank of Thailand (2009e)) and Talerngsri and Vonkhorporn (2005)

1/ Since May 2004, the EU comprised 25 countries, including also Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Slovakia, Poland and Slovenia. Since Jan 2007, the EU comprised 27 countries, including also Bulgaria and Romania.
2/ Prior to 1999, ASEAN did not include Cambodia, Laos, Myanmar and Vietnam.

Nevertheless, ASEAN has become an active trading partner of Thailand in the post-1997 crisis period. After the 1997 financial crisis exports substantially increased due to the depreciation of the baht, the easing of labour pressure, and reversal of persistent real wage growth experienced before the crisis (Lombaerde, 2008). The trade deficit disappeared after 1997, averaging surpluses of 104,686 million baht, 45,121 million baht, and 91,949 million baht during 1996-2000, 2001-2005, and 2006-2008 respectively. In 2008, the country's trade balance, however, moved into deficit at 90,379 million baht as a consequence of the decline in world demand, resulting from the financial crises in the US, Europe, and Asia, contributing to a contraction of Thailand's export value. Moreover, industries that have been the main source of Thai export growth in recent years, such as the electronics and vehicle industries, were particularly impacted upon by the sharp global contraction (Bank of Thailand, 2009d).

Figure 2.20: The size of trade volume relative to Thai GDP (%)



Source: The Bank of Thailand (2009e)

Comparing Thailand's trade volume with its GDP, Thailand's trade volume relative to its GDP has gradually increased during the period 1995 to 2008. More specifically, Thailand's trade volume relative to its GDP during the period 1995-1999, 2000-2004, and 2005-2008 averaged 80.16 percent, 109.78 percent, and 126.06 percent, respectively (see Figure 2.20).

Investment promotion and trade policy regimes in Thailand

The government has adopted trade and investment promotion policy regimes to influence the allocation of the private sector's resources (Kohpaiboon, 2006). Trade and investment promotion policy regimes began when the government introduced an import-substitution policy in the 1960s, which provided an incentive for enterprises to produce products for the domestic market. With respect to the trade policy regime, tariffs have played an important role as a trade instrument to protect local industries. To support the import-substitution policy, as set by the government, investment promotion schemes were also introduced, resulting in the establishment of the Board of Investment (BOI) in 1959. The BOI[22] is an independent government

[22] Besides the BOI, there are a number of government agencies which can facilitate Thai manufacturing firms, such as (i) Ministry of Commerce which can control the import and export of certain goods, as well as ban those goods' imports and exports and (ii) Ministry of Industry which can issue licences to build factories, regulate business conduct, and enforce zoning laws (Rock, 2000, p 185).

agency which has the authority to provide investment promotion privileges for firms under the Investment Promotion Act (1960)[23] (Kohpaiboon, 2006).

The introduction of investment promotion privileges aimed to support the restrictive trade regime for promoting import-substituting industries[24], leading to increased numbers of multinational enterprises (MNEs) in Thailand and especially during the late 1960s and 1970s in the consumer-import-substituting industries (Kohpaiboon, 2006). In addition, import-substituting industries were aggressively promoted in the late 1970s due to the 1977 Investment Promotion Act which allowed the BOI to protect locally promoted industries in agriculture, mining and services by imposing import surcharges. With regard to the trade policy regime, tariffs on imported inputs, such as machinery and equipment for both agricultural and industrial sectors, were reduced to 10 percent in 1974. This was to protect local industries, and prevent inflationary pressure caused by the world oil price hike (Kohpaiboon, 2006). During the import-substitution (IS) industrialization period (1960-1985), the Thai manufacturing sector rapidly expanded, especially in textiles and clothing, transport equipment, basic metal industries, and chemical products (Kohpaiboon, 2006, p98). This IS industrialization period, however, distorted the domestic incentive structure in the country.

Import-substituting activities, however, shifted to export promotion since the early 1980s. To comply with this change the BOI introduced tariff exemptions for imported raw materials as an additional privilege for export-oriented firms. Focusing on the trade policy regime the escalating tariff structure also caused inefficiency in allocating domestic resources during the early 1980s. This was because a large number of local firms entered into the production of highly protected finished goods (Kohpaiboon, 2006). During the export-promotion industrialization period (1986 - present), there were massive flows of FDI to the Thai manufacturing sector, resulting in a rapid expansion of Thai manufacturing exports during the period 1986 to 1995.

[23] The Investment Promotion Act (1960) was amended in 1965, 1968, and 1972, when there were minor revisions in the promotion privileges (Kohpaiboon, 2006, p54).
[24] The tariff structure has been used to promote import-substituting industries in Thailand since 1964 (Kohpaiboon, 2006, p58).

Thai manufacturing exports increased from 21.7 percent of total exports during the period 1970 to 1985 to 72.2 percent in the 1990s (Kohpaiboon, 2006, p102).

Due to consecutive budget balance deficits, high levels of public debt, and inflationary pressures from the oil price crisis in the late 1970s, trade liberalisation reform stagnated during the early 1980s (Kohpaiboon, 2006, p58). However, both the trade and investment regimes have gradually moved towards liberalization. With regard to the trade policy regime an escalation of the tariff structure was observed until the late 1980s. The simple average applied tariff rate dramatically decreased from 40 percent during the period 1985-1994 to 17 percent in 1997 (Kohpaiboon, 2006, p63). In the mid 1980s the rapid growth in manufacturing exports also resulted in a rapid growth in manufacturing output. In addition, the overall nominal rate of protection (NRP) and the overall effective rate of protection (ERP) were reduced from 22.90 percent in 1985 to 13.80 percent in 2003, and from 65.0 percent to 18.20 percent in 2003, respectively. Focusing on the investment promotion policy regime, it started to become more neutral since the mid 1980s due to the industrial decentralization in the country. Three promoted zones[25] have been established to support this industrial decentralization policy. From the mid 1980s, Thai manufacturing outputs rapidly increased due to the rapid growth in manufacturing exports.

After the 1997 financial crisis the BOI's promotion criteria were slightly adjusted as follows: (i) privileges granted to promoted export-oriented activities were no longer available in order to be in line with the WTO commitment to the trade-related investment measures (TRIMs) agreement; (ii) foreign ownership was relaxed up to 49 percent for promoted activities in Zone 1 and 2 (Kohpaiboon, 2006, p55). According to the Board of Investment (2010a), at least 51 percent of the registered capital must be held by Thai investors in the following industries under List One of the Foreign Business Act B.E. 2542: (i) agriculture, (ii) animal husbandry, (iii)

[25] Zone 1 consists of six provinces such as Bangkok, Nakhon Pathom, Nonthaburi, Pathoum Thani, Samut Prakan, and Samut Sakhon; Zone 2 consists of 12 provinces in the central and eastern parts of Thailand such as Ang Thong, Ayutthaya, Chachoengsao, Chon Buri, Kanchanaburi, Nakorn Nayok, Ratchaburi, Samut Songkhram, Saraburi, Supanburi, Phuket and Rayong; Zone 3 consists of the remaining provinces (The Board of Investment, 2011a).

fisheries, (iv) mineral exploration, and (v) mining and service businesses. However, for manufacturing projects there are no equity restrictions for foreign investors (The Board of Investment, 2010a).

Kohpaiboon (2006, p57) also concluded that domestic and foreign investors are treated equally. The effectiveness of investment promotion privileges, however, remains unclear, since most firms which intend to have a long-term investment do not become profitable. The imposition of import surcharges to protect promoted industries distorts the incentive structure, and the use of this measure has been limited and applied only on a temporary basis since the late 1980s. Focusing on the Trade policy regime, average tariff rates were significantly reduced during the mid 1990s. The escalating tariff structure, however, still remained, since the tariff reduction was mainly on intermediate products (Kohpaiboon, 2006, pp61-63). The BOI has implemented its new investment promotion policies since 23 April, 2010, such as measures to promote the improvement of production efficiency and energy conservation, and measures to solve environment problems. These measures aim to promote the country's sustainable development (The Board of Investment, 2010a).

Manufacturing production and its exports

This part aims to provide the linkages between Thai manufacturing products and export intensity classified by (i) exporting by less than 30 percent of total production, (ii) exporting between 30 percent to 60 percent of total production, and (iii) exporting more than 60 percent of total production.

Table 2.8 indicates that the group of Thai manufacturing products where exports are less than 30 percent of total production had the highest production over the period 1995 to 2008, followed by the group of manufacturing products where exports are more than 60 percent of total production, and manufacturing products where exports are between 30 percent to 60 percent of total production. In addition, liquors, hard disk drives, shampoos, computers, and commercial cars are the top five manufacturing goods produced (see Table 2.8).

Table 2.8: Manufacturing production index (base year 2000) by export origin and major export manufactured products

	1995-1997	1998-2000	2001-2003	2004-2006	2007-2008	2000 -2008
Export less than 30% of total production	**101.17**	**99.72**	**124.39**	**157.23**	**172.01**	**119.44**
Liquor	811.32	765.60	412.25	595.25	561.28	591.72
Shampoo	n.a.	100.00	161.72	289.70	329.26	211.28
Radio and tape recorders	284.41	219.17	97.77	42.65	0.00	128.80
Concrete Products	n.a.	100.00	122.52	214.05	241.39	159.25
Passenger car	129.68	69.27	198.00	300.45	369.06	188.69
Export between 30% to 60% of total production	**84.64**	**88.46**	**113.70**	**140.08**	**145.37**	**104.76**
Fans	264.92	97.98	133.23	129.16	116.17	140.55
Commercial car	113.11	73.66	128.13	250.64	312.22	154.74
Refrigerators	105.45	80.47	131.69	192.17	231.34	132.80
Cement	143.60	96.18	120.43	147.60	132.01	119.16
Printing & Writing paper	76.15	98.41	109.88	116.86	117.76	95.96
Export more than 60% of total production	**76.00**	**86.36**	**104.63**	**166.12**	**233.67**	**117.78**
Hard Disk Drive	n.a.	100.00	134.59	394.26	763.38	321.33
Computer	n.a.	100.00	140.87	289.15	205.68	180.14
Rubber glove	n.a.	100.00	124.85	164.28	203.79	137.50
Leather Footwear	n.a.	100.00	107.37	126.89	161.15	112.51
Wood furniture	n.a.	100.00	132.07	123.23	72.36	101.06

Source: The Bank of Thailand (2009e)

Table 2.9: Industrial capacity utilization by export origin (1995 - 2008)

	1995-1997	1998-2000	2001-2003	2004-2006	2007-2008	1995-2008
Export less than 30% of total production	**77.54**	**66.38**	**66.96**	**77.20**	**75.70**	**72.55**
Downstream petrochemical	112.47	85.90	91.94	93.28	92.70	95.44
Zinc metal	86.57	91.38	94.16	89.17	97.34	91.32
Pulp	83.65	93.52	93.86	85.05	82.36	88.07
Craft paper	n.a.	74.93	76.60	91.23	87.40	83.69
Petroleum products	89.15	83.99	76.25	85.97	82.62	83.67
Export between 30% to 60% of total production	**66.61**	**51.95**	**63.08**	**71.74**	**67.10**	**63.88**
Printing & writing paper	n.a.	94.16	102.04	103.48	93.21	99.68
Synthetic fiber	81.36	93.81	97.93	92.62	72.51	88.72
Tyre	85.48	83.64	86.42	88.98	87.86	86.38
Intermediate petrochemical	60.62	80.07	94.72	98.36	93.55	84.89
Rice cooker	89.18	77.58	72.29	66.10	65.70	74.77
Export more than 60% of total production	**75.02**	**69.22**	**66.99**	**67.46**	**64.96**	**69.00**
Rubber glove	n.a.	81.01	87.64	98.26	79.09	88.54
Washing machines	69.80	78.90	83.07	89.03	101.25	83.21
Hard disk drive	n.a.	85.61	93.73	72.71	78.40	82.41
Integrated circuits	83.19	83.80	51.26	83.98	86.99	77.19
Glass sheet	80.65	67.48	74.86	73.36	71.04	73.65
Overall industrial capacity utilization	**74.45**	**64.30**	**66.24**	**72.51**	**70.05**	**69.47**

Source: The Bank of Thailand (2009e)

Similarly, the group of industrial products which exports less than 30 percent of total production show the highest level of capacity utilization, followed by the group of industrial products which export more than 60 percent of total production, and the group of industrial products which exports between 30 to 60 percent of total production (see Table 2.9).

Table 2.10: Industrial capacity utilization by product group (1995 - 2008)

	Product	1995-1997	1998-2000	2001-2003	2004-2006	2007-2008	1995-2008
1	Printing & writing paper	n.a.	94.16	102.04	103.48	93.21	99.68
2	Downstream petrochemical	112.47	85.90	91.94	93.28	92.70	95.44
3	Zinc metals	86.57	91.38	94.16	89.17	97.34	91.32
4	Chemical products	86.54	84.39	92.76	94.72	92.20	89.97
5	Synthetic fibres	81.36	93.81	97.93	92.62	72.51	88.72
6	Rubber glove		81.01	87.64	98.26	79.09	88.54
7	Pulp	83.65	93.52	93.86	85.05	82.36	88.07
8	Paper & paper products	83.65	89.97	87.86	90.57	85.88	87.71
9	Tyre	85.48	83.64	86.42	88.98	87.86	86.38
10	Intermediate petrochemical	60.62	80.07	94.72	98.36	93.55	84.89
	Capacity utilization						
	Total	**74.45**	**64.30**	**66.24**	**72.51**	**70.04**	**69.47**
	Total (exclude liquor)	**74.41**	**64.26**	**66.38**	**72.62**	**70.15**	**69.52**

Source: The Bank of Thailand (2009e)

In addition, printing and writing paper, downstream petrochemicals, zinc metals, chemical products, synthetic fibres, rubber gloves, pulp, paper and paper products, tyre, and intermediate petrochemicals are the top ten industrial products, which have the highest utilized capacity respectively (see Table 2.10).

2.7.3 Net flow of foreign direct investment (FDI) into Thailand

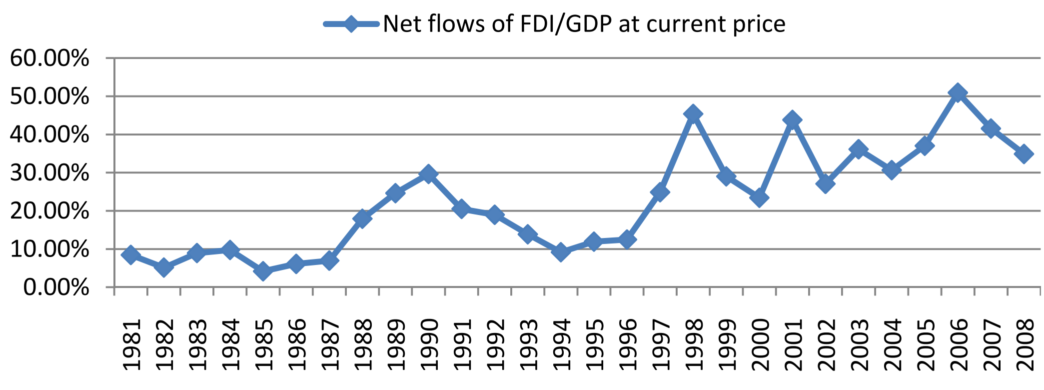
Foreign direct investment (FDI) is the result of a firm's commitment to diversify all or some operational activities across countries (Khopaiboon, 2006, p9). There are at least three channels for FDI spillovers[26] as follows (Khopaiboon, 2006, p11): (i) a demonstration effect enables local enterprises to adopt the superior technologies, marketing and managerial practices of foreign firms. (ii) linkage effects indicate where foreign investors are tied to both backward (upstream) and forward

[26] There are also non-FDI channels such as (i) technology licensing, (ii) international subcontracting, and (iii) MNE buyer (Khopaiboon, 2006, p18).

(downstream) linkages in host countries (invested countries). Foreign investors can create a demand for inputs from local suppliers in upstream industries. This inter-firm relationship can improve the productivity of local supplies, since they are forced to supply high quality and reliable raw materials on a timely basis. The creation of forward linkages also refers to the usage of other industries' outputs as an industry's inputs. (iii) Labour mobility indicates that local labour can be trained or educated through foreign firms' technologies and production methods. This occurs when foreign employees are assigned to work in host countries where they can share their previous working experience learned in their home countries with local employers and employees.

FDI has played an important role in the Thai economy since the size of net FDI flow relative to Thai GDP has been on an upward trend during the period 1981 to 2008 (see Figure 2.16). More specifically, net flows of FDI relative to Thai GDP during the period 1981-1985, 1986-1990, 1991-1995, 1996-2000, 2001-2005, 2006-2008 averaged 7.29 percent, 17.04 percent, and 14.88 percent, 27.03 percent, 34.93 percent, 42.45 percent, respectively (see Figure 2.21).

Figure 2.21: The size of net FDI flow relative to Thai GDP (%)



Source: The Bank of Thailand (2009e)

From Table 2.11 the net flow of foreign direct investment (FDI) into Thailand increased during the 1980s and 1990s. Net flows of FDI during the period 1981-1985, 1986-1990, and 1991-1995 averaged 6,602 million baht, 30,862 million baht, and 46,404 million baht respectively. The main investors were Japan, the United

States of America, Hong Kong, and the EU during the period 1981-1995. The largest recipient of FDI during the period 1981-1985, 1986-1990, and 1991-1995 was the industry sector, which accounted for 33 percent, 49 percent, and 31 percent of total net flows of FDI respectively. As mentioned previously, after the 1997 crisis the 1999 Foreign Business Act B.E. 2542 (FBA) was enacted, allowing foreign ownership of up to 75 percent or 100 percent in most manufacturing activities subject to specific requirements from the Board of Investment (BOI) of Thailand (Talerngsri and Vonkhorporn, 2005; Sally, 2007). In the financial sector, foreign investors were allowed ownership of up to 100 percent in the banking and securities sector (East Asia Analytical Unit, 2000).

In addition, the Trade Competition Act of 1999 has been enacted, which includes anti-competitive practices such as (i) abuse of dominant market positions, (ii) unfair trade practices, (iii) mergers which may result in "monopoly" or unfair competition, and (iv) cartel agreements which may restrict competition (Sally, 2007, p1599). This helps increase free and fair competition between domestic and foreign firms.

Table 2.11: Net flow of foreign direct investment by country (1981-2008) (In million baht)

Country	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2008
Japan	1,799	13,524	9,791	34,030	98,284	96,720
ASEAN 1/	304	2,407	4,885	16,066	50,604	116,046
EU 2/	1,082	2,473	5,037	25,090	14,253	36,975
United States of America	2,123	3,534	7,065	27,644	18,390	20,599
Hong Kong	556	3,458	9,193	11,810	8,232	6,591
Taiwan	51	3,236	2,138	4,608	4,122	848
Malaysia	44	112	54	699	1,647	5,020
Korea, South	4	215	312	876	2,441	3,412
Australia	58	89	621	1,563	1,049	2,002
China	20	105	23	51	418	2,236
Others	478	1,029	6,579	2,728	7,098	59,868
Total	**6,601.92**	**30,861.68**	**46,404**	**126,987**	**209,514**	**356,604**

Source: The Bank of Thailand (2009e) and Talerngsri and Vonkhorporn (2005)

1/ Prior to 1999 ASEAN was comprised of 5 countries: Brunei Darussalam, Indonesia, Malaysia, Philippines and Singapore. Since 1999, ASEAN has comprised of 9 countries, including also Cambodia, Laos, Myanmar and Vietnam. 2/ Prior to May 2004, the EU comprised 15 countries: Austria, Belgium, Germany, Denmark, Spain, Finland, France, United Kingdom, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal and Sweden. Since May 2004, the EU comprised 25 countries, including also Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Slovakia, Poland and Slovenia. Since Jan 2007, the EU comprised 27 countries, including also Bulgaria and Romania.

As a result FDI was relatively unaffected by the financial crisis, increasing rapidly from 46,404 million baht during the period 1991-1995 to 126,687 million baht during the period 1996-2000. ASEAN has become the major investor after the crisis (see Table 2.11). In addition, the net flow of FDI has continued to increase, amounting to 356,604 million baht during the period 2006-2008. Most of the FDI is still concentrated in the industry sector, accounting for almost 40 percent of total FDI during the period 2006-2008 (see Table 2.12). Furthermore, machinery and transport equipment, electrical appliances, and metal & non metallic products are the major sub - industrials that have attracted FDI, accounting for almost 60 percent of total FDI in the industry sector during the period 2006 to 2008.

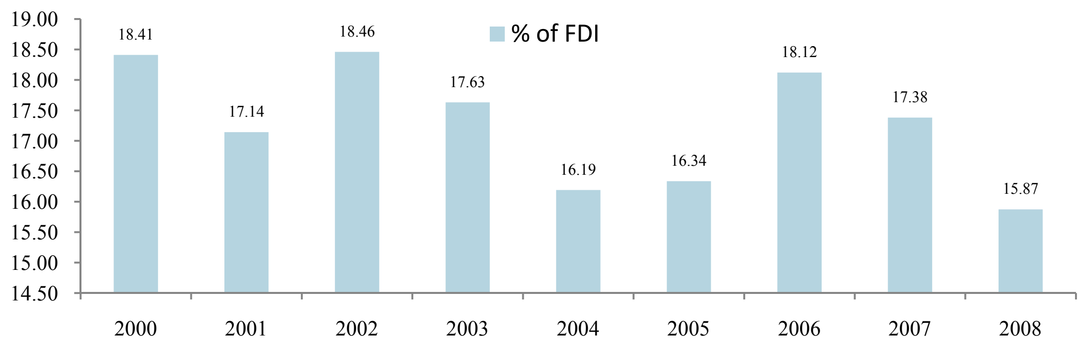
Table 2.12: Net flow of foreign direct investment by sector (1981 - 2008) (In million baht)

Sector	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2008
1 Industry	2,167	15,179	14,303	57,783	120,170	141,956
Food & sugar	122	1,071	1,173	3,689	6,263	5,481
Textiles	183	931	838	1,651	2,775	1,498
Metal & non metallic	255	1,621	1,950	6,005	13,373	15,729
Electrical appliances	602	5,521	5,157	14,587	27,033	21,082
Machinery & transport	186	871	1,769	16,777	37,414	47,961
Chemicals	275	1,910	2,750	7,410	13,775	4,663
Petroleum products	410	520	-1,140	1,796	1,480	14,844
Construction materials	17	27	277	832	740	649
Others	117	2,707	1,529	5,036	17,317	30,048
2 Financial institutions	18	2,181	3,167	10,916	13,106	75,331
3 Trade	1,169	5,250	8,008	26,375	26,080	28,921
4 Construction	1,081	2,330	4,870	1,991	1,369	-940
5 Mining & quarrying	1,441	524	2,221	-2,097	10,906	19,855
6 Agriculture	43	434	170	42	368	194
7 Services	454	1,235	1,573	12,124	15,823	29,838
8 Investment	0	0	301	8,218	-3,255	21,630
9 Real estate	228	3,503	12,804	6,406	-137	30,855
10 Others	0	225	-1,013	5,230	25,084	8,964
Total	**6,602**	**30,862**	**46,404**	**126,987**	**209,514**	**356,604**

Source: The Bank of Thailand (2009e)

Even though Thailand has attracted FDI, the progress on liberalisation and regulatory reform has been slow, especially in telecommunications services which are filled with several unresolved issues (e.g., the privatisation of state-owned enterprises) (Sally, 2007). Thai institutional weaknesses can also be a barrier to market access for foreign-owned firms as well as competition in the domestic market (Sally, 2007). This is because the government policy changes, such as tariff changes, granting investment incentives, and relaxing legislative restrictions on foreign ownership are unpredictable and incoherent, subject to case-by-case decisions, and often made by ministerial announcement without forewarning or clear explanation (Sally, 2007, p1599).

Figure 2.22: The average percentage of FDI in Thai listed manufacturing firms (2000-2008)



Source: Author

Finally, Figure 2.22 also shows that foreign direct investment in Thai listed manufacturing firms was 18.41 percent on average in 2000 and 15.87 percent on average in 2008, averaging 17.28 percent during the period 2000 to 2008. In 2004, the FDI in Thai listed manufacturing firms was relatively low, accounting for 16.19 due to several negative factors affecting investment conditions, such as (i) oil price hikes in the world market, (ii) increasing interest rates in the world market, and (iii) the bird flu outbreak (The Stock Exchange of Thailand, 2004). In 2008, the percent of FDI reached its lowest level due to the global recession and political unrest in Thailand (The Stock Exchange of Thailand).

2.8 Conclusions

The Thai capital market, where corporate listed firms have been trading their securities in the SET since 1977, has contributed significantly to the development of the Thai economy. The size of the capital market, as measured by market capitalization, has been more than half of Thai GDP during 1992 to 1996 and during

2003 to 2007. Compared with other Asian Exchanges its size, however, is relatively small, and hence the Thai capital market needs to develop further before it can become a significant source of funding for firms (see Tables 2.2 and 2.3).

According to the business performance of listed enterprises in the SET, manufacturing listed firms had a strong financial performance during the period 2000 to 2008, since their gross and net profits averaged 209,433 and 308,297 million baht respectively, accounting for 24.29 percent of total gross profits and 24.09 percent of total net profits (see Table 2.4). In addition, their ROE and ROA averaged 0.13 and 0.06, respectively over the period 2000 to 2008, which ranked as the second highest performing sector besides the resources sector (see Figures 2.6 and 2.7). More importantly the D/E and D/A ratios of the manufacturing sector averaged 1.15 and 0.51, which remains the lowest compared with other sectors, suggesting that the manufacturing sector is one of the better sectors for investment (see Figures 2.8 and 2.9).

Before the 1997 financial crisis the Thai economy performed well for a decade. Economic growth in Thailand was steady and high throughout the 1980s. During the first half of the 1990s Thailand's growth rate remained significantly high, with an annual average real GDP growth rate of 9 percent. The economic expansion in Thailand before the 1997 Asian financial crisis was supported by rapid growth in exports, accompanied by a substantial shift from traditional agricultural exports towards manufactured exports (Athukorala and Suphachalasai, 2004). In addition, the Thai financial sector had been developing progressively due to comprehensive liberalization of the Thai financial system in the first half of the 1990s. However, a resilient financial system based on cautious management of assets and liabilities, trustworthy information disclosure, generally accepted accounting standards, and effective supervision and prudential regulation, was lacking (Kawai and Takayasu, 1999).

The major problems causing firm-level inefficiency became apparent as a result of the 1997 Asian Financial Crisis. Weaknesses in the corporate governance and risk management of Thai firms were key causes of the 1997 financial crisis. The crisis highlighted, for example, problems of lack of transparency in corporate governance and an inefficient and mismanaged banking system (i.e., excessive lending to non-productive assets and a lack of adequate debt monitoring) among the crisis-affected countries in South East Asia as well as Thailand. The problem of weak corporate governance was related to, for example, the dominance of controlling shareholders, the separation of voting and cash flow rights (or the disparity between control and ownership), and the limited protection of minority rights (Claessens et al., 2000). A major change of the financial market in Thailand can be observed since the 1997 financial crisis. As part of the Financial Sector Master Plan (FSMP) the second capital master plan (2006 - 2010) was implemented, focusing upon seven principal measures to strengthen the Thai capital market, including the equity (capital), bond, and derivative markets.

After the 1997 Asian financial crisis the corporate governance system has been strengthened in Thai capital markets, such as through enhancing the institutional framework for accounting and auditing practices, improving the disclosure practice of listed companies (see Section 2.6.3), encouraging best practices for directors of listed companies (see Section 2.6.1), and relaxing foreign ownership controls (East Asia Analytical Unit, 2000; Talerngsri and Vonkhorporn, 2005; Sally, 2007). Minority shareholder rights through protection measures, such as market regulation and enforcement, trading and settlement system reliability, information disclosure, quality accessibility and also securities investor protection funds (SIPF), have been improved (see Section 2.6.2). The World Bank (2005, pp3-4), however, suggested that Thailand still needs to further focus on (i) enhancing legal enforcement (e.g., more strict fines and imprisonment for corporate fraud), (ii) implementing the legislation and regulation, (iii) improving financial reporting and disclosure to meet international standards, and (iv) promoting business ethics and good practices.

Domestic corporations and individuals were the major shareholders of Thai listed enterprises, accounting for 46.5 percent and 33.10 percent of total shares, respectively, over the period 1994 to 2001. After the Crisis the old 1972 Alien Business Law was replaced by the 1999 Foreign Business Act B.E. 2542 (FBA), relaxing foreign ownership limitation up to 75 percent or 100 percent in most of manufacturing activities subject to specific requirements from the Board of

Investment (BOI) of Thailand. Foreign individual investors, however, have become active shareholders after 2001 due to an increase in their ownership of listed securities from 2.4 percent in 2001 to 25.61 percent of total shares in major shareholders in 2008. Foreign corporations have also remained active major shareholders of securities listed in the SET, since their ownership has increased from 17.07 percent in 1994 to 31.61 percent of total shares in major shareholders in 2008. From 2002 to 2008 the ownership of foreign corporations and individuals averaged 50.94 percent for all SET securities of listed firms (see Figure 2.10). However, regulatory reform has been slow due to Thai institutional weaknesses (see Section 2.7.3).

Regional economic integration has become an important development in increasing the productivity of factors and real income among cooperating countries (Lloyd, 2008). Thailand's trade policy has also become more outward oriented. Thailand has successfully agreed bilateral preferential trading arrangements with several trading partners (e.g., Australia, China, New Zealand, Korea, and Japan) (see Table 2.3). Thailand mainly exported to NAFTA (mainly to United States), the European Union (EU), and Japan during the 1980s and the mid 1990s. ASEAN, however, has become an active trading partner of Thailand after the 1997 crisis. However, a number of studies found that the FTAs export creation is not significant for Thai manufacturing sector. The awareness of Thai manufacturing exporters on FTAs, the use of government agencies and business support institutions for their business adjustment to FTA is still low (see Section 2.7.1).

As discussed in Section 2.2, Thailand has recently confronted a problem of sustaining its growth and escaping from its "*middle income trap*" (World Bank Office-Thailand, 2008). Therefore, measures to improve productivity and competitiveness over the long term in all sectors are urgently needed for Thailand to transition to higher income and growth, especially for the manufacturing sector as the main sector in Thailand, accounting for 40.10 percent of Thai GDP in 2008. In addition, traditional agricultural exports have shifted towards manufactured exports (see Table 2.16). The upward trend of Thailand's manufactured exports after 1996 has also continued, accounting for 87 percent of total export value (see Figure 2.17).

Even though Thai listed manufacturing firms have also played an important role in promoting the overall growth of the economy, none of the measures to improve their long-term efficiency performance has been conducted. More specifically, the relative significance of firm-specific and business environment factors affecting firm inefficiency have not been empirically investigated for Thai listed manufacturing enterprises after the 1997 financial crisis. As a result, empirical results obtained from this thesis can help improve their long-run performance and also promote the overall growth of the Thai economy.

In the next chapter, a review of the literature with respect to factors that significantly affect the performance of publicly listed firms is conducted. These factors include (i) financial factors (e.g., financial constraints, sources of finance), (ii) ownership structure (e.g., types of firm ownership, controlling ownership, and managerial ownership), and (iii) research and development (R&D) and innovation. Other factors that affect a firm’s performance are also discussed. A review of the literature regarding the two-way relationship between a firm’s performance and its export participation (the self-selection and learning-by-exporting hypotheses) is also conducted.

CHAPTER 3

LITERATURE REVIEW

3.1 Introduction

The purpose of this chapter is to establish a basic understanding of the key factors that significantly affect the performance of publicly listed firms. These factors include (i) financial factors (e.g., financial constraints (leverage), sources of finance), (ii) ownership structure (e.g., types of ownership, controlling ownership, and managerial ownership), (iii) research and development (R&D), and (iv) executive remuneration. Other factors that affect a firm's performance are also discussed. This chapter also aims at examining the two-way relationship between a firm's performance and its export participation (the self-selection and learning-by-exporting hypotheses). These business environment and firm-specific factors will be used in subsequent chapters to conduct an empirical analysis. An overview of these is summarized in the form of a schematic diagram as indicated in Figure 3.1.

Several methods used to measure a firm's performance are, firstly, discussed in section 3.2, which cover financial performance, efficiency, productivity, growth, and other measurements of firm performance. Section 3.3 starts with a review of the literature that uses "financial variables" to investigate their effects on, for example, a firm's growth, investment, and technical efficiency (see Table 3.1). This section also provides the concepts of liquidity, leverage and sources of finance. A review of the literature regarding the effects of financial factors (e.g., liquidity, financial constraints (leverage), and sources of finance) on a firm's performance is also discussed in this section. Section 3.4 focuses upon explanations regarding agency problems and asymmetric information problems, which are related to the topics of ownership structure and sources of finance. Section 3.5 provides explanations of ownership structure, which include (i) ownership concentration, (ii) types of ownership for listed enterprises, and (iii) managerial ownership, as well as a review of the literature with regard to the effect of ownership structure on a firm's performance. Section 3.6 provides a review of the literature with respect to the effects of innovation and research and development (R&D) on a firm's performance.

Section 3.7 provides a review of the literature regarding the effect of executive remuneration on a firm's performance. Section 3.8 provides a review of the literature on the two-way effect between firm performance and its export performance (the self-selection and the learning-by-exporting hypotheses respectively). Section 3.9 discusses other factors that also affect a firm's performance, which include (i) government assistance, (ii) networking, (iii) foreign cooperation, (iv) geographical diversification, (v) firm size, and (vi) firm age. Section 3.10 presents a summary of the major conclusions from this chapter.

3.2 Measurements of firm performance

There are a number of methods to measure a firm's performance, such as financial performance, efficiency, productivity, growth, employment, exports, and market share. From the finance and accounting literature financial ratios are widely used to reflect the firm's financial performance, such as profitability measures, market value measures, efficiency measures, capital structure measures (financial leverage), and liquidity (cash flow) as shown in Figure 3.2. From an economics perspective key economic concepts, such as productivity, efficiency, and growth can also be used to measure a firm's performance, as well as employment, exports, and market share (see Figure 3.2). Each of these will be discussed in turn.

3.2.1 Financial performance

Profitability measures

Profitability can measure how efficiently a firm uses its assets to manage its operations. Financial ratios that indicate how well a firm is performing include, for example, profit margin, return on assets (ROA), return on investment, and return on equity (ROE). Some empirical studies find that a firm's profitability is positively associated with the firm's stock price, and also technical efficiency (Cho and Pucik, 2005; Mok et al., 2007). Cho and Pucik (2005) find that a firm's profitability has a significant and positive effect on its market value for US firms, since the firm's profitability can directly reflect investors' confidence and in turn increase its stock price. Mok et al. (2007) find that a firm's profitability has a positive effect on its technical efficiency based on a sample of 238 of the largest foreign-invested toy manufacturing firms in southern China in 2002.

Market Value Measures

Market value can be used to measure the performance of publicly listed firms, since it requires information on current stock prices. These ratios include, for example, the price to earnings (P/E) ratio and market-to-book value ratio (Ross et al., 2007). A number of empirical studies have used these ratios to represent the firm performance of publicly listed enterprises (McConnell and Servaes, 1990; Smith, 1990; Cho, 1998; Xu and Wang, 1999; Claessens et al., 2000; Dewenter and Malatesta, 2001; Joh, 2003; Yammeesri and Lodh, 2003; Cho and Pucik, 2005; Chang and Shin, 2007; Lee, 2008).

Efficiency measures (Asset management)

Asset management measures demonstrate how efficiently management uses a firm's assets to generate sales over a certain period of time. Asset management ratios (asset utilisation ratios) show how efficiently and intensively assets are used to create sales efficiently and intensively. These ratios include, for example, inventory turnover, receivables turnover and asset turnover (Ross et al., 2007). Lang et al. (1995) argue that firms that sell assets to increase their operating efficiency are typically poor performers. Firms are likely to sell their own assets if they find that alternative funding is too expensive.

Capital structure measures (financial leverage)

There are two types of leverage, which include (i) operating leverage and (ii) financial leverage. Operating leverage refers to the rate at which earnings rise as sales volume increases (Asaf, 2004). A firm that has a higher operating leverage is likely to face greater risk (Quiry et al., 2005). Financial leverage is a capital structure measure, and reflects a firm's ability to meet its long-run obligations (Ross et al., 2007). The debt-to-equity ratio (D/E) can be used to measure financial leverage. In other words, it refers to the use of debt, financial leases, and preference shares in a firm's capital structure to increase returns to equity shareholders (Petty et al., 2006; Beal et al., 2008).

Figure 3.1: Summary of factors that contribute to firm performance from the literature

A: Ownership structure

1. **Ownership concentration**
   - Controlling ownership
   - Managerial ownership
2. **Types of ownership**
   Listed enterprises
   - Family ownership
   - Domestic ownership (Individuals & Institutions)
   - State ownership
   - Foreign ownership (Individuals & Institutions)

C: Executive remuneration

E: Research & development (R&D)

Business innovation
- Product Innovation
  - * New Product
  - ** Product Improvement
- Process Innovation

Note:* The improvement of new products that differ considerably from existing products. **a significant development in the existing product technologically (see Lee and Kang, 2007, p344).

B: Sources of finance

1. Internal sources
- Retained Profit
- Saving
- Sales of assets
- Loans from directors / shareholders

2. External sources
- **Ownership capital**
  - Ordinary shares
  - Preference shares
- **Non-ownership capital**
  - Debentures
  - Bank loans
    - Working capital facilities
    - Short-term and long-term loans
  - Lines of credit from other creditors
  - Hire purchase
  - Venture Capital
  - Franchising
  - Government assistance
  - Leasing

D: Financial constraints

1. **Low liquidity**
   - Quick Ratio
   - Current Ratio
2. **Low profitability**
3. **High financial leverage**
   - Debt to Assets Ratio
   - Debt to Equity (D/E) Ratio

F: Other factors

1. Government assistance
2. Business networking
3. Foreign cooperation
4. Geographical diversification
5. Size
6. Age

Firm Performance ⟺

The self-selection hypothesis

Firm Performance → Export

The learning-by-exporting hypothesis

Export → Firm Performance

Figure 3.2: Measurements of firm performance

Firm performance

1. **Financial Performance**
   Profitability Measures
   - Profit Margin
   - Return on Assets
   - Return on Investment
   - Return on Equity

   Market Value Measures
   - Price/Earnings (P/E) ratio
   - Market-to-book ratio (market value)

   Efficiency Measures (Asset management)
   - Asset turnover
   - Inventory turnover
   - Receivables turnover

   Capital Structure Measures (financial leverage)
   - Debt to Equity (D/E) Ratio
   - Debt to Asset Ratio
   - Interest Coverage Ratio

   Cash Flow

Financial measures

2. **Efficiency**
   - Input & output analysis
3. **Productivity**
   - Labour Productivity
   - Capital Productivity
   - Total Factor Productivity
4. **Growth**
   - Assets Growth
   - Sales Growth
5. **Others**
   - Employment
   - Export
   - Market Share

Economic measures

Source: Author

Firms also have an obligation to pay cash or returns for their use of debt, financial leases, and share issuance. For instance, debt requires periodic interest and principle payments; leases require rental payments; preference shares require dividend payments (Petty et al., 2006, p125). Petty et al. (2006) suggest that firms normally should not increase their financial leverage if their operating leverage is high, but they can do so with a low operating leverage. The leverage level of each industry may be different depending on the nature of its own business. The banking sector is likely to have high leverage ratios compared with other industries. Therefore, corporate financial analysts, investors, bankers, and debt-rating agencies practically compare the leverage ratios of a firm with its industry leverage ratio. Since the leverage ratio in the banking sector is normally high compared with other sectors, a bank's leverage ratio should be compared with its industry leverage ratio.

Cash flow

Cash flow can indicate changes in a firm's financial position, which consists of three main activities, as follows: (i) operating activities, (ii) investment activities, and (iii) financing activities. Cash flow from operating activities shows a firm's day-to-day activities of selling its products and services. Investment activities, however, focus on long-term activities which have a longer life time than operating activities. Long-term investment causes increased expenditure to firms, but it will increase firms' revenues and cash flows in the future (Quiry et al., 2005). Cash flow from financing activities can be supported by investors, shareholders, creditors, and lenders. In other words, financial resources can be obtained by either shareholder's equity or debt capital, or both. The difference between equity financing and debt financing is that equity financing transfers powers and control over firms to shareholders, but debt financing does not. For debt financing, banks will grant their loans after they have carefully analysed their borrowers' financial ability to repay debts.

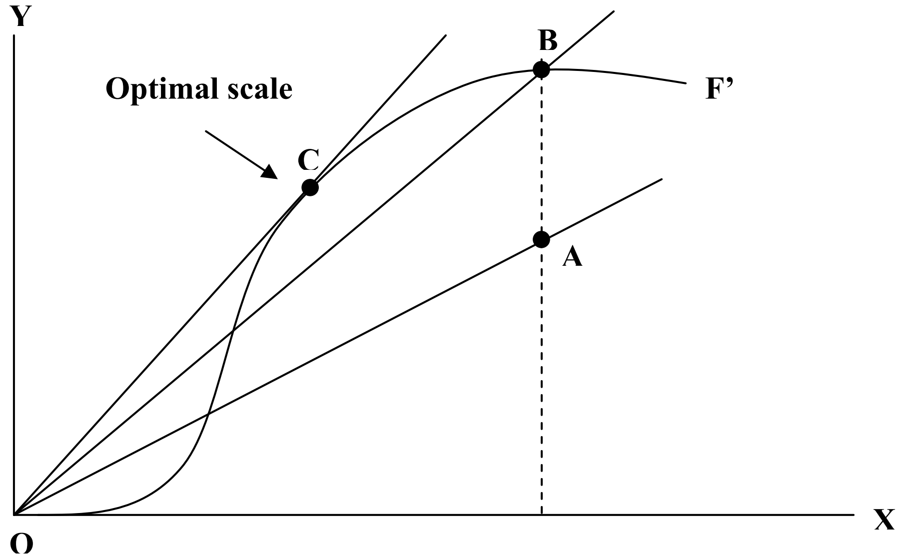
3.2.2 Productivity

Productivity is widely used in the economic literature to measure a firm's performance. It can be defined as the ratio of the output(s) that a firm produces with respect to the input(s) that it uses. In addition, total factor productivity normally refers to a productivity measure, which includes all factors of production (Coelli et al., 2005). Other productivity measures, such as labour productivity used in factories, power stations, and farming, are partial productivity measures. Labour productivity is commonly measured by labour value-adding over the number of workers, but total factor productivity captures all factors of production. Nevertheless, they can provide a misleading result of overall productivity when considered in isolation (Coelli, 2005, p3). A number of empirical studies have measured a firm's performance in terms of productivity (Aw and Hwang, 1995; Pushner, 1995; Aw et al., 1998; Bernard and Jensen, 1999; Nickell and Nicolitsas, 1999; Castellani, 2002; Li, 2009). Labour productivity and total factor productivity are most commonly used to measure a firm's performance (see Table 3.3).

3.2.3 Efficiency

The concept of economic efficiency is used to measure a firm's performance, which consists of two components; (i) technical efficiency and (ii) allocative efficiency. Technical efficiency means the capacity and ability of a firm to produce at the maximum possible output from a given bundle of inputs and a given technology. Allocative efficiency refers to the ability and willingness of a firm to equate its marginal revenue with its marginal cost (Kalirajan and Shand, 1999).

Figure 3.3: Production frontier and technical efficiency



Source: Coelli et al. (2005, p5)

The term "*productivity*" basically refers to "*total factor productivity*" (see Section 3.2.2). More importantly, the concept of productivity and efficiency are different. The productivity of a firm is defined as the ratio of total outputs over total inputs, as indicated by the slope of a production frontier (such as the OF' line) in Figure 3.3. From Figure 3.3 a firm is technically efficient if its operation is on the production frontier (the OF' line), for example, points B and C. It is, however, technically inefficient if its operation is beneath the production frontier (the OF' line), for example, at point A. A firm operating at point A can achieve the same level of output as at point B without requiring more input (Coelli at el., 2005, p3). A firm's operation that is defined as being technically efficient can also raise its productivity by moving to a point which provides a greater slope on the production frontier (Coelli et al., 2005). For example, its productivity increases when a firm's operation moves from point B to point C, even though both points B and C are of technically efficient scale. The operation at point C results in maximum productivity, or (technically) optimal scale. A review of the theoretical literature on efficiency will be comprehensively conducted in Chapter 4 (Methodology Overview: Firm Efficiency Concepts and Measurement).

3.2.4 Growth

Growth is another indicator used in measuring a firm's performance. Firms with a high level of growth capacity (e.g., profit growth) are likely to gain higher earnings, leading to higher (free) cash flow than firms with a lower level of growth capacity. This leads to favourable firm market value (firm performance). For publicly listed firms some empirical studies find a positive relationship between a firm's growth and its market value (Cho and Pucik, 2005; Chang and Shin, 2007). Cho and Pucik (2005) also find a positive relationship between a firm's growth and its market value for US firms. Chang and Shin (2007) find a positive association between a firm's growth and its market value for 15 Korean chaebols (conglomerates). In addition, the concept of growth can be applied to other measures of firm performance. For instance, it can be used to analyse the change of sales revenue, employment, market share, and exports.

3.2.5 Other measures of firm performance

Other measures of firm performance are also important to be considered, such as employment, exports, and market share. Harvie (2002) focuses upon the development of small rural manufacturing enterprises, or township and village enterprises (TVEs), in China. He also comprehensively measures a TVEs' performance not only in terms of output, improvements in productivity as measured by labour productivity and total factor productivity, and sustained profitability, but also by an upgrading of technology, employment, and exports. Sahakijpicharn (2007) also finds that network embeddedness is the most important factor that improves business performance for Sino-Thai SMEs. His business performance analysis focused upon cash flow, sales growth, profitability, exports and market share.

3.3 Agency and asymmetric information problems

This section provides a basic understanding of agency and asymmetric problems. These can be used to explain why ownership structure and sources of funds affect a firm's performance. Sections 3.3.1 and 3.3.2 discuss agency problems and asymmetric information problems respectively.

3.3.1 Agency problems

Berle and Means (1932)[27] provide a basic understanding of the classical economic model of the free-market firm. They then initiate the idea that the corporation is an economic organization with *"equity capital",* which is widely held by individual shareholders. In other words, the ownership of capital is widely dispersed. For example, equity capital is a necessary factor to promote a firm's growth. The firm's owner, however, does not have adequate funds, since he faces limited personal wealth. Therefore, he may need to obtain funds by issuing the firm's shares. Obviously, publicly listed firms are likely to draw on financial resources from individual investors. The corporation system, therefore, has become "*the principal factor in economic organisation through its mobilisation of property interests*" (Berle and Means, 1932, p2). At this stage, the owner cannot effectively manage or control the firm, since ownership becomes dispersed, and several investors have their rights to control the firm. The oversight and management, therefore, is delegated to professional corporate management. Professional managers (the agent) have their responsibilities to ensure that shareholders (the principals) will receive the maximum return on the firm's investment. The concept of separation of ownership from control, therefore, was originally obtained from this theory of the firm first proposed by Berle and Means (1932).

For publicly listed firms, agency problems arise when authority over the firm is transferred to professional managers due to the dispersion of shareholders. In addition, managers may not pay much attention to management of the firm's resources, as an owner-manager does, and might transfer the firm's resources to maximize their own benefits (Jensen and Meckling, 1976). According to Jensen and Meckling (1976, p308) agency costs are the sum of (i) monitoring expenditures by

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[27] See the "*The Modern Corporation and Private Property", 1932.*

shareholders, (ii) bonding expenditures by managers[28], and (iii) the residual loss. First, shareholders can also limit divergences from the managers' interests by (i) establishing appropriate incentives for managers and by (ii) incurring monitoring costs designed to limit harmful activities (Jensen and Meckling, 1976). For example, managers may be offered bonus stocks in the company they manage to ensure profitability and performance remain consistent with shareholder interests. Second, managers can be asked to guarantee that their actions will not harm the firm, or to ensure that shareholders will be compensated from aberrant activities. This is called "bonding costs" paid by managers. The third agency cost is called the "residual loss" due to the reduction in shareholders' wealth affected by limited divergences from managers' interests. In addition, a conflict of interest can also arise between shareholders and creditors, particularly banks. Due to debt contracts or covenants, creditors have rights to control over borrowing firms (e.g., a debtor must be consented by creditors before borrowing external loans, or creditors may appoint their representatives to participate in the board of directors' meetings). In particular, creditors normally prevent borrowing firms, for example, from investing in high-risk projects, since if the investment fails banks are highly affected and bear some of the costs (Shleifer and Vishny, 1997). Banks, therefore, have a strong incentive to monitor borrowing firms to ensure that they can repay debts without any default. In this regard the monitoring behaviour of banks can be too conservative, which can raise agency problems.

According to capital structure theory based on agency costs the conflict of interest between managers and shareholders can be alleviated by reducing the amount of free cash flow available to managers, unless free cash flow is returned to investors. This is because managers cannot transfer firm resources (available cash) to their own personal benefits by decreasing free cash flow available or increasing the leverage of the firm (Jensen, 1986). Moreover, managers may have their own incentives to pursue only safe projects, although other projects will yield higher returns for shareholders. This is because their reputation is threatened if they undertake projects that default. For leveraged firms managerial reputation building

[28] Managers are required to pay the principle (bonding costs) to ensure that they will not take certain actions which would harm the principal or to guarantee that the owner (principal) will be compensated if they take such harmful actions (Jensen and Meckling, 1976).

can reduce the agency cost of risky debts, but shareholders' value is not optimized due to an excessive conservatism in investment policy for unleveraged firms (Hirshleifer and Thakor, 1992). Another agency problem is that of asset substitution. This problem arises because shareholders are likely to invest in risky projects (value-decreasing projects), since their liabilities are limited to the value of their shares. If their investment projects are not successful, debt holders are mostly affected.

3.3.2 Asymmetric information problems

Asymmetric information problems occur when firm insiders (managers) can access better information than market participants, typically shareholders, on the value of firms' assets and investment opportunities (Klein et al., 2002). This asymmetry distorts the real price of a firm's securities. From the capital structure literature the separation of ownership and management can be one of the causes of asymmetric information problems (Myers and Majluf, 1984). Harris and Raviv (1991) survey capital structure theories based on asymmetric information. They conclude that a new stock issue can have a negative effect on a firm's stock price, but a positive relationship is found between a firm's (risky) debt issue and its stock price.

Myers and Majluf (1984) also suggest the existence of a pecking order theory where managers prefer internal sources of funds, and then they prefer debt to equity if external finance is required. Managers are likely to use internal sources of funds rather than external funds. For example, if mangers need external funds they will prefer bonds to stock, since they can avoid the discipline of capital markets. Myers and Majluf (1984) also suggest that a firm's leverage increases with the extent of asymmetric information. For example, managers who act in existing shareholders' interest may prefer the choice of debt (e.g., issuing bonds) rather than issue new shares (due to the stock dilution) if they ensure that the project undertaken provides a good investment opportunity. Narayanan (1988) also indicates that managers have a preference for debt (e.g., bank loans) rather than equity due to the dilution of existing shareholders in controlling the firm. However, investors may misperceive that firms undertake projects that do not provide positive - net present value (NPV) returns due to this asymmetric information. Therefore, it may cause a decrease in a firms' shares due to the misperception of firms' increased leverage. On the contrary, managers will issue new shares when the firm's share price is overvalued. In other words, the firm's share price is higher than the true value of its share price.

A dispersed ownership structure can cause asymmetric information problems between managers and shareholders, since small shareholders lack expertise and incentives to monitor managers who work as their agents. DeAngelo and DeAngelo (1985) argue that managerial ownership (insiders hold a large stake of the firm) may solve asymmetric information problems. As a result, asymmetric information problems can be used to explain two problems. First, managers can cause "*adverse selection*" problems, since they may possess some information which is unknown to outside investors. Due to information asymmetry, firms prefer a financial hierarchy. In other words, firms will use their retained earnings, and the use of other riskless debts are required if their internal sources of funds are depleted. Equity will be used as a last resort (Myers and Majluf, 1984). Second, managers can cause "*moral hazard*" problems, since they may not maximize shareholders' benefits. In other words, there is a conflict of interest between managers and shareholders (the principal - agent conflict). The agency and asymmetric information literature discussed in this section provides a basic and useful background to studying the relationship between finance and firm performance (see Section 3.4) and ownership structure and firm performance (see Section 3.5).

3.4 Finance and firm performance

This section consists of three main parts. Section 3.4.1 overviews the literature that uses "financial variables" to study their effects on, for instance, a firm's growth, investment, and technical efficiency (see Table 3.1). Section 3.4.2 will provide background to the concepts of liquidity and leverage, and relate these to firm performance. Section 3.4.3 discusses sources of finance, and relates these to firm performance.

3.4.1 Financial variables on various areas of interest

Over two decades, a number of studies have employed *"financial variables"* to examine their effect on firm investment (Bond and Meghir, 1994; Kaplan and Zingales, 1997; Kadapakkam et al., 1998; Guariglia, 1999; Bond et al., 2003; Cleary, 2006), firm export decisions (Greenaway et al., 2005; Greenaway et al., 2007; Mok et al., 2007; Bellone et al., 2010), firm survival and growth (Musso and Schiavo, 2008), and firm technical efficiency (Maietta and Sena, 2003; Sena, 2006; Mok et al., 2007). Previous empirical studies that examined the effect of a firm's financial variables (e.g., liquidity or leverage) on its investment, firm growth, or exporting decisions as mentioned in Table 3.1 are discussed in Section 3.4.2. From Table 3.1 it can be seen that there are a number of financial variables which can be used as a proxy for financial constraints (leverage) such as debt to asset ratio (D/A ratio), interest coverage ratio (ICR), quick ratio, current ratio, cash flow, and gross operating profit. Some empirical studies also combine financial variables together to form their own financial index (Bellone et al., 2010).

Table 3.1: Financial constraints as the segmenting variables used in the previous studies

Authors	Financial variables	Dependent variables (Methods)	Results
Bond and Meghir (1994)	Dividend over capital stock and share issues	Investment (GMM[29])	Measures of dividend payments and new share issues are found to be statistically significant.
Kaplan and Zingales (1997)	Qualitative data from financial statements (investment-cash flow sensitivities)	Investment (OLS)	Less financially constrained firms show significantly greater investment-cash flow sensitivities than more financially constrained firms.
Kadapakkam et al. (1998)	Cash flow and firm size (firm value, total assets, and sales volume)	Investment (OLS)	The large firm size group shows the highest cash flow - investment sensitivity, but the lowest cash flow-investment sensitivity is found for the small firm size group

[29] Hall (2005, p2) states that "generalized method of moments (GMM) is a set of population moment conditions which are deduced from the assumptions of the econometric models". In addition, the advantage of its estimation compared with the maximum likelihood estimation is that the exact distribution of the disturbances is not required.

Authors	Financial variables	Dependent variables (Methods)	Results
Guariglia (1999)	Interest coverage ratio (the pre-tax and pre-interest earnings to total long and short-term interest payments)	Inventory investment (GMM)	The coverage ratio has a significant impact on inventory investment for financially constrained firms, but has weaker effects for other firms.
Becchetti and Trovato (2002)	Leverage (Bank debt to total assets ratio)	Firm growth (OLS)	Size and age are not the only important factors for SME growth and that financial constraints and access to foreign markets significantly affect on their growth.
Maietta and Sena (2003)	Debt-to-asset ratio (DAR)	Technical efficiency (DEA, 2 stage approach)	The shortage of financial resources can have a positive impact on the growth in a firm's technical efficiency with profit-sharing schemes.
Bond et al. (2003)	Cash flow and gross operating profit	Investment (OLS, GMM)	Cash flow and profit terms are both statistically and quantitatively significant for investment in the UK but not in Belgium, France, and Germany.
Greenaway et al. (2005)	Liquidity ratio (current assets to current liabilities), coverage ratio (total profits before tax and interest, and total interest payments), short-term debt to total assets ratio, and total debt to assets ratio	Exporting decisions (Probit models)	Less financially constrained firms tend to export compared with more financially constrained firms.
Cleary (2006)	Size (total assets), dividend payout ratio (dividend over EBIT), and change of dividend payout ratio	Investment (OLS)	Financially healthy firms are more investment-cash flow sensitive than financially constrained firms. In addition, financially constrained firms are likely to have greater risk as measured by cash flow volatility.

Authors	Financial variables	Dependent variables (Methods)	Results
Sena (2006)	Interest coverage ratio (ICR) and Debt-to-Asset ratio (DAR)	Technical efficiency (SFA)	If firms are not able to access external financial resources, they will enhance their technical efficiency over time to assure positive gains in productivity.
Greenaway et al. (2007)	Liquidity ratio (current assets less current liabilities over total assets), leverage ratio (short-term debt to current assets), and Quiscore (a number in range from 0 to 100)	Export decisions (Probit models, GMM)	Exporters show a stronger financial performance than non-exporters. Continuing exporters show better financial performance than export-starters. Exporting helps improve a firm's financial performance.
Mok et al. (2007)	Leverage ratio (Total liabilities / total assets)	Technical efficiency and profitability (DEA, two stage approach)	The findings reveal a positive association between leverage and a firm's technical efficiency as well as a firm's technical efficiency and its profitability.
Bellone et al. (2010)	Synthetic Index (seven financial variables such as total assets, returns to total assets, current assets over current liabilities, cash flow, owned funds over total liabilities, trade credit over total assets, financial debt over cash flow)	Firm export participation / intensity (OLS, Heckman Two-Step model)	Balance sheet variables are important determinants of a firm's exporting decision. They find that exporting does not improve firm financial performance. Finally, there is a negative association between export intensity and financial health. Export intensity leads to higher sunk start -up costs, and therefore worsens the financial health of exporters.
Musso and Schiavo (2008)	Synthetic index (seven financial variables)	Firm survival and firm productivity growth (OLS)	Financial constraints are found to be an important factor in determining the probability of firm survival. Financial constraints also positively affect a firm's productivity growth in the short run.

Source: Author

3.4.2 Liquidity, leverage, and firm performance

Liquidity and firm performance

Liquidity refers to a firm's ability to meet its short-term obligations on time for its normal business activities, to obtain new sources of financing, and to ensure financial balance between income and expenditure (Quiry et al., 2005). In other words, liquidity is simply a firm's ability to convert its assets into cash in order to meet its coming debt payments. The concept of liquidity, therefore, can be measured by some financial ratios, such as working capital, equity, debt, and current ratio (current assets/current liabilities). If a firm has more liquidity, it is likely to face less financial distress (e.g., less difficulty in paying debts or buying needed assets) (Ross et al., 2007). Manufacturing assets, for example, are not liquid, since they are machinery and equipment, which cannot be converted into cash very quickly (Ross et al., 2007). In addition, a highly liquid asset can be converted into cash without significant loss of value. The most liquid assets are placed first in a firm's balance sheet. Current assets are a group of assets that are relatively liquid, including cash and assets convertible into cash within 12 months. However, intangible assets (e.g., a trademark, patent, and goodwill) are also very valuable, but they are not liquid. Non-current assets are relatively non-liquid, including buildings, machinery, and equipment. Goldar et al. (2003) find that the liquidity ratio (the ratio of current assets minus inventories to current liabilities) has a significant and positive effect on the technical efficiency of Indian engineering firms during the period 1997 to 2000, but such a significant result is not found during the period 1990 to 1997. They conclude that liquidity is an important factor to facilitate production operations, since the liquidity ratio indicates the ability of a firm to meet its financial liabilities in a short run of one year. Financially constrained firms, therefore, may have difficulty in operating their businesses efficiently (Goldar et al., 2003, p12).

Financial constraints (leverage) and firm performance

Studies focusing upon the relationship between financial constraints (leverage) and a firm's performance can be linked to the literature on agency problems. Agency costs can arise from the conflicts of interest among managers, shareholders, and debtors as mentioned previously (Jensen and Meckling, 1976). Firms with a higher level of leverage are likely to induce managers to improve their managerial performance to avoid bankruptcy and liquidation. In other words, leverage can decrease agency costs, and hence there exists a positive effect between leverage and a firm's performance. For example, debt constrained firms hardly obtain external finance. These firms, therefore, are forced to reduce their operating costs by cutting back their labour and other operating expenditures. Furthermore, workers also face a high risk of losing their jobs leading to an increase in workers' efficiency (Sena, 2006).

A number of empirical studies find a positive relationship between leverage and a firm's performance (Grossman and Hart, 1982; Lang et al., 1996; Nickell and Nicolitsas, 1999; Maietta and Sena, 2003; Weill, 2003; Sena, 2006; Mok et al., 2007). Grossman and Hart (1982) also suggest that firms under the threat of bankruptcy induce managers to increase their efforts to avoid bankruptcy. Consequently, a firm is forced to reduce its internal inefficiency. Maietta and Sena (2003) and Sena (2006) suggest that once a firm cannot gain access to external financial resources, it has an incentive to enhance its technical efficiency over time to ensure positive profits. Mok et al. (2007) find that leverage has a positive impact on a firm's performance, as measured by technical efficiency. They also find that there exists a positive association between a firm's technical efficiency and its profitability for the 238 largest foreign-invested toy manufacturing firms in southern China in 2002.

Nickell and Nicolitsas (1999) conclude that leverage has a positive effect on firm performance, as measured by productivity for 670 UK manufacturing companies during the period 1972 to 1986. Lang et al. (1996) empirically documented a positive association between leverage and firm performance, measured by a firm's growth for all industrial firms with sales of 20 million dollars in a given year during the period 1986 to 1991. Crutchley et al. (1999) find a significant positive relationship between firm leverage and firm performance, as measured by dividend payout for publicly listed firms on the New York and American Stock Exchanges. Similarly, financially constrained firms may be more efficient than financially unconstrained firms, since borrowing money to finance financially constrained firms' operations may force them to be more efficient (Dilling-Hansen et al., 2003). Dilling-Hansen et al. (2003) find that financial solvency has a negative effect on firm performance, as measured by technical efficiency for 2,370 Danish firms in 1997. A number of empirical studies, however, find a negative association between leverage and a firm's performance (Pushner, 1995; Chang and Shin, 2007; Weill, 2008). Pushner (1995) finds a negative relationship between leverage and firm performance, as measured by productivity for 1,247 Japanese manufacturing firms during the period 1976 to 1989. Weill (2008) also observes a negative relationship between leverage and firm performance, as measured by technical efficiency for 4,403 Italian manufacturing firms and 2,312 Spanish manufacturing firms during the period 1998 to 2000. Chang and Shin (2007) also find a negative effect between leverage and firm performance, as measured by firm market value for 15 Korean chaebols.

3.4.3 Sources of finance

Sources of finance can be classified into short-term and long-term financing. Petty et al. (2006) suggest that firms can receive funds from one of four principal sources: (i) from its operations, (ii) by borrowing, (iii) by the sale of assets, and (iv) by issuing shares. This section, however, classifies sources of finance into two categories: (i) internal financing and (ii) external financing.

Internal financing

There are two arguments regarding the effect of internal financing on a firm's performance. First, internal financing can enhance a firm's resource allocation, since investment information is produced and transferred at less cost in an internal capital market than in an external one (Kim, 2003, p134). The reason is that there exists a strong incentive for a firm to monitor the allocation of its internal funds when these have been lent by either the owner manager or by major shareholders. In particular, Gertner et al. (1994) conclude that the ownership aspect of internal capital allocation has three significant consequences: (i) increased monitoring incentives, (ii) decreased entrepreneurial incentives, and (iii) better asset redeployability. Consequently, a firm's capital is allocated more efficiently in an internal capital market than an external one, because it improves the efficiency of investments and resource allocation (Kim, 2003). Du and Girma (2009) also find that self-raised finance[30] appears to be the most efficient for smaller firm's growth, as measured by total factor productivity (TFP) growth for Chinese manufacturing firms during the period 1998 to 2005.

On the contrary it is argued that internal financing has a negative effect on a firm's technical efficiency due to the agency problem, implying that mangers can easily mobilize internal funds to maximize their own interests and lack the desire or necessity to maximize shareholders' interests due to the lack of external monitoring from banks or financial institutions. Managers, therefore, have strong incentives to abuse internal funds (Jensen, 1986). This is especially the case in underdeveloped countries where firms' managerial rights are not fully developed and their information is not fully publicized, and managers attempt to maximize their benefits rather than the firm's value (Kim, 2003, p134). Ayyagari et al. (2008) also find that a small percentage of firms in their 2,400 Chinese firms during the period 1999 to 2002 utilized external financing in the form of bank loans, and also relied mostly on informal sources (e.g., self-raised financing). However, formal financing (e.g., bank loans) is associated with faster firm growth, but self-financing (informal financing) is not statistically significantly associated with firm growth. Finally, internal financing can be funded by the following financing options: (i) retained earnings, (ii) saving, (iii) sales of assets, and (iv) loans from directors / major shareholders / related parties.

External financing

External financing can be raised through the following financing options: (i) Ownership capital and (ii) Non-ownership capital. Ownership capital consists of (i) ordinary shares and (ii) preference shares. Non-ownership capital consists of (i) debentures, (ii) lines of credit from banks, (iii) lines of credit from other creditors, (iv) hire purchase, (v) venture capital, (vi) government assistance, and (vii) leasing.

[30] Self - raised finance includes finance from individual capital, collective capital, and corporate or legal person's capital (Du and Girma, 2009, p30).

Ownership capital

(i) **Ordinary shares** represent ownership rights or equity capital. Ordinary share purchasers are called "shareholders" who receive profits in the form of dividends. Ordinary shareholders have voting rights specified by the firm. They, however, can be viewed as unsecured creditors (Ross et al., 2007). In other words, in the case of winding-up, creditors and preference shareholders are eligible to exercise their claim on the firm's assets before ordinary shareholders. Dividends are determined by the firm's board of directors and must be approved by shareholders (Petty et al., 2006).

(ii) **Preference shares** typically are identified as equity, but they also contain some elements of debt. In other words, preference shareholders can receive dividend payments at a fixed dividend rate before other classes of shares (e.g., ordinary shares), and have preferential rights over ordinary shareholders to claim the firm's assets during winding-up (Petty et al., 2006; Ross et al., 2007). In addition, some preference shares have the feature of being convertible into a number of ordinary shares. Most preferred shares have no voting rights, but such voting rights can also be found in some firms.

Non-ownership capital

(i) **Debentures** are long-term debt securities used by firms, particularly during 5 to 10 years, which offers fixed rates of interest for certain periods to creditors. They are usually known as "bonds", or refer specifically to a firm's securities (Ross et al., 2007). Bonds can be subordinated, convertible, or redeemable in shares (Quiry et al., 2005, p517). In addition, debentures are an alternative source of finance for corporations to raise funds for their investments. Bonds become popular for corporations, since the cost of issuing bonds is cheaper than direct borrowing from banks. Some corporations view direct borrowing from banks as more restrictive, since banks normally require lenders to follow their debt covenants. Debentures normally become more popular under the case of low bank interest rates.

(ii) **Lines of credit from banks** can be viewed as working capital facilities, short - term, and long-term loans. Working capital facilities and short-term loans provided by banks help firms to bridge the time gap between payments to suppliers and settlements, and to invest in current assets. Common working capital facilities are documentary credits (Letter of Credit - L/C) and trust of receipts (T/R), bank guarantees, overdrafts (O/D), promissory notes, factoring, export credit, and stock or inventory loans (Quiry et al., 2005; Petty et al., 2006). Long-term bank loans can also be used to invest in long-term assets.

(iii) **Lines of credit from other creditors** can be any credit made available by the firm's suppliers (or trade credit). Trade credit can be normally observed in nearly all business entities. It allows firms to purchase materials without immediate cash, which is normally granted for at least 30 days (Beal et al., 2008).

(iv) **Hire purchase** is a form of instalment credit and similar to leasing, where financial institutions buy, for example, equipment required by customers, and then they hire them to customers for certain periods. Unlike leasing, customers can own equipment or any good if they pay the outstanding balance at the end of the period, whereas a lessee in leasing never becomes the owner of that equipment or those goods. Hire purchase used to be highly demanded for customers, but it is currently less attractive due to increasing demand for credit-card finance and personal loans (Beal et al., 2008).

(v) **Venture capital** is an alternative source of finance for firms which have difficulty in obtaining funds, since they are typically small and young firms with high risk of failure. These firms might have few tangible assets as collateral, and operate in a market which is highly volatile. This causes them difficulty in obtaining loans from creditors or banks (Gompers and Lerner, 2001; Engel, 2002). The advantages of venture capital are that it provides not only financial resources for firms with high growth potential, but also significant management resources, upgraded technologies, and new markets, as well as coaching investing firms in their start-ups (Davila et al., 2003). Gompers and Lerner (2001, p152) also explain that the venture capital cycle normally begins with (i) fundraising from investors, (ii) investing in potential firms, (iii) monitoring and adding value to its investing firms,

(iv) withdrawing funds if the deals are successful, (v) returning capital to its investors, and (vi) raising additional funds from its investors again.

(vi) **Government assistance** can be another financial source for young firms or financially constrained firms, since the government can provide financial assistance (e.g., low-interest loans, capital subsidies, cash grants) and other assistance to firms (e.g., aiding the adoption of new technologies, improving a country's infrastructure, offering tax-based and non-tax incentives). Tax-based incentives include, for example, exempting or reducing import duties on machinery and raw materials, and corporate income tax (CIT) exemptions. Non-tax based incentives include, for instance, permitting foreign workers to work for local firms, remitting foreign currency abroad as part of its policy to promote the economy (Girma et al., 2007; The Board of Investment, 2009a).

(vii) **Leasing** is one of the long-term financing options, where both parties (the lessee and the lessor) engage in a leasing agreement. The lessor can be either the asset's manufacturer or an independent leasing firm. The lessee has the right to use assets, but make periodic payments as stated in a leasing contract. There are two types of lease: (i) finance leasing and (ii) operating leasing. Finance leasing is a long-term lease where a lessee receives assets without immediately paying for them. This type of leasing is normally long-lived and non-cancellable prior to the expiry date of a contract (Ross et al., 2007, p831). The lessee is also solely responsible for upkeep and maintenance of the asset. It normally requires that the leasing period must be greater than 75 percent of the asset's life. Operating leasing is a rental agreement for operating assets, which is usually, but not always, short-lived and cancellable. According to operating leasing, leased equipment or goods will not be stated in the lessee's balance sheet, and will not be reflected in the firm's gearing ratios (leverage ratios). Examples of operating leasing, for instance, are telephones, photocopiers, motor vehicles, construction equipment, and computers (Ross et al., 2007, p831).

According to the external financing literature, banks and other financial institutions are likely to screen efficient firms (e.g., collateral level, sufficient cash flow, age, and size) before those firms are allowed to borrow capital. Kim (2003) examines the effect of external financing on a firm's technical efficiency using the ratio of interest expenditure to total capital as the proxy of external financing. His results reveal that for the case of Korea external financing has a negative relationship with a firm's technical efficiency in the food and paper industries, but such a relationship is not found in the textile, basic-metal, and fabrication industries. The latter industries consist of large firms that have easy access to bank loans and other external funds. Moreover, these industries are major exporting industries in the Korean manufacturing sector, and received government support during the 1970s and 1980s. Du and Girma (2009) also suggest that domestic bank loans are found to be more supportive to Chinese large-sized manufacturing firms during the period 1998 to 2005. Cull and Xu (2005) also find similar results that external financing, in the form of bank loans, are positively associated with profit reinvestment for Chinese firms across a number of industries during the period 2000 to 2002. In addition, Gökçekus (1995) finds no significant effects of the relative efficiency of internal versus external financing on a firm's technical efficiency for the Turkish rubber industry.

The conclusion from the literature is, therefore, that the relative efficiency of internal versus external financing is still inconclusive. Some studies argue that a firm's capital is allocated more efficiently in an internal capital market than an external one, since internal financing can increase monitoring incentives, decrease entrepreneurial incentives, and have better asset redeployability. In other words, internal financing improves the efficiency of investments and resource allocation. (Gertner et al., 1994). Other studies, however, argue that internal financing causes the agency problem, which implies that managers lack the desire or necessity to maximize shareholders' interests. This is especially the case in underdeveloped countries where firms' managerial rights are not fully developed and their information is not fully publicized, and managers attempt to maximize their benefits rather than the firm's value (Kim, 2003, p134).

3.5 Ownership structure

Ownership structure plays an important role in influencing a firm's goals and its profitability, which finally affects shareholders' wealth. Blair (1995, p4) also states that "*ownership of private property is the central mechanism by which incentives are created for the efficient use of resources in a free market economy*". In this regard, it is interesting to examine the effect of ownership structure on a firm's performance. For this thesis ownership structure can be considered in terms of (i) ownership concentration (Section 3.5.1), (ii) types of ownership (Section 3.5.2), and (iii) managerial ownership (Section 3.5.3). Ownership concentration and managerial ownership are only discussed in the finance literature, but types of ownership are discussed in both the finance and economics literature.

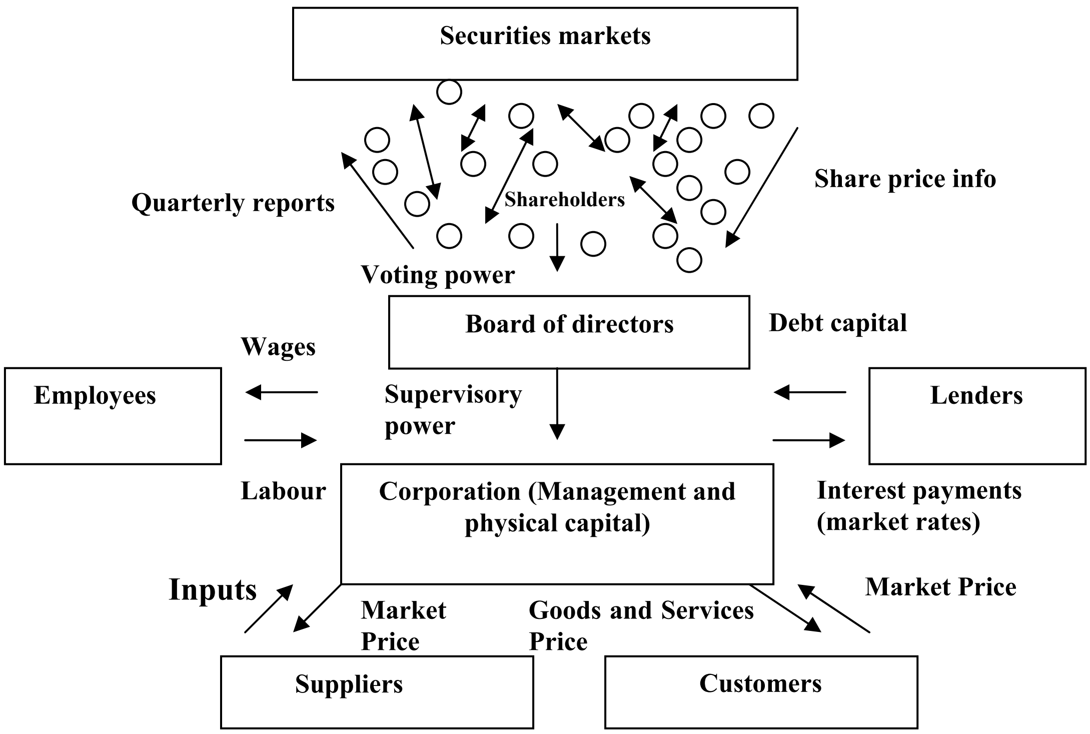
3.5.1 Ownership concentration

Ownership concentration refers to the shares of a firm that are owned by a shareholder or a small number of shareholders, namely controlling shareholders. For empirical studies controlling ownership can be measured by the percentage of equity owned by the five largest shareholders (Wiwanttanakantang, 2001; Yammeesri and Lodh, 2003; Zeitun and Tian, 2007). In addition, controlling shareholders are likely to exert their influence over the firm's management through their voting rights at shareholders' meetings, or they influence the firm by being a member(s) of the board of directors.

Ownership dispersion, however, refers to separate investors whose share holdings in the firm are very small compared with the value of the whole firm (Blair, 1995). Figure 3.4 illustrates the "Berle-Means" model of the corporation, which explains that the voting power of any individual shareholder is much less influential due to the dispersion of equity ownership Shareholders can sell their shares if they dislike the way that the firm is operating its business. In this regard, the firm's security price will fall if a large number of shareholders simultaneously sell their shares, and few investors are willing to buy them. Dispersed shareholders, however, are not likely to monitor the firm's management as well as controlling shareholders, since monitoring costs are much higher than the benefits that dispersed shareholders will receive. There are both costs and benefits associated with ownership concentration. The presence of controlling shareholders (shareholders with large stakes) is likely to deteriorate a firm's performance, since the interest of controlling shareholders may not align with those of non-controlling shareholders (Shleifer and

Vishny, 1997; Bebchuk et al., 1999). There is a possibility that controlling shareholders may conduct corrupt activities (i.e., using a firm's cash flows for their own benefits). A number of empirical studies support a negative relationship between controlling ownership and a firm's performance, or that such a relationship is not found between them (Demsetz and Lehn, 1985; McConnell and Servaes, 1990; Leech and Leahy, 1991).

Figure 3.4: Basic "Berle-Means" model of the corporation



Source: Blair (1995, p31)

Demestz and Lehn (1985) find no significant evidence of a relationship between controlling ownership (ownership concentration) and accounting profit rates for 511 U.S. firms. Leech and Leahy (1991) find a negative association between ownership concentration and firm performance, measured by firm value, trading profit margin, and rate of growth of net assets for 470 UK listed firms, including 325 from the 1,000 largest industrial companies ranked by Time magazine, during the period 1983 to 1985. McConnell and Servaes (1990) also find no significant evidence of a relationship between controlling ownership (block ownership) and Tobin's q. According to agency theory, however, controlling shareholders are likely to perform better than dispersed shareholders, because a high level of ownership concentration can reduce agency costs. Shareholders with large stakes alleviate the free rider problem of monitoring a firm's management, and therefore reduce agency costs (Shleifer and Vishny, 1986; Admati et al., 1994).

Dilling-Hansen et al. (2003), however, find that firms owned by large shareholders do not seem to be more efficient than other firms. Zeitun and Tian (2007) find that ownership structure is positively associated with firm performance, as measured by return on assets (ROA) and return on equity (ROE), for 59 publicly listed firms in Jordan. In the case of Thailand, Yammeesri and Lodh (2003) find that controlling ownership has a strong and positive association with stock returns and profitability. In addition, Wiwattanakantang (2001) also suggests a similar result that controlling ownership is associated with higher performance as evaluated by accounting measures such as ROA and sales-asset ratio.

3.5.2 Types of ownership

The aim of this section is to focus on the various types of ownership of listed enterprises, which will be related to the analysis of firm performance for this thesis.

Listed enterprises

Types of ownership in publicly listed firms are different among countries (see Table 3.2). Firm performance has largely been measured by firm value (Tobin's q) and profitability ratios (e.g., return on equity (ROE)). There has been a large number of studies analysing the effect of ownership structure on a firm's performance, as measured by firm profitability - financial ratios and corporate value (Tobin's q) for a number of countries (e.g., China, Korea, and all East Asian countries) (McConnell and Servaes, 1990; Smith, 1990; Cho, 1998; Xu and Wang, 1999; Claessens et al., 2000; Dewenter and Malatesta, 2001; Joh, 2003; Chang and Shin, 2007; Lee, 2008).

Few studies in the finance and economics literature, however, have analysed firm ownership and its effect on technical efficiency. This is the main focus of this thesis. Table 3.2 summarises a number of empirical studies that have examined the effects of types of ownership on a firm's technical efficiency, applying the SFA approach (Jones et al., 1998; Wen et al., 2002; Goldar et al., 2003; Bottasso and

Sembenelli, 2004; Sirasoontorn, 2004; Sheu and Yang, 2005) and two-stage DEA approach (Zheng et al., 1998; Fukuyama et al., 1999; Zhang et al., 2001; Sirasoontorn, 2004; Zelenyuk and Zheka, 2006; Hoang, 2007; Bachiller, 2009).

Table 3.2: Empirical studies: The effects of ownership structure on a firm's technical efficiency

Author	Country (year)	No. of firms	Method
Jones et al. (1998)	Bulgaria (1989-1992)	490	SFA
Zheng et al. (1998)	China (1986-1990)	1,759	DEA
Fukuyama et al. (1999)	Japan(1992-1996)	364	DEA (two-stage procedure)
Zhang et al. (2001)	China (1996-1998)	1,989	DEA (two-stage procedure)
Zelenyuk and Zheka (2006)	Ukraine (2001-2002)	158	DEA (the truncated regression with iterated bootstrap approach)
Dilling-Hansen et al. (2003)	Denmark (1997)	2,370	SFA
Goldar et al. (2003)	India (1990-2000)	63	SFA
Bottasso and Sembenelli (2004)	Italy (1978-1993)	1,306	SFA
Sirasoontorn (2004)	Thailand (1992-2001)	24	DEA (two stage procedure) and SFA
Sheu and Yang (2005)	Taiwan (1996-2001)	416	SFA
Hoang (2007)	Vietnam (2000-2005)	1,171	DEA (two-stage procedure)
Bachiller (2009)	Spain (1984-2005)	5	DEA (two-stage procedure)

Author	Types of Ownership	The key findings
Jones et al. (1998)	1. State firms 2. Non-state firms 3. State joint stock 4. Private firms 5. Independent cooperatives 6. Joint ventures	• Private ownership has a positive effect on a firm's technical efficiency. • Cooperative ownership is always not significant. • State firms, state joint stock and joint ventures do not affect firm performance.
Zheng et al. (1998)	1. State-owned enterprises (SOEs) 2. Urban collective-owned enterprises (COEs) 3. Township-village enterprises (TVEs)	• State-owned enterprises (SOEs) are less efficient than Township-village enterprises (TVEs), but more efficient than COEs.
Fukuyama et al. (1999)	1. Japan firms 2. Foreign firms	• All credit cooperatives in Japan are owned by foreigners, and Koreans own more than 90 percent of those firms. • Foreign - owned firms are found to be more efficient than the others, and also have higher productivity growth over the same period.

Table 3.2: Empirical studies: The effects of ownership structure on a firm's technical efficiency

Author	Types of Ownership	The key findings
Zhang et al. (2001)	1. State-owned enterprises (SOEs) 2. Collective-owned enterprises (COEs) 3. Private-owned enterprises (POEs) 4. Foreign-owned enterprises (FOEs) 5. Domestic joint ventures (DJVs) 6. Hong Kong - Macao - Taiwan owned Enterprises (HMTs)	• Non-state enterprises have a higher average level of productive efficiency than SOEs. • HMTs and FOEs are the most technically efficient groups.
Sheu and Yang (2005)	Insider ownership is classified as follows: 1. Executives 2. Outside directors 3. Large shareholders	• Executive shareholders firstly cause a decrease and then an increase in a firm's technical efficiency. • Outside - director shareholders is negatively associated with a firm's technical efficiency.
Dilling-Hansen et al. (2003)	1. Block shareholders (> 5 % of total shares) 2. LTDs (legal form)	• Block ownership is not statistically significant. • LTDs are the most efficient firms.
Goldar et al. (2003)	1. Foreign - owned firms 2. Domestically - owned firms 3. Public - owned firms	• Foreign - owned firms have higher efficiency than domestically owned firms. • There is no significant difference between domestic and public sectors. • Domestically owned firms are likely to enhance their technical efficiency and attain the same technical efficiency level as that of foreign owned firms.
Bottasso and Sembenelli (2004)	1. Independent firms 2. State owned firms 3. Multinational firms 4. Other national firms (Group firms)	• Multinational firms are the most efficient group in most industries. • State owned firms indicate systematic lower efficiency levels.
Sirassontorn (2004)	Thai state owned electricity generating firms	• The Thai state owned electricity generating company performs better than other electricity suppliers in OECD and non -OECD countries on average.
Zelenyuk and Zheka (2006)	1. State firms 2. Foreign firms	• State firms are negatively associated with a firm's technical efficiency. • Foreign ownership is negatively related to a firm's technical efficiency. • However, the finding suggests a positive association between the levels of corporate quality and a firm's efficiency.
Hoang (2007)	1. State 100 % owned (SOEs) 2. State dominant shareholding (SDSHs) 3. Private Shareholding (PDSHs) 4. State Joint-Venture (SJVs)	• SJVs exhibit the highest technical efficiency Scores. • SOEs exhibit the lowest.

Source: Author

Types of ownership can be classified as (i) family ownership, (ii) foreign ownership, (iii) institutional ownership, and (iv) state ownership

(i) Family ownership

Family ownership (control) is an important type of ownership, since most firms around the world are controlled by family founders (Burkart et al., 2002). In addition, family ownership is commonly found in privately held firms, but also dominant among listed firms. There are two opposite views with regard to an individual or a group (family) as a controlling shareholder. On the one hand, family ownership can cause agency problems, since it has the power to expropriate the interests of minority shareholders. In other words, it is likely to implement policies which benefit themselves, but harm a firm's overall performance (Porta et al., 1999).

On the other hand, family members actually provide good monitoring in their family-controlled firms, since they have advantages in communicating with other related members (Fama and Jensen, 1983). In other words, the separation of management and control, which causes agency problems, is reduced due to the close relationship among family members within the firm. A number of empirical studies suggest that family ownership has a positive impact on a firm's performance (Wiwattanakantang, 2001; Yammeesri and Lodh, 2003; Maury, 2006). Maury (2006) finds that active family firms have higher profitability compared with non-family firms for 1,672 non-financial firms in Western Europe, but such a relationship is not found for passive family ownership

In the case of Thailand, Yammeesri and Lodh (2003) find that family ownership of listed firms has a positive impact on a firm's performance, as measured by profitability (ROA) during the period 1993 to 1996.Wiwattanakantang (2001) also finds that family ownership has a positive effect on firm performance, measured by profitability (ROA) for 270 non-financial listed firms in 1996 for the case of Thailand. Few studies, however, have linked family ownership with a firm's technical efficiency. Lauterbach and Vaninsky (1999) used a dummy variable[31] to capture the effect of family ownership on a firm's technical efficiency, as measured by the two-stage DEA approach. Their results revealed a negative association

[31] The number "one" is assigned for any firm which is controlled by a family or a partnership of individuals; otherwise the number "zero" is used.

between family ownership or partnership ownership and firm technical efficiency for 280 Israeli firms.

(ii) Foreign ownership

Foreign ownership has become one of the most important ownership types. Foreign ownership has superior technology, managerial expertise, good corporate governance, and strong foreign - market network (Kimura and Kiyota, 2007). A number of empirical studies find that foreign ownership has a positive association with a firm's performance, as measured by profitability and productivity (Takii, 2004; Choi and Yoo, 2006; Aydin et al., 2007; Kimura and Kiyota, 2007; Greenaway et al., 2008). Aydin et al. (2007) find that foreign-owned firms perform better than domestic-owned firms, as measured by return on assets (ROA) for 301 Turkish listed firms during the period 2003 to 2004. Greenaway et al. (2008) also find that foreign ownership has a positive effect on a firm's performance, as measured by return on assets (ROA), return on sales, labour productivity, and total factor productivity. In addition, they also find an inverted U-shaped pattern between foreign ownership and a firm's performance. In other words, a firm's performance increases as foreign investors own up to about 47 percent to 64 percent, and declines thereafter. Takii (2004) also finds that foreign-owned firms are more productive than domestically owned firms for Indonesian manufacturing firms in 1995. Moreover, wholly foreign-owned firms are likely to have higher productivity than partly foreign-owned plants.

Choi and Yoo (2006) also find a positive association between foreign ownership and firm performance, as measured by Tobin's q for Korean firms during the period 1993 to 2002. Kimura and Kiyota (2007) also find that foreign-owned firms perform better than domestically-owned firms, as measured by returns on assets (ROA), value added productivity, and total factor productivity for Japanese firms over the period 1994 to 1998. They also reveal that foreign-owned firms achieve faster growth in terms of profitability and productivity than domestically-owned firms. Moreover, they suggest that foreign investors bring useful firm-specific assets such as new technology, managerial skills, and effective corporate governance into Japan (Kimura and Kiyota, 2007). In addition, they also find that foreign investors tend to invest in firms that have the most profitability in the future, but may not be immediately profitable. Yammeesri and Lodh (2003), however, study 243 non-financial firms listed in the Stock Exchange of Thailand during the period 1993 to 1996, and find that foreign ownership is not associated with a firm's performance, as measured by profitability (return on assets (ROA), Average Return (AR), and Sales/Assets ratio).

Focusing upon measures of a firm's performance in terms of technical efficiency a number of empirical studies suggest that foreign-owned firms have a positive association with a firm's technical efficiency (Fukuyama et al., 1999; Goldar et al., 2003; Bottasso and Sembenelli, 2004). Zhang et al. (2001) use panel data for 1,989 Chinese industrial firms during 1996 to 1998 to quantify the effects of ownership and market competition on a firm's technical efficiency. Their findings reveal a strong ownership effect on a firm's technical efficiency. Foreign-owned enterprises exhibit the highest efficiency scores, but state-owned enterprises exhibit the lowest. Goldar et al. (2003) use panel data for 63 Indian engineering firms during 1990 to 2000 to analyse the effect of ownership on a firm's technical efficiency. Their findings reveal that foreign-owned firms have higher technical efficiency than domestically owned firms. Bottasso and Sembenelli (2004) use panel data for 1,306 Italian manufacturing firms during 1978 to 1993 to examine the relationship between corporate ownership and a firms' technical efficiency in twelve industrial sub-sectors. Subsidiaries of multinational enterprises are found to be the most efficient group in most industries, but state owned enterprises indicate systematically lower efficiency levels.

(iii) Institutional ownership

Institutional investors (e.g., pension funds, mutual funds) can decrease agency costs, since they prefer to monitor the actions of firm managers more effectively to increase firm performance (Crutchley et al., 1999). Navissi and Naiker (2006) studied 123 listed firms on the New Zealand Stock Exchange in 1994. They find that institutional investors with board representation have a positive impact on firm value at lower levels of ownership, but institutional investors without board representation is unrelated to firm value. In addition, they find a non-linear relationship between institutional ownership and firm value, since it becomes negative when the share ownership increases. Agrawal and Mandelker (1990) also support the active monitoring hypothesis, proposed by Shleifer and Vishny (1986), that the existence of controlling shareholders (ownership concentration) leads to better monitoring of managers and also higher firm performance for 372 NYSE and AMEX firms during the period 1979 to 1985. In particular, ownership is concentrated in institutional investors rather than individual investors. Zeitun and Tian (2007) also find that institutional ownership raised firm performance and decreased the probability of default for 59 publicly listed firms in Jordan during the period 1989 to 2002. McConnell and Servaes (1990) find a significant and positive association between Tobin's q and the fraction of shares owned by institutional investors for 1,173 U.S. firms in 1976 and 1,093 U.S. firms in 1986. Crutchley et al. (1999) find a significant association between institutional ownership and firm profitability, as measured by return on equity (ROE), for U.S. publicly listed firms in the New York and American Stock Exchanges in 1987 and 1993 (Crutchley et al., 1999).

(iv) State ownership

The effects of state ownership on a firm's performance are widely discussed and controversial. Most empirical studies find a negative association between state ownership and a firm's performance (see the survey by Djankov and Murrell, 2002). From agency problems state-owned firms are controlled by politicians, and they can exploit the firm's assets easily (Le and Buck, 2009). In other words, they may have an increased incentive to avoid maximizing a firm's profitability for other minor shareholders who are not the government. A number of studies also reveal that, in competitive markets without significant externalities, government ownership is inferior to private ownership, since the objectives of government ownership is quite different from private ownership which focuses on profit maximization (Boycko et al., 1996; Shleifer, 1998; Dewenter and Malatesta, 2001; Sun et al., 2002). Sun et al. (2002, p1) state that this is normally described by (i) the government's lack of transferable residual claims, (ii) the government's choice of social and political policy objectives rather than profit maximization, (iii) the government's employment of officers and workers based on political relationship rather than their performance capability, and (iv) the government's higher transaction costs.

Boycko et al.(1996) and Sheifer (1998) also mention that public firms around the world are highly inefficient, since they adopt strategies, such as excess employment, which satisfy policy interests. This is because state firms are likely to serve the public interest better than private firms. In other words, state ownership may generate significant positive externalities which are not captured by profitability. Boycho et al. (1996, p318) suggest that the inefficiency of state firms is due to the agency problem with politicians rather than that with managers, since politicians aim to obtain voting support from employees of state firms and labour unions by raising higher labour spending, but this leads to the expense of the Treasury and other shareholders[32]. In this regard, privatisation may be implemented for public firms to improve their efficiency. Sheifer and Vishny (1997, p48), however, suggest that public firms, which are privatized without increasing the number of investors, are likely to face the agency problem due to insufficient investors to monitor firms. Zeitun and Tian (2007) also suggest that reducing government ownership increased firm performance for 59 Jordanian listed firms during the period 1989 to 2002.

A number of empirical studies, however, argue that state ownership has a positive impact on a firm's performance. According to Le and Buck (2009) state ownership can increase a firm's performance since it produces a "helping hand", which is based on efficiency or state power. In efficiency terms the government may act as a controlling shareholder (a strategic block holder), and control managers more efficiently than widely dispersed ownership In power terms the government may use its power by providing supportive environments (e.g., subsidies) to improve a firm's performance. Le and Buck (2009) also find a positive association between state ownership and firm performance for more than 1,000 Chinese listed firms during the period 2003 to 2005. Hence, this issue is a complex one and can depend upon a number of factors, such as the stage of economic development and how performance is measured.

[32] However, this is a very generalised statement that is unlikely to always be the case.

3.5.3 Managerial ownership

Managerial ownership[33] can help align the conflict of interests between shareholders and managers (Jensen and Meckling, 1976). If managers' interests coincide more closely with those of shareholders, the conflicts between managers and shareholders are alleviated. A number of empirical studies have investigated the significance of the relationship between managerial ownership and firm performance (McConnell and John, 1990; Morck et al., 1988; Wiwattanakantang, 2001; Yammeesri and Lodh, 2003). McConnell and John (1990) find a significant non-linear association between managerial ownership ` as measured by market valuation (Tobin's Q) for 1,173 U.S. and 1,093 U.S. enterprises in 1976 and 1986, respectively. More precisely, they find a significant and positive upward trend until managerial shareholding contributes approximately 40% to 50% of total shares ownership, and then begins to decline thereafter. Morck, et al. (1988) examined the association between management ownership and market valuation as measured by Tobin's Q for 371 out of Fortune 500 enterprises in 1980. They reveal that the association between managerial ownership and firm performance is "non-linear" or "nonmonotonic". More specifically, at the 0% - 5% managerial shareholding range, managerial shareholders are found to have a significant and positive impact on firm performance.

Managerial shareholding, however, is found to be significantly and negatively related with firm performance in the 5% - 25% managerial shareholding ownership range. This problem causes difficulty for minority shareholders to monitor or control managerial shareholders' actions, and, therefore, the firm's performance can deteriorate. Finally, a significant and positive association between managerial ownership and firm performance is found when managerial shareholding is over 25%. Short and Keasey (1999) also find a positive non-linear relationship between managerial ownership and firm performance, focusing upon both accounting and market measures for UK firms quoted on the Official List of the London Stock Exchange during the period 1988 to 1992. In addition, their results suggest that UK managerial shareholders become entrenched at higher levels of ownership than is the

[33] Managerial ownership is defined as being the owner manager who owns the company's shares and also works as an executive for the company (Jensen and Meckling, 1976, p56).

case of US managerial shareholders due to greater institutional monitoring within the UK.

In the case of Thailand, Wiwattanakantang (2001) examined the relationship between managerial shareholding and firm performance for 270 non-financial enterprises listed in the Stock Exchange of Thailand (SET) in 1996. The level of managerial shareholding is classified into three different groups (i) 25% to 50%, (ii) 50% to 75%, and (iii) 75% to 100%, and is compared with non-managerial shareholding. At the 25% - 50% range, the results reveal that there is a significant and negative association between managerial shareholding and firm performance as measured by ROA and sales-to-assets. A positive result is also found when managerial shareholding is over 75 %, but is not statistically significant. Yammeesri and Lodh (2003) examined the effects of ownership structure on firm performance for 243 non-financial firms listed in the SET over the period 1993 to 1996. They find that there is a strong positive relationship between managerial ownership and profitability (ROA), but such a relationship is not found in the case of market returns and sales-to-assets. Finally, they suggest that a non-linear relationship between managerial ownership and firm performance is not found in the case of Thailand. They, however, find a significant non-linear relationship between managerial-non-family shareholding and market returns (average return rate (AR)). In other words, managerial-non-family shareholding is significantly and positively related to estimated market returns at the 0% to 15.39% managerial shareholding range, significantly and negatively at the 15.39% to 50.61% managerial shareholding range, and significantly and positively when managerial shareholding exceeds 50.61%.

Very few empirical studies, however, have examined the effect of managerial ownership on a firm's technical efficiency. Liao et al. (2010) separated the percentage of equity owned by managers and the percentage of equity owned by the board, and examined the effects of these variables on a firm's technical efficiency as measured by two-stage DEA. Their results found that managerial and board equities are positively related with a firm's technical efficiency, but their results are not statistically significant. Liao et al. (2010) examined this hypothesis for securities firms in Taiwan using only the two-stage DEA approach.

3.6 Research and development (R&D) and firm performance

Business Innovation

Business innovation is another important factor in enhancing a firm's performance. Innovation can be broadly classified into two dimensions: (i) Product innovation and (ii) Process Innovation. Some studies also include organizational innovation as one of the innovative dimensions (Yamin et al., 1999). Product innovation refers to the novelty of new products and product improvement, which can promote growth, increase sales and profits (Dwyer and Mellor, 1993). Process innovation, however, refers to the novelty of technology and technological improvement, which is also a crucial component of business innovation.

A number of empirical studies find a positive association between innovation and a firm's performance (Yamin et al., 1999; Salavou, 2002; Cho and Pucik, 2005; Prajogo, 2006). Yamin et al. (1999) reveal that an innovation index, which captures three innovative dimensions (managerial innovation, process innovation, and product innovation) positively affects firm performance, as measured by marketing effectiveness, financial performance, asset management, and operational efficiency for 237 Australian manufacturers during the period 1991 to 1992. Cho and Pucik (2005) examine the linkage between innovativeness, product quality, growth, profitability, and market value for U.S. firms (Fortune 1,000 companies) during the period 1998 to 2000. Their results reveal that innovativeness, along with product quality, positively affects a firm's growth and also its profitability, which in turn drives firm value to increase. Salavou (2002) also shows that product innovation has a positive effect on firm performance, based on return on assets (ROA) for Greek SMEs operating in the food and beverages industry during the period 1995 to 1997. Prajogo (2006) reveals that process innovation has a relatively stronger association with firm performance, based on sales, market share, and profitability than product innovation in Australian manufacturing firms.

Research and development (R&D)

Research and development (R&D) enhances the level of a firm's existing technology or creates new technologies for a firm, and hence improves a firm's technical efficiency. A number of empirical studies examine the effects of research and development (R&D) on a firm's performance, as measured by profitability, growth, or firm value. For example, Denis et al. (2002) find that research and development (R&D) is significantly associated with firm performance (firm value) for 44,288 U.S. firms during the period 1984 to 1997. Yasuda (2005) reveals that research and development (R&D) per employee has a positive effect on firm growth for nearly 14,000 Japanese manufacturing firms in 1992 and 1998. Short (1999) also finds that research and development (R&D) is positively associated with firm performance using both accounting and market measures for UK listed firms during the period 1988 to 1992. Choi and Yoo (2006) reveal that research and development (R&D) expenditure has a positive impact on firm performance, measured by Tobin's q for Korean firms during the period 1993 to 2002. In addition, they find that foreign investors may not necessarily invest in R&D-intensive firms.

A number of studies also examine the effects of research and development (R&D) on a firm's technical efficiency (Aw and Batra, 1998; Dilling-Hansen et al., 2003; Kim, 2003; Sheu and Yang, 2005). They find a positive relationship between research and development (R&D) and a firm's technical efficiency. Aw and Betra (1998) use micro data from Taiwan to estimate technical efficiency for manufacturing firms. Their findings indicate that a firm's technical efficiency has a positive association with a firm's investment in training and research and development (R&D). Sheu and Yang (2005) also find that research and development (R&D), as measured by annual R&D expenditure and deflated by the general WPI, positively influences technical efficiency in Taiwan's electronics industry. Kim (2003) identifies and estimates the factors affecting a firm's technical efficiency in Korean manufacturing industries. His results reveal that the ratio of R&D spending to total output has a positive association with a firm's technical efficiency for the textile and chemical industries, but such a relationship is not found in the fabrication industry. Dilling-Hansen et al. (2003) use a sample of 2,370 Danish firms in 1997 to examine the effects of a firm's investment in R&D on its technical efficiency. Their results reveal a positive relationship between a firm's investment in R&D on a firm's technical efficiency.

3.7 Executive compensation and firm performance

There are a number of empirical studies that have investigated the effect of executive compensation on firm performance (Mehran, 1995; Baek and Pagán, 2002; Kato et al., 2007; Ozkan, 2007; Buck et al., 2008; Unite et al., 2008). Buck et al. (2008) use 601 Chinese enterprises listed in the Shanghai and Shenzhen Stock Exchanges during the period 2000 to 2003. In practice, top executive compensation includes total remuneration to the members of the board of directors, the supervisory boards and senior management (Buck et al., 2008, p10). However, the top three Chief Executive Officers' (CEOs) pay was used as a proxy for executive pay due to the information available from the annual report of Chinese listed companies. Their results indicate that there is a two-way relationship between executive pay and firm performance. Kato et al. (2007) examined the relationship between cash compensation of Korean executives and firm performance for 246 publicly-traded firms in Korea over the period 1998 to 2001. Their results reveal that cash compensation of Korean executives is significantly associated with stock market performance. In addition, Unite et al. (2008) suggest that there is a positive association between executive compensation and firm performance for publicly-traded corporations which are not affiliated to a cooperative group listed on the Philippine Stock Exchange (PSE) over the period 2001 to 2003.

Ozkan (2007) examined the relationship between firm performance and the level of CEO cash compensation for 390 UK non-financial firms over the period 1999 to 2005. Her results reveal a significant and positive association between firm performance and CEO cash compensation, but such a significant and positive relationship is not found for total CEO compensation (cash and equity-based CEO compensation (stock options and long term incentive plans)). Mehran (1995) examined the executive compensation structure for 153 randomly-selected manufacturing firms over the period 1979 to 1980. His empirical results indicate that the percentage of equity owned by CEOs and the percentage of CEOs' equity-based compensation have a significant and positive effect upon firm performance, as measured by Tobin's q and returns on assets. Focusing on firm performance, as measured by technical efficiency, very few empirical studies examined the effect of executive remuneration on a firm's technical efficiency. Baek and Pagán (2002) conducted a stochastic frontier analysis (SFA) to measure a firm's technical efficiency, and found that the level of CEO total compensation is positively associated with a firm's technical efficiency for S&P 1,500 firms.

3.8 Export performance

The role of exports in promoting a firm's performance based on productivity and growth has been discussed in several studies (see Table 3.3), but discussions of the role of exports on a firm's technical efficiency have rarely been emphasised. This section will firstly provide a review of the literature on sunk start-up costs and heterogeneity in firm productivity, and then discuss the two-way hypotheses (the self-selection and the learning-by-exporting hypotheses).

3.8.1 Sunk start-up costs and heterogeneity in firm productivity

Sunk start-up costs and heterogeneity in firm productivity can provide the reason as to why not all firms can export to foreign markets. New exporters face significant start-up costs, since they have to spend in gathering information on foreign markets, developing marketing channels, modifying products to satisfy foreign consumption, and improving existing packaging (Greenaway et al., 2005). Recent trade literature studies show how sunk start-up costs, heterogeneity in firm productivity, and other significant factors affect firm exporting decisions.

Roberts and Tybout (1997) examine exporting decisions for a large group of Colombian manufacturing firms. They find that sunk start-up costs are significant for firm exporting decisions. They also reveal that exporting experience can statistically increase the probability of exporting, but the significance of exporting experience declines once firms stop exporting to foreign markets. Moreover, they find that firms that are large, old, and owned by corporations are likely to export. Finally, they also suggest that any country which is undertaking export-promotion policies should clarify whether these policies aim at increasing the export volume of existing exporters, or promoting the entry of new exporters. Therefore, if the latter policy is desired, then reducing entry costs and uncertainty (e.g., providing information about targeting foreign markets, enhancing exporting infrastructure, or providing a stable macroeconomic policy) is required.

Similarly, Melitz (2003) analyses a new transmission channel for the effect of trade on industry structure and performance. His results reveal that sunk start-up costs significantly affect foreign trade, which is distributed across different types of firms. Furthermore, only more productive firms enter exporting markets, while less productive firms continue to produce only for the domestic market, and the least productive firms will simultaneously be forced to exit. Export participation can also be very costly, but firms will decide to export after they gain knowledge of their productivity.

Bernard and Jensen (1999) also study export participation for U.S. manufacturing firms during the period 1984 to 1992. The factors that affect export participation such as barriers to entry, individual plant attributes, exchange rates, spillovers, and export promotion on exporting decisions are examined in their model (Bernard and Jensen, 1999, p20). They conclude that sunk start-up costs are significant, and firm heterogeneity is also important in firm exporting decisions. Furthermore, they find that exchange rate movements significantly affect a firm's exporting decisions, but spillovers, subsidies, and state government exporting promotion are not significant and positively related to firm export participation. Campa (2004) also finds sunk cost hysteresis in entry and exit to be an important factor in determining export market participation for Spanish manufacturing firms during the period 1990 to 1997. Sunk costs of entering the market appear to be much larger than the costs of exiting the market. Similarly, Máñez et al. (2008) study the sunk costs explanation for hysteresis in exports for Spanish manufacturing firms during the period 1990 to 2000. Their results support the sunk costs explanation for hysteresis for Spanish manufacturing firms. Furthermore, they find that large firms have significantly smaller sunk costs than small firms.

3.8.2 The two-way effect between firm performance and export performance

There are a large number of empirical studies examining the two-way relationship between a firm's performance and its export participation (World Bank, 1993; Rhee, 1994; Aw and Hwang, 1995; Clerides et al., 1996; Bernard and Wagner, 1997; Aw et al., 1998; Bernard and Jensen, 1999; Liu et al., 1999; Castellani, 2002; Kraay, 2006; Granér and Isaksson, 2007) (see Table 3.3). The direction of causality as to whether exporting decisions improve a firm's technical efficiency or vice versa has been proposed by at least two different mechanisms. According to the so-called "self-selection hypothesis", only more efficient firms will self-select into the export market. The main reason is that the most productive firms can survive in highly competitive markets. The reason for this hypothesis is that there exist additional costs in exporting to foreign countries. These costs include transportation costs, marketing costs, or production costs in developing existing products for foreign customers, which obstruct small or less successful firms to become new exporters (Wagner, 2005). In addition, only high productivity firms will participate in the export market if the fixed selling costs in exporting products are higher than for the domestic market, and exporters whose productivity decreases will be forced to leave the market (Aw et al., 1998).

Table 3.3: The self-selection and learning-by-exporting hypotheses

Author	Country (Year)	Firm Performance	Self-selection hypothesis	Learning-by-exporting hypothesis
Bernard and Jensen (1999)	U.S. (1984-1992)	- Total factor productivity - Size (total employment)	Yes	No
Bernard and Wagner (1997)	Germany (1978- 1992)	- Labour productivity - Shipments	Yes	No
Cherides et al. (1998)	Colombia (1981-1991), Mexico (1986-1990), Morocco (1984 -1991)	- Labour productivity - Costs	Yes	No
Liu et al. (1999)	Taiwan (1989-1993)	-Total factor productivity growth - Shipments per employee growth - Labour productivity Growth	Yes	No

Table 3.3: The self-selection and learning-by-exporting hypotheses

Author	Country (Year)	Firm Performance	Self-selection hypothesis	Learning-by-exporting hypothesis
Aw et al. (1998)	Taiwan (1986,1991) Korea (1983, 1988, 1993)	- Average total factor productivity - Average total factor productivity	Yes Yes	Yes No
Granér and Isaksson (2007)	Kenya (1992 -1994)	-Technical efficiency	Yes	Yes
Castellani (2002)	Italy (1989 -1994)	- Labour productivity Growth	Yes	Yes
Kraay (2006)	China (1988 -1992)	- Labour productivity - Total factor productivity - Unit costs	Not examined	Yes
Blalock and Gertler (2004)	Indonesia (1990 - 1996)	- Production output	Not examined	Yes
Hansson and Lundin (2003)	Sweden (1990 -1999)	- Total factor productivity - Labour productivity	Yes	Yes
Girma et al. (2004)	UK (1988 - 1999)	-Total factor productivity growth - Output growth - Employment Growth - Labour productivity Growth	Yes	Yes
Hallward-Driemeier et al. (2002)	Indonesia, Korea, Malaysia, Philippines, Thailand (1996 - 1998)	-Total factor productivity	Yes	Yes
Baldwin and Gu (2003)	Canada (1974 - 1996)	-Labour productivity growth - Total factor productivity Growth	Yes	Yes
Máñez et al. (2003)	Spain (1990 - 2000)	-Labour productivity	Yes	Not Examined

Source: Author

According to the learning-by-exporting hypothesis, knowledge and expertise gained from export market experience is an alternative explanation as to why the productivity of exporting firms is relatively higher than non-exporting counterparts. This is because the communication between foreign customers and exporting firms provide exporting firms with access to new technical expertise (e.g., new product designs and production methods). Aw et al. (1998, p3) also mention that both the self-selection and learning-by-exporting hypotheses are plausible, but their actual importance is likely to vary across countries and industries with different products and process innovation, which can change the possibilities for a country's learning and its trade policy. The learning-by-exporting hypothesis may be particularly relevant for the East Asian countries (World Bank, 1993; Rhee, 1994; Kraay, 2006).

The self selection hypothesis

According to Table 3.3 there exists strong evidence that the self selection hypothesis, where only more efficient firms can participate in the export market, can be observed in several countries. Bernard and Jensen (1999) use unbalanced panel data for over 50,000-60,000 U.S. manufacturing plants during the period 1984 to 1992, to investigate whether good firms become exporters or whether exporting improves a firm's performance. As part of their results, total factor productivity (TFP) is found to be statistically significant in explaining the firm decision to export. Bernard and Wagner (1997) find that German manufacturing firms had to be successful before beginning exporting. In other words, good firms most certainly become exporters. Cherides et al. (1996) reveal that relatively efficient firms will be exporters, but previous export participation does not affect the unit costs of firms. Therefore, the efficiency gap between non-exporters and exporters is because the more efficient firms self-select into the export market, rather than learn by exporting.

Similarly, results found in Taiwan by Aw et al. (1998) and Liu et al.(1999) support the self-selection mechanism that firms entering into the foreign market have higher productivity prior to entry in comparison to firms that choose not to enter into the export market. Furthermore, Aw et al. (1998) reveal less evidence of the self selection hypothesis, compared with Taiwan, for two of five Korean industries, where significant differences between firms that enter into the foreign market and those that do not was found. Granér and Isaksson (2007) also suggest that self-selection behaviour appears among Kenyan manufacturing firms during the period 1992 to 1994. Castellani (2002, p625) finds that the higher the orientation towards foreign markets, the higher is a firm's productivity growth for the case of Italian manufacturing firms over the period 1989-1994. Hanssan and Lundin (2003) study the relationship between exporting and productivity for Swedish Manufacturing firms during the period between 1990 to 1999. Their results reveal that firms that begin exporting show higher productivity than firms that are non-exporters after two years. Girma et al. (2004) also investigate the link between exporting and productivity for UK manufacturing firms during the period 1988 to 1999. They find that exporting firms were more productive than non-exporters before entering export markets, since their growth rate of employment and output were faster before exporting.

Baldwin and Gu (2003) also find that more productive firms were likely to participate in the export market for Canadian manufacturing firms during the period 1990 to 1996. Their results reveal that firms that start exporting have higher labour productivity than non - exporters, and exporters that exit from export markets have lower labour productivity than continuing exporters. Hallward-Driemeier et al. (2002) study the patterns of manufacturing productivity for Indonesia, Korea, Malaysia, the Philippines, and Thailand during the period 1996 to 1998. They explain that firms can export after improving their technologies and production processes, making new investments to improve their efficiency, training their work force, and using external auditing. A series of these decisions, therefore, raise their productivity.

The learning-by-exporting hypothesis

According to the learning-by-exporting hypothesis, Bernard and Jensen (1999) find no evidence that future productivity growth is significantly higher for U.S. exporting plants. Cherides et al. (1996) also find little evidence of efficiency gains from the export experience in Colombia, Mexico and Morocco. On the contrary, Castellani (2002) finds support that entering into export markets produces a learning-by-exporting effect in Italy. Aw and Hwang (1995) and Liu et al. (1999)

find that exporting improves plant performance in Taiwan. Similarly, Aw, Chung et al. (1998) also support the learning-by-exporting hypothesis in Taiwan, but such support is not found in Korea. Aw and Hwang (1995) use the 1986 census of plants in the electronics industry collected by the Taiwanese Bureau of Statistics. Their results reveal that exporting activity is generally correlated with higher firm-level productivity, but the pattern is product specific. Their results indicate that the magnitude of the contribution of productivity differences to value-adding differences between exporters and non-exporters are product specific (Aw and Hwang, 1995). Granér and Isaksson (2007) also provide evidence of a learning-by-exporting hypothesis among Kenyan manufacturing firms. Kraay (2006) also finds evidence to support the learning-by-exporting hypothesis in China.

Blalock and Gertler (2004) use panel data for Indonesian manufacturing firms to investigate evidence from the self selection hypothesis that firms can improve their productivity by learning through exporting during the period 1990 to 1996. Their results contradict previous results from developed countries that the productivity of exporting firms increases between 2 percent to 5 percent after exporting (see Table 3.3). Hansson and Lundin (2003) also support the view that exporting firms are significantly more productive than non-exporters. Their results reveal that continuing exporters have significantly higher labour productivity than non-exporters, but they find no significant differences in TFP growth between various exporters and non-exporters.

Girma et al. (2004) reveal that exporting is likely to have boosted productivity for UK manufacturing firms during the period 1988 to 1999. They also point out that the US market is a larger and more competitive market than the UK market, since most US firms have similar technological frontiers and, therefore, the learning-by-exporting hypothesis appears to be less important than for UK firms (Girma et al., 2004, p864). Baldwin and Gu (2003) reveal that export participation improved firm productivity for UK manufacturing firms during the period 1990 to 1996. However, the learning effect is much stronger for domestic firms than for foreign firms, and for younger firms than for older firms. Hallward-Driemeier et al. (2002) also find that foreign-owned firms and exporting firms have significantly higher productivity for Indonesia, Korea, Malaysia, the Philippines, and Thailand during the period 1996 to 1998.

3.9 Other sources and firm performance

This section reviews the literature with regard to other factors that can affect a firm's performance, including: (i) government assistance, (ii) networking, (iii) foreign cooperation, (iv) geographical diversification, (v) firm size, and (vi) firm age.

(i) Government assistance

Government assistance can take a number of forms, such as (i) providing financial assistance (e.g., low-interest loans, capital subsidies, cash grants), aiding the adoption of new technologies, (ii) improving a country's infrastructure, (iii) offering tax-based incentives (e.g., exempting, or reducing import duties on machinery and raw materials, and corporate income tax exemptions), and non-tax based incentives (e.g., permitting foreign workers to work for local firms, remitting foreign currency abroad) (Girma et al., 2007; The Board of Investment, 2009a).

The effects of government assistance on a firm's performance are still ambiguous. Tran et al. (2008) find that the effect of direct government support (e.g., government credit assistance and government technical support) on firm performance in Vietnam varied across years and industries. For instance, they find a positive effect of "government credit assistance" on technical efficiency for the machinery and transport equipment sector and also the miscellaneous industries sector in 1996. Their empirical results also reveal that "government technical support" has a significant and positive effect on technical efficiency for the machinery and transport sector in 1996, and for the (i) food processing and (ii) miscellaneous manufacturing sectors in 2002. Girma et al. (2007) find that government grants enhance firm performance, as measured by survival probabilities for Irish manufacturing firms during the period 1983 to 1998. Tzelepis and Skuras (2004) find that government capital subsidies are positively associated with firm growth, but not the efficiency and profitability measures for Greek firms in the food-and-drinks manufacturing sector during the period 1982 to 1996. They provide explanations as to why efficiency and profitability are not significantly associated with capital subsidies. Capital subsidies may be spent on non-productive activities, such as lobbying and advertisement, which do not help to increase the efficiency and profitability of a firm.

However, Le and Harvie (2010) find that government assistance in the form of land, premises, and credit have a significant and negative effect on the technical efficiency of Vietnamese manufacturing SMEs using surveys for 2002, 2005, and 2007, but such a significant and positive evidence is only found for government credit assistance for newly established SMEs in the 2002 survey. Beason and Weinstein (1996), however, find no evidence that productivity was improved by industrial policy measures (e.g., tariff, tax relief, and Japan Development Bank (JDB) loans, subsidies) for Japanese industries during the period 1955 to 1990. Bergström (2000) also studies the effects of public capital subsidies on total factor productivity (TFP) for Swedish firms during the period 1989 to 1993. His results suggest that subsidization positively affects a firm's growth, but not productivity. He also argues that subsidization can make firms less efficient due to market failure.

(ii) Networking

Networking can provide value to members by allowing them access to social resources embedded within a network (Watson, 2007, pp852-853). It can be one of the factors which can enhance a firm's performance. Inter-firm networks (or inter-organizational networks) are increasingly perceived as a model for entrepreneurial firm growth, since they can enhance the survival and capabilities of firms by exchanging shared learning, technical knowledge, and resources (Nohria and Eccles, 1992; Lechner and Dowling, 2003). Tseng (2005) suggests that a business community relationship can improve large firms' profit growth, but such a relationship is found to be negative for small firms, based on a survey of 138 Taiwanese FDI cases that invested in China and the United States. Watson (2007) examined the potential effect of networking on a firm's performance, measured by survival, growth, and ROE for Australian SMEs. He finds that networking is significantly and positively associated with firm survival and, to a lesser extent, firm growth, but such a significant relationship is not found for ROE. Sahakijpicharn

(2007) also finds that network embeddedness has a positive effect on Sino-Thai SMEs' business performance for 298 Bangkok based Sino - Thai SMEs.

(iii) Foreign cooperation

Cooperation with foreign partners can increase a firm's performance, which can take a number of forms, such as technology transfer, subcontracting, licensee production, trademark, employee training program, financial support, and market information (e.g., new customers and suppliers). Schmitz and Nadvi (1999) also suggest that firms which increase co-operation are likely to improve their performance. Le and Harvie (2010) empirically show that co-operation with foreign partners are likely to have a significant and negative effect upon the technical efficiency of Vietnamese SMEs, since they have to follow the agreement set by foreign partners. This might limit the flexibility and innovation and hence adversely affect their efficiency performance.

(iv) Geographical diversification

The effect of geographical diversification on a firm's performance is still ambiguous. For multinational corporations geographic diversification can benefit from new foreign operations, since they can increase firm value through economies of scale, location-specific advantages, and synergy effects (e.g., sharing market, production, technology, knowledge, and expertise) (Kim and Mathur, 2008, p749). According to the agency view by Jensen and Meckling (1976), geographical diversifications can create more difficulty for shareholders to monitor management's decisions. In other words, geographical diversification increases agency problems, which deteriorate a firm's performance. In addition, geographical concentration of economic activity and market integration can lead to more efficient production, since firms can operate at a larger scale and capitalize on internal economies of scale (World Bank, 2009).

Kim and Mathur (2008) find a negative association between firm value and geographical diversification for 28,050 firms during the period 1990 to 1998. Denis et al. (2002) also find that geographical diversification does not increase firm value, based upon purely domestic firms in the U.S. during the period 1984 to 1997. However, some studies find a positive association between geographical diversification and a firm's performance. Bodnar et al. (1997) find that geographical diversification is positively associated with firm value for U.S. firms during the period 1987 to 1993. Driffield et al. (2008) find a positive relationship between geographical diversification and corporate performance (total factor productivity) for more than 400 UK MNEs during the period 1990 to 1999. Rijkers et al. (2009) also suggest that location and institutions have become increasingly recognized as key factors in promoting economic performance.

(v) Firm size

The effect of firm size on firm performance is still inconclusive, differing across countries and sectors. A number of studies empirically reveal a positive association between a firm's size and its performance (Hall and Weiss, 1967; Admassie and Matambalya, 2002; Joh, 2003; Bottasso and Sembenelli, 2004; Limpaphayom and Ngamwutikul, 2004; Oczkowski and Sharma, 2005). Oczkowski and Sharma (2005) find that firm size is positively associated with firm efficiency for 121 Nepalese manufacturing firms during the period 2000 to 2001. Joh (2003) finds that firm size (total assets) has a significant and positive relationship with profitability (net income to assets) for 5,829 Korean firms during the period 1993 to 1997. Bottasso and Sembenelli (2007) also find that firm size has a positive effect on efficiency (only for foreign subsidies) for manufacturing Italian firms during the period 1978 to 1993. Firm size, however, might be negatively associated with efficiency if large firms face management and supervision problems (Admassie and Matambalya, 2002). Limpaphayom and Ngamwutikul (2004), however, find that firm size (total assets) has no significant association with operating performance changes for Thai listed firms that conducted equity offerings in the Stock Exchange of Thailand during the period 1991 to 1994.

(vi) Firm age

The effect of firm age on firm performance is also ambiguous depending on sectors and countries. Sheu (2005) suggests a significant and positive association between firm age and efficiency for 416 Taiwanese listed firms during the period 1996 to 2001. Malerba (1992) also states that such a positive age-efficiency association results from learning-by-doing effects. In other words, a firm can become more efficient as a result of accumulating its expertise. However, some empirical studies find no evidence of such a relationship (Yammeesri and Lodh, 2003; Berghall, 2006; Zeitun and Tian, 2007). Berghall (2006) suggests that firm age is not significantly associated with its performance, as measured by technical change and efficiency for the Finnish ICT equipment manufacturing industry during the period 1990 to 2003. Zeitun and Tian (2007) find no significant relationship between firm age and performance, as measured by return on assets (ROA), return on equity (ROE), and market value of equity/book value of equity ratio for 59 listed firms in Jordan during the period 1989 to 2002. Lundvall and Battese (2000) also find no significant association between firm age and technical efficiency in all sectors for 235 Kenyan manufacturing firms during the period 1992 to 1994.

In the case of Thailand, Yammeesri and Lodh (2003) find that firm age has no association with performance, as measured by return on equity (ROA), sales-assets ratio, and stock returns for Thai non-financial listed firms during the period 1993 to 1996. Wiwattanakantang (2001) found mixed results that firm age has a significant and positive effect on return on assets (ROA), but such a significant relationship is not found for the sales-assets ratio and Tobin's q for Thai non-financial listed firms in 1996. The age-performance relationship, however, has been found to be significant and negative in some studies (Chi, 2009; Yusuda, 2005; Park, 2009). Chi (2009) finds that firm age has a significant and negative association with performance, as measured by Tobin's q for 880 Taiwanese listed firms in 2005. Yusuda (2005) finds that firm age has a negative effect on growth for Japanese manufacturing firms. Park (2009) also finds a significant negative effect between firm age and growth for 7,889 Korean manufacturing firms during the period 1994 to 2003.

3.10 Conclusions

There are a number of ways to measure firm performance, such as financial performance, efficiency, productivity, growth, exports, employment, and market share. The finance and accounting literature widely measure a firm's performance by applying several financial ratios (see Figure 3.2). Financial ratios, such as profitability measures, market value measures, efficiency measures, capital measures, capital structure measures (financial leverage), and liquidity (cash flow), can be used to measure how firms perform well relative to others. According to the economics literature the concepts of productivity and efficiency are different (see Section 3.2.3). Productivity, however, is widely used to measure a firm's performance compared with efficiency. A review of the literature with regard to (i) the effects of financial constraints (leverage) and liquidity on a firm's performance as well as (ii) the effects of internal and external financing on a firm's performance, as measured by technical efficiency, has not been widely addressed (see Sections 3.4.2 and 3.4.3). None of these studies have been conducted before for Thailand. These empirical studies also provide mixed results. On the one hand firms with a high level of leverage are likely to improve their efficiency, but some studies find a negative association between financial constraints and a firm's performance.

A review of the literature with respect to the effect of ownership concentration on a firm's performance, as measured by financial performance, are widely discussed in the finance and accounting literature. None of these studies, however, has focused upon technical efficiency as a measure of firm performance before in Thailand. The results of these empirical studies are still ambiguous. A review of the literature with regard to the effects of types of ownership on a firm's performance, as measured by financial performance (e.g., ROE, ROA, and Tobin's q) have been widely discussed in the finance and accounting literature, but few studies have analysed this in terms of technical efficiency (see Table 3.2). Types of ownership can be classified into (i) family ownership, (ii) foreign ownership, (iii) institutional ownership, and (iv) state ownership From a review of the literature, family ownership has a positive association with a firm's performance, as measured by profitability. There are opposite views with regard to family-controlled firms.

On the one hand family-controlled firms may expropriate the interest of minority shareholders causing a negative effect on a firm's performance. On the other hand, they may have advantages in communicating with other related members leading to a positive association with a firm's performance. In addition, a number of empirical studies find that institutional ownership (e.g., pension funds, mutual funds) has a positive effect on a firm's performance (see Section 3.5.2), since institutional shareholders are likely to monitor the actions of firm managers more effectively to increase a firm's performance. None of the studies with regard to the effects of family and institutional ownerships on a firm's performance, as measured by technical efficiency, has been examined before for Thailand. Moreover, most of the empirical studies have found that state ownership negatively affects a firm's performance, since the government can exploit the firm's assets easily due to control by politicians. In addition, they aim at following the government's choice of social and political policy goals rather than profit maximization. Some studies, however, argue that state ownership can positively affect a firm's performance due to their state power (see Section 3.5.2). A number of empirical studies have shown that foreign ownership can positively affect a firm's performance, since it has superior technology, managerial expertise, good corporate governance, and a strong foreign - market network (see Section 3.5.2).

Managerial ownership can alleviate the conflict of interests between shareholders and managers. A number of empirical studies also support that managerial ownership significantly increases a firm's performance and some studies find a non-linear relationship between managerial ownership and performance (see Section 3.5.3). None of these studies have linked managerial ownership with a firm's technical efficiency before for Thailand. Many empirical studies have investigated the relationship between executive remuneration and firm performance, as measured by accounting or financial measures (see Section 3.6). Very few empirical studies have examined the linkage between executive remuneration and firm performance, as measured by the firm's technical efficiency, but none of these empirical studies has been conducted for Thailand.

A number of empirical studies have examined the two-way effects between a firm's performance and its export participation (the self-selection and the learning-by -exporting hypotheses). According to the self-selection hypothesis, only more efficient firms are likely to self-select into the export market. Sunk start-up costs and heterogeneity in firm productivity provide the reasons as to why not all firms can self-select to export markets (see Section 3.7.1). According to the learning-by-exporting hypothesis export experience can help increase a firm's performance. This is because exporting firms gain new technical expertise (e.g., new product designs and production methods). It is obvious that the self-selection hypothesis exists in almost all countries, but the learning-by-exporting hypothesis is not supported in some countries, especially in developed countries. Most empirical studies have examined these two hypotheses in terms of productivity (see Table 3.3). None of the studies, however, have focused upon technical efficiency before for Thailand. Finally there are other factors that significantly determine a firm's performance, such as (i) government assistance, (ii) networking, (iii) foreign cooperation, (iv) geographical diversification, (v) firm size, and (vi) firm age.

According to the review of the literature discussed previously, key firm characteristics affecting technical efficiency will be hypothesised and examined in Chapters 5 and 6, respectively. These are as follows: (i) finance (leverage and liquidity; internal financing and external financing), (ii) research and development (R&D), (iii) ownership structure (controlling and managerial ownerships), (iv) executive remuneration, (v) types of owned firms (foreign and family-owned firms), (vi) exporting (the learning by exporting and self-selection hypotheses[34]). Other factors that significantly determine a firm's performance, such as (i) firm size, (ii) firm age, (iii) government assistance, and (iv) foreign cooperation will also be investigated in Chapter 6.

Before identifying hypotheses and variables in Chapter 5, the next chapter (Chapter 4) will discuss the methodology (an overview of firm efficiency concepts and measurement) to be used for the empirical analysis conducted in Chapter 6. Chapter 4 will also provide a review of firm efficiency measurement concepts, and review two competing parametric and non-parametric efficiency methods for measuring technical efficiency.

[34] For the self-selection hypothesis there are a number of business environment and firm specific variables that affect a firm's export decision, such as firm size, firm age, leverage, and foreign investment (see Table 5.3).

CHAPTER 4

METHODOLOGY OVERVIEW:
FIRM EFFICIENCY CONCEPTS AND MEASUREMENT

4.1 Introduction

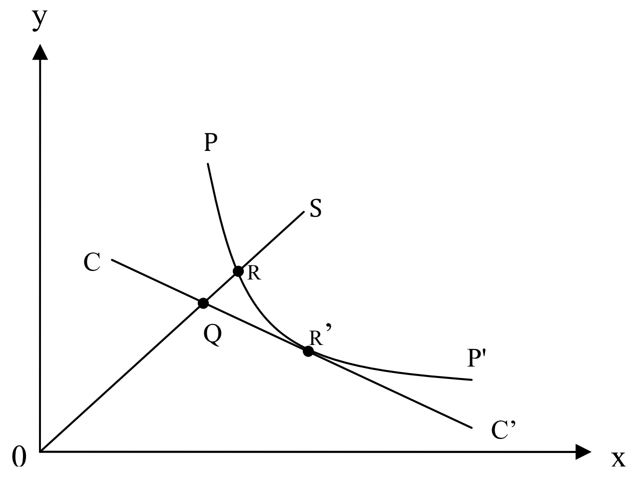
The purpose of this chapter is to provide a review of firm efficiency measurement concepts, which include (i) technical efficiency, (ii) allocative efficiency, (iii) scale efficiency, and (iv) cost and revenue efficiencies. This chapter also reviews competing parametric and non-parametric efficiency methods, which include Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), respectively. These methods will be used to predict firm technical efficiency in Chapter 6.

This chapter is structured as follows: Section 4.2 presents a review of efficiency measurement concepts. Section 4.3 illustrates two competing approaches in estimating firm technical efficiency, which are “Stochastic Frontier Analysis (section 4.3.1) and “Data Envelopment Analysis (DEA)” (section 4.3.2). Section 4.4 explains production functions accounting for technical (technological) change. Section 4.5 discusses the strengths and weaknesses of non-parametric DEA and parametric SFA approaches. Section 4.6 provides a summary of this chapter.

4.2 Efficiency measurement concepts

This section discusses efficiency concepts which are of common interest: (i) technical efficiency, (ii) allocative efficiency, (iii) scale efficiency, and (iv) cost and revenue efficiency.

Figure 4.1: Technical and allocative efficiencies from an input-orientation



Source: Farrell (1957, p254)

4.2.1 Technical efficiency

Farrell (1957) firstly proposed efficiency measurements of a firm based on "*an efficient production function*" which was not addressed in the previous works of Debreu (1951) and Koopmans (1951), and which consists of (i) technical efficiency and (ii) price (allocative) efficiency[35]. He defined "technical efficiency" as the ability of a firm to produce maximum output from a given set of inputs, and "price (allocative) efficiency" as the ability of a firm to use an optimal proportion of inputs, given different prices and production technology. Farrell (1957) provided the explanation of a firm's efficiency in a simple way using two factors (inputs) (x and y) to produce a unit of output (R) under the assumption of constant return to scale[36]. The "isoquant" line (PP') in Figure 4.1 represents the minimum combinations of the two inputs that a fully efficient firm[37] might use to produce a unit of output (Farrell, 1957, p254). The various combinations of the two inputs along the isoquant line (PP') are considered to be technically efficient. However, any point which is located above and to the right of the isoquant line (PP') is defined as technically inefficient. The point S represents the various combinations of the two inputs that a firm uses to

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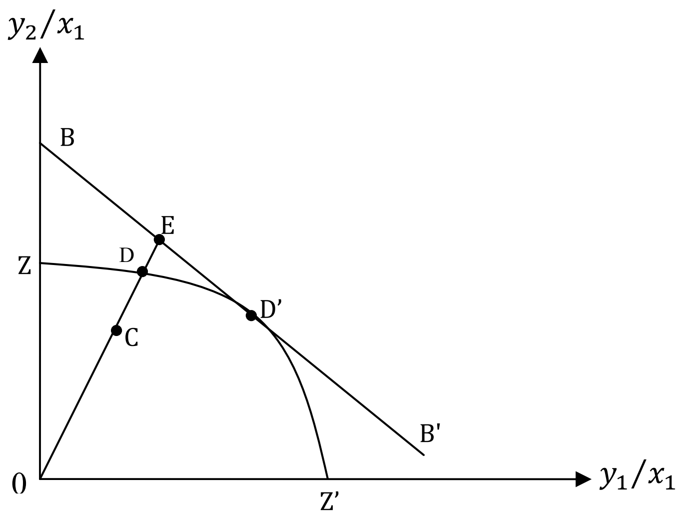
[35] Coelli at el. (2005, p51) pointed out that the terminology of "*price efficiency*" used in Farrell (1957) is also equivalent to "*allocative efficiency*" used in recent literature.
[36] The assumption of constant returns to scale allows the technology to be presented in a simple "isoquant" diagram (Farrell, 1957, p254).
[37] The production frontier of perfectly efficient firms is not observed in practice. It must be estimated from a sample of firms in the industry (Coelli et al., 2005, p52).

produce a unit of output, but this point indicates technical inefficiency since the firm can reduce inputs by the distance RS without reducing output. In other words at the point S a firm needs to reduce its inputs to achieve technically efficient production, which can be represented by the ratio RS/0S. At the point R the firm can be technically efficient by producing the same unit of output as it produces at the point S but it uses only 0R inputs, which can be defined by the ratio 0R/0S.

As a result, the technical efficiency (TE) of a firm can be measured by the ratio TE = 0R/0S. This ratio ranges between zero and one, indicating the level of technical efficiency of the firm. If TE equals one this indicates technically efficient production. This can be observed at the point R, since this point lies on the efficient isoquant line (PP') (Coelli et al., 2005, p52). In addition, technical efficiency can be measured from an output-orientated perspective, assuming that an efficient firm uses a single input (x) to produce two outputs (y_1 and y_2). From Figure 4.2 the distance CD indicates the technical inefficiency of a firm, which is the amount by which output could be increased without requiring additional input (Coelli et al., 2005, p 56). Therefore, the technical efficiency (TE) of a firm can be measured by the ratio 0C/0D.

Figure 4.2: Technical and allocative efficiencies from an output-orientation



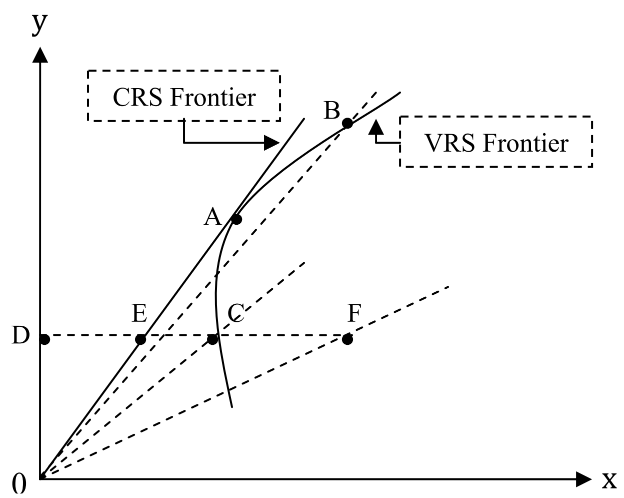
Source: Coelli et al. (2005, p55)

4.2.2 Allocative efficiency

Farrell (1957) illustrated the term allocative efficiency (AE) when input price information is given. From Figure 4.1 allocative efficiency (AE) is measured by the ratio 0Q/0R (Coelli et al., 2005). The production of a firm is technically efficient at the point R but it can be allocatively inefficient at this point, since production costs at the point R are not efficient and can be reduced by the distance QR. At the point R' the firm's production is allocatively and technically efficient. From Figure 4.2 allocative efficiency (AE) can also be estimated from an output-orientation perspective by the ratio of 0D/0E (Coelli et al., 2005). At the point D the firm's production is technically efficient but not allocatively inefficient, since its production costs can be reduced by the distance DE. As a result, the firm's production is allocatively and technically efficient at the point D'.

4.2.3 Scale efficiency

Figure 4.3: Scale efficiency



Source: Coelli et al. (2005, p59, 61)

Coelli et al. (2005, p58) illustrated that a firm can be both technically and allocatively efficient, but its scale of operation may not be optimal. For example, under the specification of variable-returns-to-scale (VRS), a firm might operate with increasing returns to scale (irs) if its scale of production is too small. Moreover, the firm may operate with decreasing returns to scale (drs) if its scale of production is too large. From Figure 4.3, Firm C operates over the increasing returns to scale part of the production frontier. Hence, it can be more productive by increasing its scale of production towards point A. On the other hand, Firm B operates over the decreasing returns to scale part of the production frontier. It, therefore, can become more productive by decreasing its scale of operation towards the point A. At the point A, the firm cannot change its production scale, since it operates at the most productive scale size (MPSS) or at the technically optimal productive scale (TOPS) (Coelli et al., 2005, p59). Moreover, it is possible to use "*distance measures*" to estimate different types of efficiencies. For example, the ratio of the slope of the ray 0F to the slope of the ray 0C is equivalent to the ratio DC/DF, which is the technical efficiency of Firm F based on variable returns to scale technology (see Figure 4.3).

$$TE_{VRS} = DC/DF \tag{4.1}$$

Furthermore, the scale efficiency of Firm F can be estimated by the distance of constant returns to scale technology (DE) over the technically efficient data point (DC) (Coelli et al., 2005, p60).

$$\text{Scale Efficiency (SE)} = DE/DC \tag{4.2}$$

The scale efficiency measure in the Data Envelopment Analysis (DEA) literature cannot be estimated directly, as mentioned before, but it can be estimated using the ratio of technical efficiency under constant returns to scale over technical efficiency under variable returns to scale (Coelli et al., 2005). For example, the scale of efficiency of Firm F can be estimated as follows (see Figure 4.3).

$$\begin{aligned}\text{Scale Efficiency (SE)} &= TE_{CRS} / TE_{VRS} \\ &= (DE/DF) / (DC/DF) \\ &= DE/DC \end{aligned} \tag{4.3}$$

4.2.4 Cost and revenue efficiencies

Cost efficiency can be measured when "*input prices*" are provided. Cost efficiency can be estimated using input-orientated measures, since it deals with how costs can be minimized without changing the output quantities produced. Figure 4.1, for example, represents the case of input-orientated measures. The vector of input prices (w) is introduced and the vector of inputs (x, x̂ ,x*) associated with the point S, the technical efficiency point (R), and the cost-minimising point (R'), respectively (Coelli et al., 2005, p53). Cost efficiency is defined as the ratio of input costs (w) associated with input vectors, x (at the point S) and x* (at the point R') (see Figure 4.1). Therefore,

$$\text{Cost Efficiency} = \frac{w'x^*}{w'x} = \frac{0Q}{0S} \tag{4.4}$$

Furthermore, the product of technical and allocative efficiency measures is also equal to "the total overall cost efficiency (CE)" as in Equation (4.4) (Coelli et al., 2005, p53):

$$TE \times AE = \left(\frac{0R}{0S}\right) \times \left(\frac{0Q}{0R}\right) = \left(\frac{0Q}{0S}\right) = CE \tag{4.5}$$

Where, technical efficiency and allocative efficiency can be estimated using the isocost line (CC') as mentioned in Sections 4.2.1 and 4.2.2 (see Figure 4.1) as follows:

$$\text{Technical Efficiency (TE)} = \frac{w'\hat{x}}{w'x} = \frac{0R}{0S} \tag{4.6}$$

$$\text{Allocative Efficiency (AE)} = \frac{w'x^*}{w'\hat{x}} = \frac{0Q}{0R} \tag{4.7}$$

Similarly, revenue efficiency can also be estimated using output-orientated measures when "*output prices*" are given. From Figure 4.2, for example, the vector of observed output prices (p) is introduced and the vector of outputs (y, $\hat{y}$, y*) associated with the point C, the technical efficiency point (D), and the cost-minimising point (D'), respectively (Coelli et al., 2005, p53). Revenue efficiency is defined as the ratio of output price (p) associated with output vectors, y (at the point C) and y* (at the point D') (see Figure 4.2). Therefore,

$$\text{Revenue Efficiency} = \frac{p'y}{p'y^*} = \frac{0C}{0E} \tag{4.8}$$

Furthermore, the overall revenue efficiency can also be defined as the product of the allocative and technical efficiency measures as below (Coelli et al., 2005, p56):

$$TE \times AE = \left(\frac{0C}{0D}\right) \times \left(\frac{0D}{0E}\right) = \left(\frac{0C}{0E}\right) = RE \qquad (4.9)$$

Where, technical efficiency and allocative efficiency measures can be defined as follows (Coelli et al., 2005, p56):

$$\text{Technical Efficiency (TE)} = \frac{\mathrm{p'y}}{\mathrm{p'\hat{y}}} = \frac{\mathrm{0C}}{\mathrm{0D}} \qquad (4.10)$$

$$\text{Allocative Efficiency (AE)} = \frac{\mathrm{p'\hat{y}}}{\mathrm{p'}y^*} = \frac{\mathrm{0D}}{\mathrm{0E}} \qquad (4.11)$$

4.3 Efficiency methods

There are two competing measures of a firm's efficiency: (i) non-parametric approach (e.g., Data Envelopment Analysis) and (ii) parametric approach (e.g., Stochastic Frontier Analysis). This section will illustrate these two competing approaches. Stochastic Frontier Analysis (SFA) will be explained in Section 4.3.1 and Data Envelopment Analysis (DEA) will be illustrated in Section 4.3.2.

4.3.1 The stochastic production frontier

This section examines the literature with regard to the development stages of the stochastic production frontier, in measuring firm efficiency. It consists mainly of three phases of development: (i) deterministic production frontier, (ii) stochastic production frontier, and (iii) stochastic production frontier with panel data.

(i) Deterministic production frontier

The concept of this approach is that the free disposal convex hull of the observed input-output ratios can be constructed by linear programming techniques (Førsund et al., 1980, p9). The concepts of technical and allocative efficiencies were also introduced by Farrell (1957) (See Section 4.2). Førsund et al. (1980) also pointed out that the advantage of this approach is that the functional form is not required but its disadvantage is that it is restricted to the assumption of "*constant returns to scale*", and the estimated frontier is vulnerable to some extreme observations (outliers problem) and measurement error since the frontier is drawn from observations from the sample. Kumbhakar and Lovell (2000, p67) also mentioned that the major drawback of this programming approach is that the parameters are "*computed*" (applying mathematical programming techniques) rather than "*estimated*" (applying regression techniques). Farrell's work has influenced a number of contributions in the literature (Aigner and Chu, 1968; Seitz, 1971; Afriat, 1972; Richmond, 1974). The deterministic production frontier can, therefore, be written in the general form as below (Kumbhakar and Lovell, 2000, p66):

$$y_i = f(x_i;\beta) \times \exp\{-u_i\} \tag{4.12}$$

Where, y_i is the scalar output of producer i (i=1,….,n); $f(x_i;\beta)$ is the production frontier, x_i is a vector of N inputs; β is a vector of technology parameters to be estimated; $exp\{-u_i\}$ is technical efficiency (TE_i); u_i is a non-negative random variable associated with technical inefficiency ($u_i \geq 0$)[38].

Aigner and Chu (1968) considered the log-linear Cobb-Douglas production frontier ($lny_i = \beta_0 + \sum_n \beta_n lnx_{ni} - u_i$) and applied mathematical programming models (linear and quadratic programming models[39]) to obtain the production frontier. There are a number of techniques in estimating unknown parameters for Aigner and Chu's (1968) model. Afrait (1972, p581) suggested that with the Cobb-Douglas form, it is common to assume log (1/u) = z as a gamma distribution and to use the method of maximum likelihood. Richmond (1974) applied Afrait's (1972) model to conduct an empirical analysis of Norwegian manufacturing industries in 1963 using "Modified Ordinary Least Squares (MOLS)", which is estimated by Ordinary Least Squares (OLS) [40] under the assumption of a one-sided distribution (e.g., exponential or half normal).

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[38] $u_i \geq 0$ guarantees that $y_i \leq f(x_i;\beta)$, since technical efficiency is required to be less than or equal to one ($TE \leq 1$). Note that $TE_i = exp\{-u_i\}$ (Kumbhakar and Lovell, 2000, p66).

[39] Linear and quadratic programming models minimize $\sum_i u_i$ and $\sum_i u_i^2$ respectively, subject to $\beta_0 + \sum_n \beta_n lnx_{ni}\, v_i \geq lny_i$ (Kumbhakar and Lovell, 2000, p67).

[40] COLS, suggested by Winsten (1957), can be estimated in two steps. First, ordinary least squares (OLS) is applied to obtain consistent and unbiased estimates of the slope parameters, and a consistent but "*biased*" estimate of the intercept term. Second, the biased OLS intercept term will be corrected (shifted up) so that the estimated production frontier lies on or above the observations (Kumbhakar and Lovel, 2000, pp70-71).

The main problem with this deterministic production frontier, as mentioned above, is that it does not consider measurement errors or statistical noise. All deviations from the frontier are solely from the effects of technical inefficiency (Coelli at el., 2005). Pitt and Lee (1981, p44) also mentioned that the non-stochastic (deterministic) frontier does not allow for random shocks, which are outside the firm's control, and hence a few extreme observations can determine the frontier and overstate the maximum possible output given inputs. From this discussion "statistical noise" can be introduced along with non-negative random variables associated with technical inefficiency. This is called "the stochastic production frontier", which will be explained in Section 4.3.1 (ii).

(ii) The stochastic production frontier

The basic stochastic production frontier was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977) within a cross-sectional context. Their models contained two error components. First, the error component v_i allows random variation of the frontier across firms, and captures (i) the effects of the omission of relevant variables from the vector x_i, (ii) random shocks outside the firm's control, (iii) measurement errors, and (iv) approximation errors associated with the use of this functional form (Førsund et al., 1980, p13; Coelli et al., 2005, pp242-243). The error component v_i is assumed to be independently and identically distributed as $N(0, \sigma_V^2)$. Second, the error component u_i captures the effects of inefficiency relative to the stochastic frontier. The error component u_i is also assumed to be distributed independently of v_i, and u_i is non-negative $(u_i \geq 0)$[41]. For example, the following equation represents the log-linear Cobb-Douglas stochastic frontier model version, which consists of three main components: (i) a deterministic component, (ii) a noise effect, and (iii) an inefficiency effect (Coelli et al., 2005, p243).

$$ln y_i = \beta_0 + \beta_1 ln x_i + v_i - u_i$$

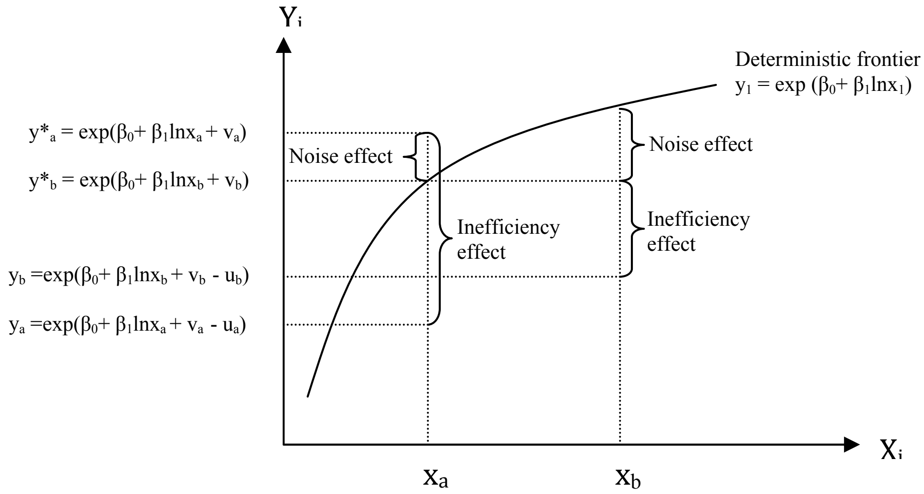
$$y_i = \exp(\beta_0 + \beta_1 ln x_i + v_i - u_i)$$

[41] The condition of $u_i \geq 0$ allows for all observations lying on or beneath the stochastic production frontier.

$$y_i = \underbrace{\exp(\beta_0 + \beta_1 ln x_i)}_{\text{Deterministic Component}} \times \underbrace{\exp(v_i)}_{\text{Noise}} \times \underbrace{\exp(-u_i)}_{\text{Inefficiency}} \quad (4.13)$$

Where v_i accounts for the two-sided statistical noise, and u_i accounts for the nonnegative random variables associated with the technical inefficiency component. Stochastic frontier analysis can be explained graphically, as shown in Figure 4.4.

Figure 4.4: The stochastic production frontier



Source: Coelli et al. (2005, p244)

From Figure 4.4 it is assumed that there are two firms (Firm A and B). Firm A uses input x_a to produce output y_a. Similarly, Firm B uses input x_b to produce output y_b[42]. The difference between Firms A and B is that Firm A's (unobserved) frontier output lies above the deterministic frontier, since its "noise effect" (v_a) is positive, but Firm B's (unobserved) frontier output lies within the deterministic frontier due to its negative "noise effect" (v_b). Hence, unobserved frontier outputs are likely to lie either above or below the deterministic frontier. However, the observed frontier outputs tend to lie below the deterministic frontier[43]. From Figure 4.4 the

[42] If the inefficiency effects of Firms A and B are zero ($u_a = 0$ and $u_b = 0$), their outputs would be at y^*_a and y^*_b respectively.

[43] For example, Firm A lies above the deterministic frontier since the "noise effect" is positive and greater than the inefficientcy effect.

output-oriented measure of technical efficiency can be specified as follows (Coelli et al., 2005, p244):

$$TE_i = \frac{y_i}{\exp(x'\beta + v_i)} = \frac{\exp(x'\beta + v_i - u_i)}{\exp(x'\beta + v_i)} = \exp(-u_i) \qquad (4.14)$$

The value of technical efficiency (TE_i) ranges between zero and one. Y_i attains its maximum feasible output if and only if $TE_i = 1$. $TE_i < 1$ illustrates a measure of the shortfall of observed output from maximum feasible output (Berg et al., 2005, p279).

The estimation of stochastic production frontiers becomes more complicated where there are two random error terms: (i) the noise component (v_i) and (ii) the inefficiency component (u_i). The noise effect (v_i) is assumed to meet the properties identified in the Classical Linear Regression Model. The inefficiency component (u_i) also has identical properties to that of the noise component, except it has a non-zero mean because $u_i \geq 0$ (Coelli et al., 2005, p245). Coelli et al. (2005, p245) also argue that the slope estimators obtained from "ordinary least squares" (OLS) are consistent, but the intercept estimator is biased downwards. Technical efficiency, therefore, cannot be predicted by using OLS. Different estimation techniques may be used to obtain a consistent estimate of the intercept and estimates of technical efficiency of each producer (Kumbhakar and Lovel, 2000, p74).

The corrected ordinary least squares (COLS)[44] can also be used to correct the bias in the intercept term. However, the method of maximum likelihood (ML) is also preferred to other estimators (e.g., COLS), since ML estimators have asymptotic properties (desirable for large samples) (Coelli et al., 2005, p245). Aigner, Lovell, and Schmidt (1977) also applied the method of maximum likelihood under the assumptions of a half-normal model. First, the statistical components ($v_i s$) are independently and identically distributed normal random variables with zero means and variances $\sigma_v^2 (v_i \sim iid\ N(0, \sigma_V^2))$. Second, the inefficiency components ($u_i s$) are

[44] See footnote 40.

independently and identically distributed half-normal random variables with variance σ_u^2 ($u_i \sim iid\ N^+(0, \sigma_u^2)$) .

(iii) Stochastic production frontier with panel data

Cross-sectional data requires strong distributional assumptions, but these assumptions are relaxed when panel data is applied. Panel data used in measuring a firm's technical efficiency provides desirable statistical properties (Kumbhakar and Lovell, 2000, p95). In addition, Schmidt and Sikles (1984,, p367) noted that stochastic frontier models that use cross-sectional data suffer three serious difficulties. First, the technical efficiency of a firm can be estimated but its estimates may not be consistent, since the variance of the distribution of technical efficiency, conditional on the whole error term, does not vanish (become zero) when the sample size increases. Second, maximum likelihood estimation of the stochastic production frontier model and the separation of technical inefficiency from statistical noise requires strong distributional assumptions of (i) technical inefficiency (e.g., half-normal distribution) and (ii) statistical noise (e.g., normal distribution). Third, maximum likelihood estimation requires that the technical inefficiency effect is not dependent on the independent variables, but it may be correlated with input vectors that a firm chooses.

Furthermore, panel data can be used to examine changes in technical efficiency as well as the underlying production technology over time (Coelli et al., 2005, p275). Kumbhakar and Lovell (2000, p96) also mentioned that having access to panel data can avoid the disadvantages mentioned above. First, panel data (repeated observations on a sample of firms) can relax the independent and strong distributional assumptions. Second, adding more observations for each firm can provide more information compared with cross sectional data, and the firm's technical efficiency can be estimated consistently since the number of observations of the firm begins to increase. For several industries the assumption that the random error term (U_{it}) is independently distributed is not realistic, since efficient firms also expect to maintain their efficiency level while inefficient firms expect to enhance their efficiency levels over time. Hence, it is crucial to impose some structure on the inefficiency effects and classify them as to whether they are time-invariant or time-varying (Coelli et al., 2005, p275).

Time-invariant inefficiency models

Time-invariant inefficiency models do not allow for technical change, making them similar to the cross-sectional production frontier model given in Equation (4.13). In addition, these models are similar to a conventional panel data model except that the inefficiency effects are introduced, and are assumed to be nonnegative ($u_i \geq 0$). More importantly, the technical inefficiency effects in these models are constant over the time period indicated as follows (Coelli et al., 2005, p 276):

$$u_{it} = u_i \quad i = 1, \ldots\ldots, I \; ; \; t = 1, \ldots\ldots., T, \qquad (4.15)$$

The parameters of the model as well as technical efficiency can be estimated using a number of methods (e.g., fixed effects model and random effects model) (Kumbhakar and Lovell, 2000, p97). The fixed effects model treats technical inefficiency effects as a fixed (non-random) parameter that is required to be nonnegative ($u_i \geq 0$) (Kumbhakar and Lovell, 2000). The technical inefficiency effects are allowed to be correlated with the independent variables or with statistical noise(v_i). However, there is no distributional assumption on the technical efficiency effects. Statistical noise (v_i) is assumed to be independently and identically distributed with zero mean and variance (σ_v^2) ($v_i \sim iid\ (0, \sigma_V^2\ )$), and is not correlated with the independent variables. The fixed effects model can be estimated by applying OLS with dummy variables (LSDV) (Kumbhakar and Lovell, 2000). The estimates of the coefficients are also consistent as the number of firms, or the number of years, increases. Moreover, the fixed effects model provides consistent estimates of a firm's technical efficiency, which is in contrast to the maximum likelihood estimate (MLE) cross-sectional model (Kumbhakar and Lovell, 2000, p100). Its estimates, however, may not be reliable if the number of firms is small, since the fixed effects model measures a firm's efficiency relative to the most efficient firm in the sample (Coelli et al., 2005, p276). In addition, technical efficiency (u_i) in the fixed effects model intends to capture variation across firms in time-invariant technical efficiency, but it also captures the effects of all phenomena (e.g., the regulatory environment) which vary across firms but which are time invariant for each firm (Kumbhakar and Lovell, 2000, p100). The drawback in this model motivates interest in the random effects model. In contrast to the fixed effects model the random effects model allows technical efficiency to be randomly distributed with constant mean and variance, but is assumed to be uncorrelated with the independent variables and the statistical error (v_i). The statistical noise (v_i) is assumed to be independently and identically distributed with zero mean and constant variance σ_v^2 ($v_i \sim iid\ (0, \sigma_V^2\ )$) (Kumbhakar and Lovell, 2000). The random effects model can be estimated either by the standard two-step generalized least squares (GLS) method or the maximum likelihood approach (MLE).

For the standard two-step generalized least squares (GLS) method the estimates of all parameters are obtained by OLS in the first step In the second step the intercept and coefficients are re-estimated by feasible GLS. Estimates of GLS are consistent as the large number of firms and long time-series data are applied. GLS requires the assumption that the technical efficiency effects are uncorrelated with the independent variables and the statistical error (v_i), but the fixed effects model does not. This assumption improves efficiency in estimation (Kumbhakar and Lovell, 2000). The method mentioned before with panel data can avoid the strong distributional assumptions or the strong independence assumptions[45]. These assumptions are usually required in the cross-sectional production frontier literature. The maximum likelihood approach for a stochastic production frontier panel data model with time-invariant technical efficiency is similar to the stochastic production frontier cross-sectional data, except that the statistical error (noise component) varies through time as well as across firms (Kumbhakar and Lovell, 2000). In addition, maximum likelihood estimation (MLE) is feasible when these assumptions hold. For instance, Pitt and Lee (1981) used these assumptions (a half-normal distribution) to obtain estimates of time-invariant technical efficiency using panel data. Kumbhakar (1987) and Battese and Coelli (1988) proposed the truncated normal specification ($u_i \sim iid\ N^+\ (0, \sigma_u^2\ )$).

[45] The distributional assumptions on the error components are (i)$v_i \sim iid\ N\ (0, \sigma_V^2\ )$, (ii) $u_i \sim iid\ N^+(0, \sigma_u^2\ )$, and (iii) u_{i} and $\mathrm{v_i}$ are distributed independently of each other, and of the independent variables (Kumbhakar and Lovell, 2000, p102).

As a result, these three approaches impose different assumptions and they have different properties. Kumbhakar and Lovell (2000, p106) pointed out that a random effects model based on GLS is preferred to a fixed effects model with dummy variables when the number of firms is large, and the time period is small. If the assumption regarding the independence of inefficiency effects and independent variables holds MLE is more preferable than the other two, since MLE has distributional assumptions that the others do not. However, if the panel data becomes longer, it is less likely that technology does not change.

Time-varying inefficiency model

The time-invariant inefficiency model restricts the technical inefficiency effects to be constant through time. The technical efficiency levels, however, can change over time, since firms expect to learn from their learning by doing effect. As the panel becomes larger, the technical efficiency effects would change. The form of time-varying technical inefficiency can be identified as (Coelli et al., 2005, p278).

$$u_{it} = f(t) * u_i \tag{4.16}$$

Where, $f(t)$ is a function that determines how technical inefficiency changes over time (Coelli et al., 2005, p278). Kumbhakar (1990) and Battese and Coelli (1992) use the maximum likelihood technique in a random effect framework to estimate the time-varying technical efficiency model. Both models assume that technical inefficiency (u_{it}) has a truncated normal distribution ($u_{it} \sim iid\ N^+ (0, \sigma_u^2)$).

Kumbhakar (1990, p204) specified $f(t) = (1 + \exp\ (\beta t + \gamma t^2))^{-1}$, which contains two parameters (β and γ) to be estimated. This function has the properties that $0 \leq f(t) \leq 1$ and $f(t)$ can be monotonically increasing or decreasing and concave or convex, depending on the signs of these two parameters ($\propto$ and γ). Battese and Coelli (1992) introduced a stochastic frontier production function for (unbalanced) panel data[46] in which the technical inefficiency effects are assumed to be distributed as truncated random variables, and vary systematically with time. Their model can be expressed as $y_{it} = x_{it}\beta + (v_{it} + u_{it})$, where $f(t) = exp - \eta(t - T)$[47]. The technical inefficiency function (u_{it}) involves only one parameter (η), and therefore becomes less flexible (Coelli et al., 2005, p278). This function $f(t)$ has the properties that $f(t) \geq 0$, and $f(t)$ decreases at an increasing rate if η > 0, increases at an increasing rate if η < 0, or remains constant if η = 0.

The Stochastic frontier model using a single-stage estimation

The one-stage process suggested by Battese and Coelli (1995) is one of the most commonly used SFA models. The one-stage process is more significant compared with the two-stage process. The inefficiency model can be estimated by two methods: (1) a one-step process and (2) a two-step process. For the two-step process the frontier production function is estimated and the prediction of technical efficiency of each sample is derived. Then, the predicted technical inefficiency effect is regressed against a set of explanatory variables in the second-stage regression (e.g., the OLS model and the Tobit model). A number of studies (e.g., Pitt and Lee, 1981) have estimated stochastic frontiers and predicted technical efficiency using the two-stage estimation. The inefficiency effects obtained from the second-stage regression, however, are biased due to the omission of relevant variables in the first-stage of the frontier estimation[48] (Kumbhakar and Lovell, 2000, p264). However, a one-step process can be estimated simultaneously. This approach is significant because it solves the problem of omitted variables in the first-stage approach. In particular, Battese and Coelli (1995) present a model for capturing technical

[46] Fifteen Indian farmers were examined during the period 1957 to 1985. Nine out of fifteen farmers were observed for all ten years, and therefore only 129 observations were used and 21 observations were missing from the study.

[47] u_{it}s are non-negative random variables and are assumed to be identically and independently distributed as truncations at zero of the $N(\mu, \sigma_u^2)$ distribution. η is an unknown parameter to be estimated (Coelli, 1996a, p4).

[48] For the two-stage process two assumptions are made: (i) the exogenous variables independently influence output via their effects on estimated efficiency and (ii) the exogenous variables are correlated with inefficiency. However, there are serious econometric problems. First, due to the second assumption the estimation of the stochastic frontier model and efficiency is biased due to the exclusion of exogenous variables in the first step of the two-stage procedure. Second, the inefficiencies are assumed to be identically distributed in the first step of the two-stage procedure, but, in fact, predicted inefficiencies are assumed to have a functional association with exogenous variables (Kumbhakar and Lovell, 2000, p264).

inefficiency using SFA based on *"panel data"*. Their model assumes that the inefficiency effects are stochastic, and also allows for the estimation of both technical change in the stochastic frontier and time-varying technical inefficiencies. Consider the stochastic frontier production function for panel data (Battese and Coelli, 1995, p326),

$$y_{it} = \exp\left(x_{it}\beta + v_{it} - u_{it}\right) \tag{4.17}$$

The above equation specifies the stochastic frontier function in terms of the original production values. *Where*; y_{it} is production (output) of the i^th^ firm; x_{it} is a (1×X) vector of inputs of production used in the production of the i^th^ firm, and other independent variables associated with the i^th^ firm; β is a (k × 1) vector of unknown parameters; v_{it}s[49] are *iid N* (0, σ^2) random errors, independently distributed of the non - negative random variables (u_{it}s); u_{it}s are non-negative random variables, associated with technical inefficiency in production, and are assumed to be independently distributed such that u_{it} is obtained by truncation (at zero) of the normal distribution with mean, $z_{it}\,\delta$, and variance, σ^2. The technical inefficiency effect, u_{it} in the stochastic frontier model shown above, can be specified in the following equation (Battese and Coelli, 1995, p327):

$$u_{it} = z_{it}\delta + w_{it} \tag{4.18}$$

Where; z_{it} is a (1×m) vector of independent variables associated with technical inefficiency effects; δ is an (m ×1) vector of unknown coefficients to be estimated; w_{it} is the unobserved random variables, which are assumed to be independently and identically distributed, obtained by truncation of a normal distribution with zero mean and unknown variance, σ^2 (*iid N* ($0, \sigma^2$)), such that u_{it} is non-negative (i.e., $w_{it} \geq -z_{it}\delta$).

[49] Note that v_{it}measures the shortfall in output Y_{it} from its maximum value given by the stochastic frontier, $f(x_{it}\beta) + v_{it}$.

However, the assumption that the u_{it}s and v_{it}s are independently distributed for all t=1,2,…,T, and i = 1,2,…..,N, is obviously a simplifying but restrictive condition (Battese and Coelli, 1995). Alternatively, the method of maximum likelihood is used for simultaneous estimation of the parameters of the stochastic frontier and the technical inefficiency effects model (Battese and Coelli, 1995). The likelihood function is expressed in terms of the variance parameters: $\sigma_s^2 \equiv \sigma_v^2 + \sigma_u^2$ and $\gamma \equiv \sigma_u^2 / \sigma_s^2$ (Battese and Coelli, 1995, p327). Where the γ parameter represents the share of inefficiency in the overall residual variance, and has a value between zero and one. The technical efficiencies of production are predicted using the conditional expectations of exp $(-u_{it})$, given the composed error term of the stochastic frontier. Hence, given the above assumptions, the technical efficiency of the i[th] firm can be defined as follows (Battese and Coelli, 1995, p327):

$$TE_{it}{}^{50} = \exp(-u_{it}) = \exp(-Z_{it}\delta - W_{it}) \qquad (4.19)$$

As a result their model can be applied in this research since it is formulated with panel data, rather than in a cross-sectional context. Finally, the two most commonly used packages for estimating SFA and inefficiency are FRONTIER 4.1 and LIMDEP In this study, FRONTIER 4.1 (developed by Coelli (1996)) will be used to estimate a firm's technical efficiency as well as an inefficiency model measured by a one-step process. LIMDEP can only estimate the inefficiency model in a two-stage process. Furthermore, FRONTIER can accommodate a wider range of assumptions regarding the error distribution term than LIMDEP (Herrero and Pascoe, 2002)

4.3.2 Data Envelopment Analysis (DEA)

Non-parametric Data Envelopment Analysis (DEA) can also be used to predict technical efficiency, which involves the use of a linear programming method to construct a non-parametric piece-wise surface (or frontier) over the data (Coelli et al., 2005, p162). The term "Data Envelopment Analysis (DEA)" was first proposed

[50] If a firm has an inefficiency effect equal to zero, technical efficiency equals one.

by Charnes, Cooper, and Rhodes (1978) (CCR model)[51], which had an input orientation and assumed constant returns to scale (CRS). CRS assumes that all firms are operating at an optimal scale. DEA can be presented as the ratio of all outputs over all inputs, which can be solved by the mathematical programming problem as follows (Coelli et al., 2005, p162):

$$\begin{aligned}
&Max_{u,v} && (u'y_i/v'x_i),\\
&\textit{Subject to} && uy_j/v'x_j \le 1, \quad j = 1,2,\ldots\ldots, I,\\
& && u, v \ge 0,
\end{aligned} \tag{4.20}$$

Where there are x inputs and y outputs for each of I firms, u is a $M \times 1$ vector of output weights, v is a $N \times 1$ vector of input weights, y is a $M \times I$ output matrix, and x is an $N \times I$ input matrix. These equations attempt to find values for u and v such that the efficiency measure for the i[th] firm is maximized, subject to the constraints that (i) values for u and v must be equal to or greater than zero, and (ii) all efficiency measures must be less than or equal to one. However, the efficiency ratio obtained from these equations has an infinite number of solutions (Coelli et al., 2005). To solve this problem the constraint $v'x = 1$ is imposed, which is specified as follows (Coelli et al., 2005, p163):

$$\begin{aligned}
&Max_{u,v} && (u'y_i),\\
&\textit{Subject to} && v'x_i = 1,\\
& && u'y_j - v'x_j \le 0, \qquad j = 1,2,\ldots\ldots, I,\\
& && u, v \ge 0,
\end{aligned} \tag{4.21}$$

Equivalently, the duality in linear programming can be derived as follows (Coelli et al., 2005, p163):

$$\begin{aligned}
&Min_{\theta,\lambda} && \theta,\\
&\textit{Subject to} && -y_i + Y\lambda \ge 0,\\
& && \theta\, x_i - X\lambda \ge 0, \qquad j = 1,2,\ldots\ldots, I,\\
& && \lambda \ge 0,
\end{aligned} \tag{4.22}$$

Where, θ is a scalar, and λ is a $I \times 1$ vector of constants.

[51] The technical efficiency calculated under CRS is known as total technical efficiency. It can be decomposed into two parts, (VRS) technical efficiency and scale efficiency.

This duality form (4.22) has fewer constraints than the multiplier form (4.23), which is the preferred form to solve (Coelli et al., 2005, p163). The value of θ indicates the efficiency score for the i^{th} firm. A value of $\theta = 1$ indicates that a firm is technically efficient, since its operation is on the frontier (Coelli et al., 2005). A value of $\theta < 1$ indicates that a firm is technically inefficient. However, it is possible that a firm does not operate at optimal scale due to imperfect competition, government regulations, and financial constraints (Coelli et al., 2005). As a result, the use of the CRS specification is not applicable if not all firms are operating at the optimal scale. Hence, a number of subsequent papers (e.g., Färe, Grosskopf, and Logan (1983); Banker, Charnes and Cooper (1984) (BCC model)[52]) proposed variable returns to scale (VRS). The use of the VRS assumption can enable the calculation of efficiency (TE) which is devoid of scale efficiency (SE). Equation (4.22) shows that the CRS linear programming problem can be modified to account for the VRS linear programming problem, by adding the convexity constraint ($I1'\lambda = 1$) as follows (Coelli et al., 2005, p172):

$$
\begin{array}{llll}
Min_{\theta,\lambda} & \theta, & & \\
\textit{Subject to} & -y_i + Y\lambda \geq 0, & & \\
 & \theta\, x_i - X\lambda \geq 0, & j = 1,2,\ldots\ldots,I, & \\
 & I1'\lambda = 1, & & \\
 & \lambda \geq 0, & & (4.23)
\end{array}
$$

Where, $I1$ is an $I \times 1$vector of ones[53]

The convexity constraint ($I1'\lambda = 1$) illustrates that an inefficient firm is only "benchmarked" against similar firms in terms of the size. For the CRS case this convexity constraint is not imposed, and hence a firm may be benchmarked against firms that are considerably larger or smaller than it (Coelli et al., 2005). In addition, there are two common orientations, input and output, using DEA models. Input-orientated models measure technical efficiency as a proportional reduction in input usage, but output levels are fixed. Input orientation is useful when firms have fixed output levels, and, therefore, where they are forced to minimize their input usage. On

[52] Unlike the CCR model, the BCC model considers variable returns to scale between inputs and outputs. Allowing variable returns to scale, means that the convexity condition for the weights λ_j is necessarily required. Where$\sum_{j=1}^{n} \lambda_j = \mathbf{1}$ is a new constraint (convexity condition).

[53] There are I rows, and one column in which all values are equal to "unity".

the other hand output-orientated models identify technical efficiency as a proportional increase in output production, where input levels are constant. Output orientation is appropriate when firms have fixed input amounts, and hence they are forced to maximize output production. Coelli et al. (2005) suggested that the TE scores of both input and output orientations are the same under CRS. The following output-orientated DEA models are similar to input-orientated DEA models, except that φ is imposed into Equation 4.23, and θ is removed from Equation 4.23 (Coelli et al., 2005, p180).

$$
\begin{array}{lrr}
Max_{\theta,\lambda} & \varphi, & \\
\textit{Subject to} & -\varphi y_i + Y\lambda \geq 0, & \\
 & x_i - X\lambda \geq 0, & j = 1,2,\ldots\ldots,I, \\
 & I1'\lambda = 1, & \\
 & \lambda \geq 0, & \qquad (4.24)
\end{array}
$$

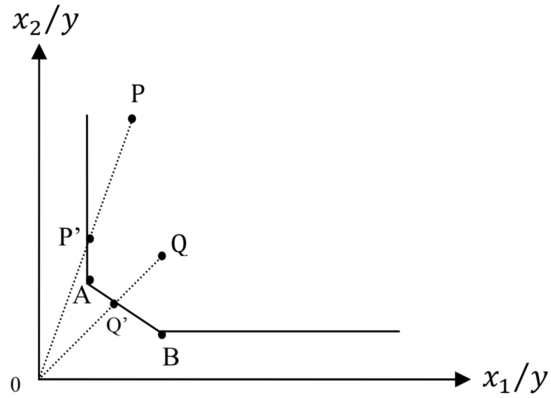
Where, $1 \leq \varphi < \infty$ and $\varphi - 1$ is the proportional increase in outputs with constant level of inputs. $\frac{1}{\varphi}$ is a technical efficiency score between zero and one.

(i) The problem of "slacks"

One problem of the piece-wise linear frontier in DEA is that the firm is operating parallel to the axes, which causes the problem of "slacks" (see Figure 4.5). From Figure 4.5 Firms A and B are efficient firms since they are operating on the frontier, but Firms P and Q are not. According to Farrell (1957) the technical efficiency of Firms P and Q can be measured as 0P'/0P and 0Q'/0Q, respectively. For Firm P point P' is located on the frontier, which is the efficient point. However, the amount of input x_2 can be reduced without changing the output. This problem is known as "*input slack*" (or input excess)[54]. There are a number of slack treatments (e.g., one-stage DEA, two-stage DEA, and multi-stage DEA) (Coelli et al., 2005). One-stage DEA is to solve the linear programming Equation (4.21), and slacks are calculated residually.

[54] For the output orientated model this problem can also be known as "output slack" (or output excess) (see Chapter 6).

Figure 4.5: Efficiency measurement and input slacks



Source: Coelli et al. (2005, p165)

Note: This figure is assumed under the input orientated model.

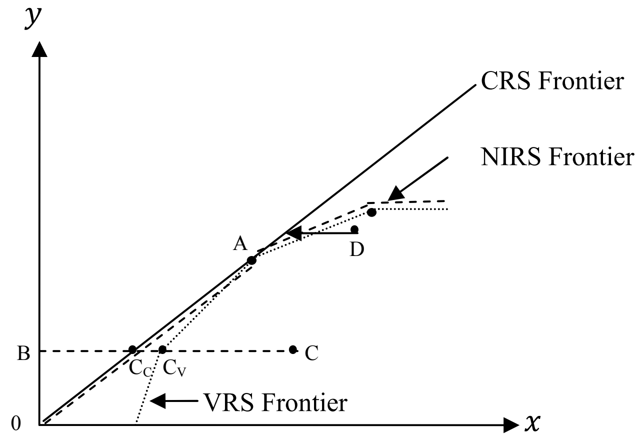
Two-stage DEA aims to maximize the sum of slacks required to move from the first-stage projected point (such as P' in Figure 4.5) to an efficient frontier point (such as A in Figure 4.5) (Coelli et al., 2005, p198). However, two-stage DEA is applicable when there is only one efficient point to select from the vertical facet, but it is not applicable when there are two or more dimensions of slacks. As a result multiple-stage DEA can be useful since it is invariant to units of measurement and its efficient projected points, and have input and output mixes that are similar to those of the inefficient points. These slack treatments can be applied by DEAP version 2.1, written by Coelli (1996). For Data Envelopment Analysis (DEA) scale efficiency can be obtained by measuring both CRS technical efficiency and VRS technical efficiency. Unlike SFA, technical efficiency can be decomposed into scale inefficiency and pure technical inefficiency under the assumption of variable returns to scale (Coelli et al., 2005).

From Figure 4.6 technical efficiency (TE) under CRS and VRS can be expressed as the ratio BC_C/BC and BC_v/BC, respectively. Scale efficiency can be measured as the ratio BC_C/BC_v or TE_{CRS}/TE_{VRS}[55]. The measurement of scale efficiency, however, does not indicate whether the firm is operating under increasing or decreasing returns to scale. By replacing $I1'\lambda \leq 1$ for $I1'\lambda = 1$ in Equation

[55] Scale efficiency (SE) = $\frac{BC_C}{BC_V} = \frac{TE_{CRS}}{TE_{VRS}} = \left[\frac{BC_C}{BC}\right] \times \left[\frac{BC}{BC_V}\right]$

(4.23), non-increasing returns to scale (NIRS) is imposed (see Figure 4.6). Increasing returns to scale exist when the NIRS technical efficiency score is not equal to the VRS technical efficiency score, but decreasing returns to scale arise when they are both equal (Coelli et al., 2005, p174).

Figure 4.6: Scale efficiency measurement in DEA



Source: Coelli et al. (2005, p174)

Note: This figure is assumed under the input orientated model.

(ii) Data Envelopment Analysis (DEA) adjusting for business environment and firm-specific factors

Business environment and firm-specific factors (e.g., government assistance, firm age, firm size, and financial constraints) can affect the efficiency of a firm. For DEA these factors are assumed not to be controlled by the manager of a firm, since they are not considered as traditional inputs (e.g., capital and labour inputs). There are a number of methods to deal with business environment variables and firm-specific variables. For example, business environment and firm-specific variables are included directly into the linear programming formulation, but the variables for this method must be continuous. In other words, they cannot be categorical variables (e.g., dummy variables). In addition, if the business environment and firm-specific variables can be ordered in terms of their values from the least to the most detrimental effect on the firm's efficiency, then the efficiency of firms can be compared with others only if their business environment and firm-specific variables have less or equal values (e.g., restaurants are only compared within the same city) (Coelli et al., 2005). However, this method requires the same detrimental direction of business environment and firm-specific variables on a firm's efficiency, and several firms must be found to be efficient.

Furthermore, if the business environment and firm-specific variables are not ordered (e.g., domestic versus foreign ownership) then the method suggested by Charnes et al. (1981) can be used, which consists of three stages. In the first stage, the sample is divided into sub-samples (e.g., domestic and foreign sub-samples), and each of them is solved by using DEA. In the second stage, all observed data are projected onto their respective frontiers. In the last stage, a single DEA is solved using the projected points and the difference in the mean efficiency of sub-samples is assessed (Coelli et al, 2005, p191). However, this method requires the business environment and firm-specific variables to be categorical variables, and many firms must also be found to be efficient. In addition, one of the problems with these methods is that they are only suitable when one business environment or firm-specific variable is considered to determine the efficiency of a firm.

The two-stage method is the most commonly adopted of the DEA methods previously mentioned. This method deals with business environment and firm-specific factors which influence the efficiency of a firm. It can accommodate more than one business environment or firm-specific variable, which can be either continuous or categorical. It is not necessary to make prior assumptions with regard to the direction of the business environment and firm-specific variables upon the firm's efficiency. Moreover, it is simple and transparent, and consists of two steps. The first-stage involves solving a DEA problem using traditional inputs and outputs. In the second stage, the efficiency scores obtained from the first-stage are regressed on the business environment and firm-specific variables. A significant proportion of the efficiency score is assumed to be equal to one. The method of ordinary least squares (OLS), however, is likely to predict efficiency scores which are greater than one (Coelli et al., 2005). The Tobit regression method is recommended in the second stage, and is applicable for truncated data (Kumbhakar and Lovell, 2000, p264; Coelli et al., 2005, p194). Hypothesis tests are conducted to test for the significance of business environment and firm-specific variables upon a firm's efficiency. However, the results of this method may be biased if the variables used as inputs and outputs in the first stage are highly correlated with the business environment and firm-specific variables in the second stage (Coelli et al., 2005, p194).

4.4 Production functions accounting for technical (technological) change

Production functions can change over time due to technological advances. In order to account for technological change, a time trend is included in the model reflecting industry-specific knowledge of technological developments (Coelli et al., 2005). There are some common functional forms for production functions such as linear, Cobb-Douglas, quadratic, normalised quadratic, Translog, generalised Leontief, and constant elasticity of substitution (CES). These functional forms have different properties. For instance, the linear and Cobb-Douglas forms are first-order flexible and have enough parameters to provide a first-order differential approximation, while the other functional forms (e.g., Translog, quadratic, normalised quadratic, generalised leontief, CES) provide second-order flexible approximation. The second-order flexible form is preferable to that of the first-order flexible form, but if there are more parameters, or more flexibility, then this may cause econometric problems (e.g., multicollinearity) (Coelli et al., 2005). In addition, the Cobb-Douglas and Translog functional forms are not linear in the parameters, but this can be solved by taking logarithms. The Cobb-Douglas function has restrictive properties, since returns to scale are constant and elasticity of substitution is unity. This functional form may not be applicable in a situation where elasticity varies across data points (Coelli et al., 2005). The most common functional forms used in several empirical studies (see Chapter 3) are the Cobb-Douglas and Translog production functions, which are given as follows (Kim, 1992; Coelli et al., 2005):

1. The Cobb-Douglas production function (restricted model)

$$lny = a_0 + \sum_{i=1}^{N} \beta_i lnx_i + \beta_T T \tag{4.25}$$

2. The Translog production function (unrestricted model)

$$lny = a_0 + \sum_{i=1}^{N} \beta_i lnx_i + \beta_T T + \frac{1}{2}\sum_{i=1}^{N} \sum_{j=1}^{N} \beta_{ij} lnx_i \, lnx_j + \sum_{i}^{N} \beta_{iT} lnx_i T + \frac{1}{2}\beta_{TT} T^2 \tag{4.26}$$

Where y is the level of output; x is a set of inputs whose elements are x_i and x_j; T is a time trend representing technical change.

Once the functional form is selected by conducting the model specification test in the first step an alternative hypothesis of the selected functional model with technical change (unrestricted model) is identified, and tested against the null hypothesis of the same selected functional model with no technical change (restricted model) using the likelihood ratio (LR) test to compare with the critical value ($\chi^2_{0.95(j)}$) where j is the number of restrictions. If the obtained likelihood ratio (LR) statistic is greater than the critical value ($\chi^2_{0.95(j)}$) then the null hypothesis that the technical (technological) change effect is zero (restricted model) is rejected, indicating that there is the existence of technical progress. From Equations (4.25) and (4.26) it is possible to calculate the percentage change in *y* in each period regarding technological change, this is given by the derivative of *lny* with respect to the time trend (*T*) as follows:

Cobb-Douglas production function: $\frac{\partial lny}{\partial T} = \beta_T$ (4.27)

Translog production function: $\frac{\partial lny}{\partial T} = \beta_T + \sum_{i=1}^{N} \beta_{iT}\, lnx_i + \beta_{TT}T$ (4.28)

From Equations (4.27) and (4.28) the technological change effect of the Cobb-Douglas production function is constant, but the technical change effect of the Translog production function can either increase or decrease with time (*T*) depending upon whether β_{TT} is positive or negative. Coelli et al. (2005, p213) suggested that a time trend can capture industry-specific knowledge of technological developments, and investigate whether labour and capital inputs have been used or saved. For the DEA approach technological progress can be examined by using the Malmquist TFP index, which is constructed by measuring the radial distance of the observed output and input vectors in periods *s* and *t* relative to a reference technology (Coelli et al., 2005, p67). The distances can be either output orientated or input orientated. The following, for example, is the output-orientated Malmquist TFP index which is the geometric mean of the indices based on period-s and period-t technologies (Coelli et al., 2005, p291).

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{0.5} \quad (4.29)$$

Where, $\frac{d_0^t\,(y_t,x_t)}{d_0^s\,(y_s,x_s)}$ represents efficiency change; and $\left[\frac{d_0^s\,(y_t,x_t)}{d_0^t\,(y_t,x_t)} \times \frac{d_0^s\,(y_s,x_s)}{d_0^t\,(y_s,x_s)}\right]^{0.5}$ indicates technical change.

According to Equation (4.29), when the firm is technically efficient in both period *s* and *t* the Malmquist TFP index indicates no productivity growth and its value is equal to one. However, if a firm is technically inefficient then it is possible that the change in its observed productivity, as reflected in the Malmquist TFP index, could be the result of a change in its efficiency and/or a change in its underlying production technology (technical change) (Coelli, et al., 2005). The Malmquist TFP index, therefore, can be decomposed into two parts which are (i) efficiency change and (ii) technical change.

For the DEA approach the Malmquist TFP index can be constructed by the DEAP computer program, which has been written to conduct DEA with regard to Equation (4.29)[56]. However, the Malmquist TFP index estimated by the DEA frontier can only be applied to "*balanced*" panel data (Coelli, 1996b). For this study the characteristics of panel data for Thai listed manufacturing enterprises over the period 2000 to 2008 are obviously "unbalanced", since new firms were listed on the Stock Exchange of Thailand (SET) while some firms were delisted from the SET over time. As a result, the SFA approach is likely to be more preferable than the DEA approach in investigating technological progress for *"unbalanced"* panel data of Thai listed manufacturing enterprises.

4.5 Strengths and weaknesses of data envelopment analysis (DEA) and stochastic frontier analysis (SFA)

The differences between the SFA and DEA approaches are that the SFA approach imposes functional forms on the production frontier, and assumes that

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[56] For the SFA approach the Malmquist TFP index can be calculated by multiplying efficiency change with technical change. Efficiency change is equal to $\frac{TE_{it}}{TE_{is}}$, where *i* is the i-th firm in periods *s* and *t*. Technical change can be calculated as the geometric mean of the two partial derivatives (production function with respect to periods *s* and *t*). For example, technical change calculated from the Translog production function can be mathematically represented as $\exp\left\{\frac{1}{2}\left[\frac{\partial lny_{is}}{\partial s} + \frac{\partial lny_{it}}{\partial_t}\right]\right\}$ (Coelli et al., 2005, p301).

firms may deviate from the production frontier not only due to technical inefficiency but also from measurement errors, statistical noise or other non-systematic influences (Admassie and Matambalya, 2002). Therefore, the advantage of the SFA approach is that it allows for statistical noise (e.g., errors of measurement), but its disadvantage is that it requires strong assumptions as to the form of the frontier production function (Jacobs, 2000, p3). In particular, estimation of an SFA production function for a single cross section of firms requires the explicit specification of the distribution of statistical noise and inefficiency variable terms.

However, such strong assumptions are not required when panel data are available (Kalirajan and Shand, 1999, p159). The DEA approach, however, does not impose functional forms, and uses linear programming to construct a frontier that envelops the observations of all firms. The DEA approach has the advantage of being non-parametric. Hence, all firms are compared relatively to the "*best*" performing firms, requiring few assumptions about the underling production technology (Jacobs, 2000). In other words, it overcomes restrictions on production specifications and distributions of various residuals. However, the DEA approach also has some weaknesses. This approach considers only the supply side, and ignores the demand side and properties of the market. Furthermore, it is likely to overstate inefficiency if a single firm (or industry) performs far better than the others (Minh and Vinh, 2007). It also allows for no statistical noise, or the estimated results are not subject to statistical properties. Statistical tests, therefore, cannot be applied. Focusing on "returns to scale" the DEA approach can examine whether a firm is operating under decreasing, increasing, or constant returns to scale, including in an industry-level context[57]. For the SFA approach "returns to scale" can be investigated through an estimated production function[58]. Furthermore, the SFA approach only provides pure (VRS) technical efficiency scores, but the DEA approach provides variable returns to scale (VRS) technical efficiency scores, constant returns to scale (CRS) technical efficiency scores, and scale efficiency scores (Coelli, 1996a). The strengths and weaknesses of each estimation approach are summarized in Table 4.1. This thesis

[57] This can be calculated as an average of each type of returns to scale (e.g., increasing, decreasing, or constant returns to scale).

[58] For the Cobb-Douglas production function returns to scale is calculated from the sum of the estimated input coefficients (elasticities). For the Translog production function it is calculated from the sum of the output elasticities with respect to each input (Kim, 1992).

will employ both the DEA and SFA approaches and attempt to select statistically superior models for each approach and then compare results.

Table 4.1: Strengths and weaknesses of the SFA and DEA approaches

Stochastic Frontier Analysis (SFA)	
Strengths	**Weaknesses**
- Statistical noise is allowed.	- Strong distribution assumptions are required. - Functional form is required. - Sufficient sample size is required. - Pure (VRS) technical efficiency is only predicted.
Data Envelopment Analysis (DEA)	
Strengths	**Weaknesses**
- Strong distribution assumptions are not required. - Sufficient sample size is not required due to this being a non - parametric approach that uses linear programming. - VRS TE, CRS TE, and scale efficiency are predicted.	- Statistical noise is not allowed. - It may overstate inefficiency if a single firm is far superior to that of other firms.

Source: Author

Note: VRS TE is variable returns to scale technical efficiency; CRS TE is constant returns to scale technical efficiency; DEA is only based on predicting a firm's technical efficiency without considering the effects of business environment and firm-specific variables on a firm's technical efficiency.

4.6 Conclusions

This chapter has discussed efficiency concepts, which include (i) technical efficiency, (ii) allocative efficiency, (iii) scale efficiency, and (iv) cost and revenue efficiency. Technical efficiency is the main efficiency measurement to be used in this thesis, which will be estimated in Chapter 6 (see Section 4.2.1). There are two competing measures of a firm's efficiency. Stochastic Frontier Analysis (SFA) is the parametric approach. The advantage of this approach is that it allows for statistical noise (e.g., measurement errors), but its drawback is that strong assumptions (e.g., distributions of random variables, adequate functional forms) are required. Other advantages and disadvantages of the SFA and DEA approaches are also summarized in Table 4.1. The most distinctive characteristics of the stochastic production frontier is that an inefficiency effect is introduced, which is represented by the nonnegative random variable (u_i) besides the deterministic component and noise effect (v_i) (see Figure 4.4). It is, however, necessary to choose an adequate frontier functional form suited for particular manufacturing sectors. The Cobb-Douglas and Translog production functions are commonly used in the literature. A model specification test (the likelihood ratio statistic) is used to select the best functional form for the stochastic frontier production (see Chapter 6).

For the SFA approach the one-stage process suggested by the Battese and Coelli (1995) model will also be applied to conduct an empirical analysis in Chapter 6, since it is applicable for unbalanced panel data of Thai listed manufacturing enterprises. Their model allows for the estimation of both technical change in the stochastic frontier and time-varying technical inefficiencies simultaneously. Frontier 4.1, developed by Coelli (1996), can be used to predict a firm's technical efficiency, and examine the inefficiency effects upon a firm's technical efficiency simultaneously for the Battese and Coelli (1995) model (see Section 4.3.1). This can resolve bias due to the omission of relevant variables in the first stage of the frontier estimation. This will be conducted in Chapter 6 of the thesis.

Data Envelopment Analysis (DEA) is a non-parametric approach which does not require functional forms. Linear programming is used to construct a frontier that envelops the observations of all firms. The DEA approach has the advantage of being non-parametric, since all firms are compared relative to the "best" performing firm. As a result, it overcomes restrictions on production specifications and distributions of random variables, and no production function is required. However, the estimates of inefficiency may be overstated if a firm (or industry) performs far better than the others (arising from the outlier problem). The estimated results of a firm's technical efficiency are not subject to statistical properties, as there is no statistical noise. For the SFA approach only "pure" technical efficiency (or variable returns to scale technical efficiency) is predicted using FRONTER 4.1. Unlike SFA, the specification of constant returns to scale is also available for DEA, and hence scale efficiency can be estimated using this approach (see Section 4.2.3). Moreover, the DEAP version 2.1 can be used to construct the DEA frontier (Coelli, 1996b). One problem of the piece-wise linear frontier used in DEA is that there might be, for example, an input excess (input slack) for the case of the input orientated model (see Section 4.3.2). There are a number of treatments of "slack" such as one-stage DEA, two-stage DEA, and multi-stage DEA. These slack treatments can be simply applied by DEAP version 2.1 written by Coelli (1996).

The most common DEA approach in dealing with the effects of business environment and firm-specific variables on a firm's technical efficiency is "the two-stage method", which can accommodate more than one business environment or firm-specific variable. In the first stage a firm's technical efficiency is predicted by linear programming with DEA using traditional inputs and outputs. In the second stage, the efficiency scores are regressed upon a set of business environment and firm-specific variables (e.g., the Tobit regression method) (see Section 4.3.2). This two-stage approach is simple and transparent, but care must be exercised when all variables are identified since the results might be biased if the inputs and outputs used to predict the firm's technical efficiency (in the first stage) are highly correlated with the business environment and firm-specific variables (in the second stage).

It is crucial to consider whether firms improve their efficiency due to an efficiency change or technical (technological) change. For the SFA approach a time trend variable can be introduced to investigate the existence of technical progress through an estimated stochastic frontier production function (e.g., Cobb-Douglas and Translog production functions).

For the DEA approach technological progress can be examined by compiling a Malmquist TFP index, which can be applied to decompose the productivity change of a firm (see Section 4.4). However, the samples (panel data) must be "balanced" (all firms must be observed over the period) in order to conduct this index (Coelli, 1996b).

As a result, this thesis will apply both the Stochastic Frontier Analysis (SFA) based on the Battese and Coelli (1995) model and Data Envelopment Analysis (DEA) based on the two-stage DEA approach to predict a firm's technical efficiency, and analyse the inefficiency effects model. The main reasons are that it can increase the confidence of the estimations in conducting the empirical analysis of Chapter 6, since it cannot be concluded which estimation approach is more preferable due to their advantages and disadvantages as discussed in Section 4.5. Other literature also suggests that a firm's technical efficiency should be analyzed using both estimation techniques for a robust checking of the empirical results (Bauer et al., 1998; Stone, 2002; Jacobs et al., 2006; Miranda et al., 2010). More specifically, one of the advantages of DEA is that "functional form" is not required making it a useful estimation technique when predicting the technical efficiency for Thai listed manufacturing enterprises. For the SFA approach the prediction of technical efficiency and the study of an inefficiency effects model, however, are based on an estimated production function. Hence, selecting an inappropriate production function and obtaining insignificant coefficients for the estimated production function (due to high multicollinearity among the inputs in the case of the Translog production function) (Lundvall and Battese, 2000; Oczkowski and Sharma, 2005) may change the empirical results of the study. Finally, the SFA can only provide variable returns to scale (VRS or Pure) technical efficiency scores, but the DEA approach can predict constant returns to scale (CRS) technical efficiency and scale efficiency besides variable returns to scale (VRS or Pure) technical efficiency.

Before predicting technical inefficiency and analysing the inefficiency effects model using these two estimation approaches in Chapter 6, it is very important to identify hypotheses which are crucial and have not been empirically examined for Thai listed manufacturing enterprises, and then describe variables used to conduct the empirical analysis in Chapter 6. These hypotheses aim to examine the effects of important firm-specific and business environment variables on the technical efficiency of Thai listed manufacturing firms. Focusing on hypotheses discussed in Chapter 5, input and output variables used to predict technical inefficiency scores are identified and selected. Firm-specific and business environment variables, which are related to each hypothesis and used to link with predicted inefficiency scores, are also explained and employed in the conduct of an inefficiency effects model for the SFA approach, and also in the second step of the two-stage DEA approach.

CHAPTER 5

HYPOTHESES AND DATA DESCRIPTION

5.1 Introduction

This chapter identifies the hypotheses and variables which will be developed and tested in Chapter 6 (Empirical Models and Results), and also describes data sources and data selection. The organization of this chapter is conducted as follows: Section 5.2 identifies eight hypotheses that will be used to conduct the empirical analysis in Chapter 6. These hypotheses aim to investigate the relationship between business environment and firm-specific variables and firm technical efficiency. Section 5.3 discusses possible input and output variables which are used in predicting technical inefficiency effects (scores) through (i) the selected stochastic frontier production function for the Stochastic Frontier Analysis (SFA), and via (ii) the first step of the two-stage Data Envelopment Analysis (DEA). In Section 5.4 business environment and firm-specific variables related to each hypothesis are also explained and used in the conduct of an inefficiency effects model for the SFA approach, and also in the second step of the two-stage DEA approach. Finally, conclusions are provided in Section 5.5.

5.2 Hypotheses

This section aims to explain the hypotheses which will be empirically tested and the results of which will be reported in Chapter 6. There are eight hypotheses emphasising factors impacting technical efficiency which are grouped into six categories, as follows: (i) finance (leverage and liquidity; internal financing and external financing), (ii) research and development (R&D), (iii) ownership structure (controlling and managerial ownerships), (iv) executive remuneration, (v) types of owned firms (foreign and family-owned firms), (vi) exporting (the learning by exporting and self-selection hypotheses[59]). Besides these eight hypotheses there are also a number of firm-specific and business environment factors that affect a firm's

[59] For the self - selection hypothesis there are a number of business environment and firm specific variables that affect a firm's export decision, such as firm size, firm age, leverage, and foreign investment (see Table 5.3).

technical efficiency, such as (i) firm size, (ii) firm age, (iii) government assistance, and (iv) foreign cooperation, which will be discussed at the end of this section (Section 5.4.2 vii).

5.2.1 Finance and firm technical efficiency

Hypotheses 1 and 2 aim to examine the relationship between finance and a firm's technical efficiency, which were referred to in the literature review (see Section 3.4.2, Chapter 3).

Hypothesis 1[60]: *Financial constraints (leverage) have a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises. Vice versa, the more liquidity the lower is the technical efficiency of Thai listed manufacturing enterprises.*

Several empirical studies have investigated the impact of financial constraints (leverage) on a firm's performance as measured by accounting or financial ratios (see Section 3.4.2, Chapter 3). These empirical results are found to have produced ambiguous results. However, few empirical studies have examined the effect of financial constraints (leverage) on a firm's technical efficiency (Dilling-Hansen et al., 2003; Sena, 2006; Mok et al., 2007; Weill, 2008). The empirical results from these studies reveal that financial constraints have a significant and positive relationship with a firm's technical efficiency. No empirical study has examined the effects of both financial constraints (leverage) and liquidity on a firm's technical efficiency. More specifically, the following hypothesis has not been examined for the case of Thailand.

Hypothesis 2: *External financing has a significant and positive relationship with a firm's technical efficiency for Thai listed manufacturing enterprises. Vice versa, internal financing has a significant and negative effect on a firm's technical efficiency for Thai listed manufacturing enterprises.*

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[60] From the literature on agency problems, financially constrained firms are likely to induce managers to improve their managerial performance so as to avoid possible bankruptcy and liquidation of their firms (see Section 3.4.2). In addition, financially constrained firms are likely to utilize their financial resources and control input costs effectively.

This hypothesis aims to examine the effects of external and internal financing on a firm's technical efficiency as discussed in the literature review. As previously discussed in Chapter 3, Section 3.4.3, there are a number of theoretical studies focusing on the relative efficiency of internal versus external financing (Jensen, 1986; Gertner et al., 1994; Stein, 1997). Empirical studies have also revealed inconclusive results (Gökçekus, 1995; Kim, 2003). More importantly, from the perspective of this study, this hypothesis has not been examined in any empirical studies focusing on Thailand, especially for Thai listed manufacturing enterprises.

5.2.2 Research and development (R&D) and firm technical efficiency

The following hypothesis aims to examine the effect of research and development (R&D) on a firm's technical efficiency.

Hypothesis 3[61]: *Research and development (R&D) has a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises.*

As discussed in the literature review in Section 3.6 of Chapter 3, many empirical studies have found that research and development (R&D) has a positive effect on a firm's technical efficiency (Aw and Batra, 1998; Dilling-Hansen et al., 2003; Kim, 2003; Sheu and Yang, 2005). More importantly, this hypothesis has not been investigated before for Thai listed manufacturing enterprises.

5.2.3 Ownership structure and firm technical efficiency

Hypothesis 4: *Controlling ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

As discussed in Section 3.5.1 of Chapter 3, many empirical studies have examined the effect of controlling ownership on a firm's performance based on accounting or financial measures (Demsetz and Lehn, 1985; McConnell and Servaes,

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[61] A dummy research & development (R&D) variable is used in this hypothesis, since R&D expenditures were not reported consecutively over the period 2000 to 2008 (see Section 8.3 for limitations and further studies).

1990; Leech and Leahy, 1991; Wiwattanakantang, 2001; Yammeesri and Lodh, 2003; Zeitun and Tian, 2007). Their empirical findings are found to be inconclusive. In the case of Thailand, Wiwanttanakantang (2001) and Yammeesri and Lodh (2003) found that controlling ownership is positively associated with a firm's performance as evaluated by accounting or financial measures (i.e., ROA, the sales-asset ratio, and stock returns). None of these empirical studies examined the effect of controlling ownership on a firm's technical efficiency, and especially in applying both the SFA and two-stage DEA approaches. More importantly, this hypothesis has not been investigated before for Thai listed manufacturing enterprises.

Hypothesis 5: *Managerial ownership has a significant and positive effect on a firm's technical efficiency for Thai listed manufacturing enterprises.*

With respect to Section 3.5.3 of Chapter 3, empirical studies have found that managerial ownership is significantly related with firm performance, as measured by financial profitability (McConnell and John, 1990; Morck et al., 1988; Wiwattanakantang, 2001; Yammeesri and Lodh, 2003). Very few empirical studies have examined the effect of managerial ownership on a firm's technical efficiency (Liao et al., 2010). More importantly, this hypothesis has not been examined before for Thai listed manufacturing enterprises.

5.2.4 Executive remuneration and a firm's technical efficiency

Hypothesis 6: *Executive remuneration has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

Many empirical studies in the finance and accounting literature have examined the effect of executive remuneration on a firm's performance based on accounting or financial measures (see Section 3.7, Chapter 3). Most empirical findings have found a significant and positive relationship between executive remuneration and a firm's performance. Few empirical studies, however, have applied the SFA approach or the two-stage DEA approach to investigate the linkage between executive remuneration and a firm's technical efficiency (Baek and Pagán, 2002[62]). This hypothesis has not been investigated before for Thai listed manufacturing firms.

5.2.5 Types of owned-firms and firm technical efficiency

Hypothesis 7: *Foreign and family ownership[63] have a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises; foreign-owned firms perform best in terms of technical efficiency relative to other ownership types for Thai listed manufacturing enterprises.*

According to Section 3.5.2 of Chapter 3, there is strong evidence to suggest that foreign ownership has become one of the most important types of ownership Many empirical studies have found that foreign ownership has a significant and positive association with a firm's performance, as measured by accounting or financial measures (Zhang et al., 2001; Takii, 2004; Choi and Yoo, 2006; Aydin et al., 2007; Kimura and Kiyota, 2007; Greenaway et al., 2008). Similarly, a number of empirical studies have also found a positive association between foreign ownership and a firm's technical efficiency (Fukuyama et al., 1999; Goldar et al., 2003; Bottasso and Sembenelli, 2004). While information on family ownership has been extensively discussed in the finance literature (see Section 3.5.2, Chapter 3), few studies have linked family ownership with a firm's technical efficiency (Lauterbach and Vaninsky, 1999). In the case of Thailand, Wiwattanakantang (2001) and Yammeesri and Lodh (2003) studied the effect of family ownership on a firm's performance based on accounting or financial measures. This hypothesis has not been examined for Thai listed manufacturing enterprises.

5.2.6 Export performance and a firm's technical efficiency

Hypothesis 8: *A firm's exports have a significant and positive association with its technical efficiency (the learning by exporting hypothesis exists); A firm's technical efficiency has a significant and positive effect on the export participation (the self selection hypothesis exists) of Thai listed manufacturing enterprises.*

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[62] They found a significant and positive relationship between the level of CEO total compensation and the technical efficiency of 1,500 S&P firms.

[63] This refers to majority foreign and family ownership using a cut-off shareholding level of 25 percent.

This hypothesis aims to examine the existence of the learning-by-exporting and the self-selection hypotheses for Thai listed manufacturing enterprises, as discussed in Section 3.8 of Chapter 3. Many empirical studies have examined the effect of a firm's export performance on its productivity (see Table 3.3, Chapter 3). Few empirical studies have investigated the learning-by-exporting hypothesis in which a firm's performance is measured by technical efficiency (Dilling-Hansen et al., 2003; Kim, 2003; Granér and Isaksson, 2007). Moreover, there is strong evidence from the self-selection hypothesis that only more efficient firms can participate in export markets (see Table 3.3, Chapter 3). However, very few studies have examined the self-selection hypothesis using technical efficiency as the measurement of firm performance. More importantly, this hypothesis examines the existence of both learning-by-exporting and the self-selection hypotheses on the technical efficiency of Thai listed manufacturing enterprises. This has not been previously conducted.

5.2.7 Other business environment and firm-specific factors and a firm's technical efficiency

As discussed in Section 3.9 of Chapter 3, there are a number of business environment and firm-specific factors that can affect a firm's technical efficiency such as (i) firm size, (ii) firm age, (iii) government assistance, and (iv) foreign cooperation. Many empirical studies have investigated the effect of a firm's size on its performance, using either accounting (financial) or technical efficiency measures. The empirical results are inconclusive based on the countries and sectors analysed. A number of empirical studies have also investigated the effect of a firm's age on its performance, using either accounting (financial) or technical efficiency measures. These findings are also quite mixed, depending upon the countries and sectors analysed. The effect of government assistance on firm performance, using accounting (financial) measures has also been examined in a number of studies. These findings are ambiguous depending on the countries and industrial sectors studied. Finally, a number of empirical studies have examined the effect of foreign cooperation on firm performance. These results are also quite mixed, depending upon the countries analysed.

5.3 Data sources and data classification

5.3.1 Data sources

The raw data to be used in Chapter 6 was obtained from the Stock Exchange of Thailand (SET), which consists of (i) the list of board of directors and major shareholders, (ii) financial reports, (iii) and annual reports of Thai listed companies (Form 56-1). Financial reports consist of five major components: (i) an auditor's report, (ii) statements of income, (iii) balance sheet statements, (iv) statements of cash flows, and (v) notes to financial statements. In addition, there are two types of financial reports: (i) an unconsolidated financial report and (ii) a consolidated financial report.

In this study, annually consolidated financial reports are used, since all the business activities of listed firms, including their subsidiary companies, are recorded in annually consolidated financial reports. Form 56-1 is an annual company report required by the Securities and Exchange Commission (SEC), where all Thai listed firms are obligated to disclose their annual business performance for shareholders and investors. Form 56-1 consists of three main parts: (i) executive summary, (ii) company issuing securities, and (iii) confirmation of accuracy. Part (ii) is used for this study, which consists of the listed company's information, such as (a) risk factors and risk management, (b) nature of business operation, (c) business operations of the company, (d) research and development, (e) business assets, (f) future plans, (g) legal disputes, (h) capital structure, and (i) management, (j) internal control, (k) related transactions, (l) financial position and operational performance, and (m) reference information. Moreover, the data obtained from annually considered financial reports and Form 56-1 are very reliable compared with that of Thai Industrial Census as well as Thai Industry Survey data, since annually considered financial reports are prepared by professional auditors approved by the SEC and Form 56-1 is also monitored by the SEC.

5.3.2 Data classification

There are eight industrial sectors according to the SET. The SET's eight industrial sectors consist of (1) Agro and Food Industry which can be sub grouped into (i) Agribusiness and (ii) Food and Beverage; (2) Consumer Products which can be sub grouped into (i) Fashion, (ii) Home and Office Products, and (iii) Personal Products and Pharmaceuticals; (3) Financials which can be divided into (i) Banking, (ii) Finance and Securities, and (iii) Insurance; (4) Industrials which can be classified into (i) Automotive, (ii) Industrial Materials and Machinery, (iii) Paper and Printing Materials, (iv) Petrochemicals and Chemicals, and (v) Packaging; (5) Property and Construction which can be divided into (i) Construction Materials, (ii) Property Development, and (iii) Property fund; (6) Resources (energy and utilities); (7) Services which can be divided into (i) Commerce, (ii) Health Care Services, (iii) Media and Publishing, and (iv) Professional Services (Tourism and Leisure, and Transportation and Logistics); (8) Technology which can be divided into (i) Electronic Components and (ii) Information and Communications technology.

Table 5.1: Classification of listed manufacturing firms in the SET during 2000 to 2008

No of sectors	Manufacturing Sectors	No of firms	No of firms
1	Agro and Food Industry		
	1.1 Agribusiness	20	
	1.2 Food & Beverage	20	
	Total		**40**
2	Consumer Products		
	2.1 Fashion	18	
	2.2 Home & Office Products	11	
	2.3 Personal Products & Pharmaceuticals	4	
	Total		**33**
3	Industrials		
	3.1 Automotive	12	
	3.2 Industrial Materials & Machinery	19	
	3.3 Packaging	13	
	3.4 Paper & Printing Materials	2	
	3.5 Petrochemicals & Chemicals	13	
	Total		**59**
4	Publishing		**7**
5	Construction Materials		**27**
6	Technology (Electronic components)		**12**
	Total listed manufacturing firms		**178**

Source: Author

Note: The reason that listed manufacturing firms are only selected in this thesis is due to the use of SFA, which requires the firm's production function to be estimated. Other listed firms, which are not classified as listed manufacturing firms, are known as listed services firms. They are "heterogeneous" in terms of the nature of their businesses (e.g., hospitals, traders, IT services, hotels). As a result, they cannot be used to compare with listed manufacturing firms in this study.

Besides these eight industrial sectors there were also 22 listed firms under rehabilitation (NPG)[64] in 2008. The securities of these listed firms have been suspended until they can meet the SET's rules and regulations in order to resume their trading again. With regard to the International Standard Industrial Classification of all economic activities (ISIC), it is necessary to remove some listed firms that are not classified as manufacturing firms. In addition, this study also includes listed manufacturing firms that had been delisted from the SET during 2000 to 2008. As a result, 178 listed manufacturing firms over the period 2000 to 2008 will be used to conduct the empirical analysis of this study, and this is summarized in Table 5.1.

5.4 Data description

This section aims to discuss possible inputs and outputs that can be used for the empirical study in Chapter 6 to predict a firm's technical inefficiency effects (scores) through an estimated stochastic frontier production function for SFA, and via the first-stage of the two-stage Data Envelopment Analysis (DEA) model (see Section 5.4.1). In addition, business environment and firm-specific variables used to link with a firm's technical inefficiency effects (scores) for SFA, and the second stage of the two-stage DEA approach, are also described in Section 5.4.2.

5.4.1 Outputs and inputs

Coelli et al. (2005) suggested that input and output quantities, prices, and quality characteristics are important for the measurement of efficiency and productivity. This part aims to discuss possible input and output variables from the literature, and then select appropriate input and output variables to be used in the empirical analysis conducted in Chapter 6.

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[64] Listed enterprises which are likely to be delisted by the SET (e.g., having negative shareholders' equity) will be moved to the rehabilitation sector (REHABCO sector), since the SET aims not to delist them intermediately due to the SET's proposal of protecting minority shareholders, but rather encourages them to submit their rehabilitation plans in order to improve their financial performance so that they can still maintain their trading status.

(i) Outputs

It is much easier for firms which produce tangible goods and services to identify their outputs than firms which are in the service sector (i.e., universities). For this study Thai listed manufacturing firms also produce tangible goods which can be easily identified and compared with firms which are in the service sector. Value added and gross outputs are commonly used as the output in most empirical studies for the manufacturing sector (Aw et al., 1998; Lundvall and Battese, 2000; Kim, 2003; Sena, 2006; Latruffe and Davidova, 2008). For example, Sena (2006) used real value added as output for the Italian manufacturing sector during the period 1989 to 1994. Kim (2003) applied real value added as the output for Korean manufacturing firms over the period 1980 to 1993. Aw and Batra (1998) used value added as the output for the Taiwanese manufacturing sector in 1986. Lundall and Battese (2000), however, used the value of all outputs produced as the output for Kenyan manufacturing firms over the period 1992 to 1994. If value added[65] is adopted as the output, only two inputs, capital (K) and labour (L) are used.

On the contrary, three input variables, capital (K), labour (L), and intermediate inputs (M), are used when value added is not adopted. For instance, Lundall and Battese (2000) used the value of all output produced as the output. Thus, capital (K), wages (L), and intermediate inputs (M) are used as the inputs in estimating the Translog frontier production function for their empirical analysis. For this study there are two reasons why adopting value added is not applicable. First, there are a moderate number of negative values using value added. In practice, if value added is applied a negative value must be deleted from the samples, since a negative value cannot be used where natural logarithms are used in estimating the production function (i.e., Cobb Douglas and Translog production functions). Second, some years must be excluded along with the elimination of negative values for value added causing missing observations (years) for the panel data. As a result output is represented by the value of produced outputs (annual sales revenue) for this

[65] The formula for value added is calculated by subtracting intermediate inputs (i.e., costs of raw materials, solid and liquid fuel, electricity, and water) from the output (i.e., outputs produced or sales revenue).

study, which can be obtained from the income statement of Thai listed manufacturing firms.

(ii) Inputs

There are five input categories that are commonly used for empirical analysis; (i) capital (K), (ii) labour (L), (iii) energy (E), (iv) material inputs (M), and (v) purchased services (S). These five input categories are sometimes known as the KLEMS approach in productivity measurement (Coelli et al., 2005). In addition, energy (E), material inputs (M), and purchased services (S) can often be combined to form a single "other input" category (Coelli et al., 2005, p141). This study will use three inputs (i) capital (K), (ii) labour (L), and (iii) intermediate inputs (i.e., energy, material inputs, purchased services and other administrative and production costs). For intermediate inputs energy, material inputs, purchased services, and other administrative and production costs are aggregated for this study, since these input variables cannot be separated individually due to the limitation of data provided in financial statements. These three inputs are explained in detail as follows:

Labour (L)

Labour is one of the major components for a firm's total costs. There are a number of proxy variables for labour input, such as (i) number of persons employed, (ii) number of hours of labour input, (iii) number of full-time equivalent employees, and (iv) total wages and salaries bill (Coelli et al., 2005, p142). For instance, Kim (2003) used number of employees as the labour input for the Korean manufacturing sector during the period 1989 to 1994. Hossain and Karunaratne (2004) also used number of employees as the labour input for Bangladesh manufacturing industries during the period 1978 to 1994. Bottasso and Sembenelli (2004) also used total number of employees for Italian manufacturing firms during the period 1987 to 1993. Lundvall and Battese (2000) used "wages" as the labour input for Kenyan manufacturing firms during the period 1992 to 1994. In addition, labour input can also be classified in terms of (i) skilled and unskilled labour or (ii) non-production (administrative) staff and production employees. Aw and Batra (1998) also classified labour input into the number of non-production and production workers for the Taiwanese manufacturing sector in 1986.

However, total employee expenditure[66], which includes salaries, wages and other employee benefits, are used as the labour input for this study. This can be found at the "notes to financial statements" for any of the financial statements prepared by SET listed manufacturing firms. There are a number of reasons why the number of workers and working hours cannot be adopted as the labour input. First, the number of working hours is not available. Second, the number of employees is normally counted at the end of the financial year. In fact, the number of employees might have increased or decreased substantially during the year. In addition, firms that employ more employees might have less wages and salaries compared with firms that employ a lesser number of employees[67]. More importantly, the number of employees is not provided in almost all of the financial statements of listed manufacturing enterprises during the period 2007 to 2008.

Capital (K)

The selection of capital (K) is also important for efficiency and productivity studies. There are a number of variables that can be used to measure the capital input, such as (i) total capital service flows from different assets, (ii) capital stock as measured by either the perpetual inventory method (PIM), survey method, or a combination of the PIM and survey methods, (iii) replacement value, (iv) physical measures, and (v) net capital stock (OECD, 2001; Coelli et al., 2005). Capital services are referred to as the use of a financial or operating lease in the production process. In theory, an undepreciated capital stock in constant prices is equal to the undepreciated replacement value of the capital stock (Coelli et al., 2005). Some physical measures or proxies (i.e. number of computers, number of cars, total floor area, and total horsepower of machines) can be useful when there is difficulty in conducting an estimation of particular assets. Net capital stock can also be used as the capital input, which is calculated as the gross stock less the accumulated consumption of fixed capital (depreciation).

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[66] According to the financial statements provided by Thai listed enterprises, it is not possible to separate production from non production labour expenditure. Total employee expenditure, therefore, is used as one of the set of inputs (e.g., labour, capital, intermediate inputs) to obtain the maximum output in this thesis. This labour input is different from the concept, "labour productivity" (wages divided by the number of workers), since "labour productivity" is one of the productivity outputs (e.g., labour productivity, capital productivity, total productivity).

[67] Firms located in rural areas can hire more employees due to cheaper wages and salaries compared with their counterparts located in city areas.

A number of capital stock measurements have been used in various empirical studies. For instance, Hossain and Karunaratne (2004) used gross fixed assets as the capital input, which is an aggregate of the book value of land, buildings, machinery, tools, transport, and office equipment for Bangladesh manufacturing firms. Bottasso and Sembenelli (2004) used the Perpetual Inventory Method (PIM) to measure the capital stock for Italian manufacturing firms. Kim (2003) used the total value of tangible fixed assets as the capital stock for Korean manufacturing firms. Lundvall and Battese (2000) used the replacement cost of existing machinery and other equipment employed in the production process as the capital input for Kenyan manufacturing firms. Sheu and Yang (2005) applied the value of net fixed assets based on the Perpetual Inventory Method for Taiwan's Electronics Industry. Mok et al. (2007) used net fixed assets as the capital output for foreign-invested toy manufacturing firms in China.

For this study, with respect to the financial statements of listed firms, net fixed productive and net fixed non-productive assets are normally recorded separately in balance sheets. In addition, they are calculated from gross fixed productive assets less straight-line depreciation. Only net fixed productive assets, however, are used as the capital input, since net fixed non-productive assets do not lead to an improvement in efficiency and productivity. Net fixed productive assets can be taken from the section of "Property, Plant and Equipment" provided in "notes to financial report". For instance, net fixed assets provided in financial statements normally include (i) land and land improvements, (ii) building and building improvement, (iii) machinery and equipment, (iv) office furniture and fixtures, (v) motor vehicles, (vi) leasehold rights, and (vii) buildings under construction, and machinery and equipment under installation. Net fixed non-productive assets (vii) are excluded from this study, since they cannot be used for production in that financial year. In addition, net fixed productive assets also include new asset acquisitions and asset disposals. For instance, listed firms may purchase new machinery and equipment (asset acquisitions) that can be operated promptly in the production process. On the other hand, net fixed productive assets are also adjusted with respect to "asset disposals", since listed firms might sell or remove any productive assets in that financial year. As a result, net fixed productive assets will be used as the capital input for this study.

Intermediate inputs

This input category mainly includes (i) material input, (ii) energy input, and (iii) purchased services and outsourcing. Purchased services and outsourcing are also considered an intermediate input. For example, firms may use services from other outsourcing companies such as security, cleaning, and IT services. Coelli et al. (2005) also mentioned that these three inputs are normally aggregated into one category called "other inputs". In practice, many empirical studies aggregated costs for materials, fuel, and energy as the intermediate inputs. For instance, Mok et al. (2007) also used intermediate inputs which include costs for materials, fuel, and energy for foreign-invested toy manufacturing firms in China. Lundvall and Battese (2000) aggregated costs for (i) raw materials, (ii) solid and liquid fuel, (iii) electricity and water for Kenyan manufacturing firms as the intermediate inputs. The intermediate inputs can also be used to calculate gross value added (Aw and Batra, 1998; Kim, 2003; Hossain and Karunaratne, 2004).

Costs of raw materials, fuel, electricity, and other production expenses, however, cannot be separated individually for this study due to the limitation of data provided in financial reports. Separate transactions relating to production and non-production costs are not provided in listed firms' financial statements over the period 2000 to 2006. Instead, the sum of production and non-production costs is given. Each transaction for production and non-production costs, however, has been provided in listed firms' financial statements since 2007. As mentioned above, production costs directly occur from a firm's operational process. They are recorded in a listed firm's income statement as "cost of sales", which mainly include (i) material cost, (ii) energy cost, (iii) production labour cost, (iv) depreciation and amortization. Non-production costs (selling and administrative costs) are directly incurred from a firm's administrative process in the head office and company branches, which normally include (i) non-production labour cost, (ii) marketing cost, (iii) transportation cost, (iv) management remuneration, (v) stationary cost, and (vi) other related administrative costs.

To solve this problem, intermediate input costs can be obtained as follows: (i) adding costs for production and non-production together, (ii) subtracting costs obtained from (i) total employee expenditures (the sum of salaries, wages, other employee benefits, depreciation and amortization). The reasons for subtracting total employee expenditures are as follows: (i) total employee expenditures (salaries, wages, and other employee benefits) are also included in costs for production and non-production. These costs, however, are also included in labour input for this study, and, therefore, must be excluded from costs for production and non-production; (ii) depreciation and amortization are normally included in costs for production and non-production. However, these costs are known as accounting costs. In other words, they are not classified as monetary costs for production and non-production. As a result, intermediate inputs for this study mainly include costs for (i) raw materials, (ii) energy, (iii) purchased services and outsourcing, and (iv) other production and non-production costs, excluding salaries, wages, other employee benefits, depreciation and amortization.

Time trend

This study uses unbalanced panel data over the period 2000 to 2008, and, therefore, a time trend can be introduced in the stochastic frontier production function (i.e., Cobb-Douglas and Translog production functions) to represent technological progress. This variable is not classified as an input, but is used to investigate whether technical progress of a selected manufacturing sector is decreasing (or increasing) over a certain period as indicated by the negative (or positive) sign of an estimated time trend coefficient. In addition, the interaction of an estimated time trend coefficient with other estimated input coefficients (i.e., labour and capital inputs) can also be used to investigate whether technical progress has been, for example, labour-saving and capital-using for Thai listed manufacturing enterprises (see Kim, 2003). As a result, a time trend is also introduced into the estimated stochastic frontier production function in Chapter 6.

Adjustments for price changes

Dealing with panel data it is necessary to make appropriate adjustments for price changes before measuring productivity and efficiency. Coelli et al. (2005, p155) suggested that "*the deflator selected must relate to the commodities that constitute the aggregate as closely as possible*". Therefore, appropriate deflators should be selected to make real values (e.g., real value added) for selected output and inputs. For empirical studies different price indices are used to deflate selected outputs and inputs. For instance, Sheu and Yang (2005) used (i) the wholesale price index (WPI) for the electronics industry to deflate annual net sales of a firm (output), (ii) average annual earnings per employee on the payrolls of the electronic industry to deflate annual salary and wage expenditure, (iii) the WPI of capital goods to deflate the value of net fixed assets, and (iv) the WPI of intermediate materials in the electronics industry to deflate material input for panel data for 416 Taiwanese listed electronics firms. Hossain and Karunaratne (2004) used (i) the wholesale price index (WPI) of industrial products to deflate gross value added, (ii) the WPI of manufacturing excludes fuel and lighting to deflate gross fixed assets, and (iii) the WPI of raw materials to deflate intermediate inputs for Bangladesh manufacturing industries. For Kim (2003) the firms' value added was deflated by the wholesale price index (WPI) of each Korean sub manufacturing industry. Mok et al. (2007) used (i) the ex-factory output price index for consumer goods as the deflator for the gross output, (ii) the price index of raw materials, fuel, and energy as the deflator for the intermediate inputs, and (iii) the capital price index as the deflator for the net value of fixed assets for foreign-invested toy manufacturing firms in China. In addition, Hossain and Karunarantne (2004), Kim (2003), and Mok et al. (2007) all used the number of employees as the labour input, and therefore a price index is not required.

For this study the outputs produced, as measured by annual sales revenue, is deflated by the producer price index (PPI) of the manufacturing sector, which can be obtained from the Bureau of Trade and Economic Indices. The producer price index (PPI) is also equivalent to the wholesale price index (WPI) for Thailand (Bank of Thailand, 2010). The capital input, represented by net fixed productive assets, will be deflated by the PPI of capital goods. The intermediate input will be deflated by the

PPI of intermediate goods. In addition, Coelli et al. (2005, p144) suggested wage costs should be deflated for the industry either over time or across regions within a country. In Thailand, there is no specific index for labour input (i.e., labour price index). Coelli et al. (2005) also pointed out that researchers in several productivity studies are likely to select any price index that can be accessible. With respect to the unavailability of a labour price index for Thailand, the manufacturing PPI, therefore, will be used as the wage deflator for labour input.

5.4.2 Firm specific and business environment variables used for the Stochastic Frontier Analysis (SFA) and the two - stage Data Envelopment Analysis (DEA)

After discussing possible outputs and inputs in Section 5.4.1, one output and three inputs are selected to predict technical inefficiency effects (scores) obtained from the SFA and the first step of the two-stage DEA. The next procedure is to identify business environment and firm-specific variables that could significantly influence a firm's technical inefficiency. In other words, an inefficiency effects model for the SFA and the second-stage of the two-stage Data Envelopment Analysis (DEA) model needs to be examined. This section, therefore, aims to highlight business environment and firm-specific variables that affect a firm's technical inefficiency. With respect to the hypotheses discussed in Section 5.2 a number of business environment and firm-specific variables emphasised in the literature are used to examine their effects on a firm's technical inefficiency, and these can be classified into seven sub-sections as follows: (i) finance, (ii) research and development (R&D), (iii) ownership structure, (iv) types of owned firms (ownership), (v) executive remuneration, (vi) exporting, and (vii) other business environment and firm-specific variables (i.e., firm age, firm size, government assistance, and foreign cooperation) (see Table 5.2).

(i) Variables used for finance (hypotheses 1 and 2)

In this part, two financial aspects are examined as follows: (i) leverage (financial constraints) and liquidity and (ii) internal financing and external financing. A number of financial ratios can be used to represent a firm's leverage, such as the debt to asset ratio (D/A ratio) and the interest coverage ratio (ICR).

Table 5.2: Summary of variables used for hypotheses 1 to 8

Variables used for the production functions	Data Description		
Output variable			
1.Output (Y)	Annual sales revenue deflated by the PPI of the manufacturing sector		
Input variables			
1. Labour input (L)	Total employee expenditure deflated by the PPI of the manufacturing sector		
2. Capital input (K)	Net productive fixed assets deflated by the PPI of capital goods		
3. Intermediate input (IM)	Intermediate inputs deflated by the PPI of intermediate goods		
Time	Time trend (technical progress)		
Variables used for the inefficiency effects model	**Data Description**	**Hypothesis**	**Expected Sign***
Finance			
1. Leverage	The ratio of total debt to total assets (D/A ratio)	H1	(+)
2. Liquidity	The ratio of current assets to current liabilities (Quick ratio)	H1	(-)
3. Internal financing	Dummy variable (1= Short term and long term loans from related parties, 0= otherwise)	H2	(-)
4. External financing	Total interest expenses deflated by the general PPI	H2	(+)
Research and development (R&D)			
1. R&D	Dummy variable (1 = R&D, 0 = otherwise)	H3	(+)
Ownership structure			
1. Controlling ownership	The percentage of equity owned by the largest five shareholders	H4	(+)
2. Managerial ownership	The percentage of equity owned by top executives and board members	H5	(+)
Executive remuneration			
1. Executive remuneration	The ratio of top executive and board member remunerations to total employee expenditures	H7	(+)
Types of owned firms			
1. Foreign-owned firms	Dummy variable (1= Foreign, 0 = otherwise)	H6	(+)
2. Family-owned firms	Dummy variable (1= Family, 0 = otherwise)	H6	(+)
3. Domestic-owned firms	Dummy variable (1= Private domestic, 0 = otherwise)		
4. Hybrid-owned firms	Dummy variable (1= Hybrid, 0 = otherwise)		
5. Joint -owned firms	Dummy variable (1= Joint, 0 = otherwise)		
Exports			
1. Exports (the learning -by-exporting hypothesis)	The ratio of export revenue to total sales revenue (as a percentage)	H8	(+)**
Other factors			
1. Firm Size	Total assets (logarithm)		
2. Age	The number of operating years		
3. Government Assistance	Dummy variable (1 = BOI, 0 = otherwise)		
4. Foreign Cooperation	Dummy variable (1 = Foreign Cooperation, 0 = otherwise)		

Source: Author

Note: *Expected signs are based on the hypotheses and from existing studies which focus on the effects of business environment and firm-specific variables on "*a firm's technical efficiency*"; **Hypothesis 8 is only for the learning-by-exporting hypothesis; The summary of data statistics for all of the variables of all manufacturing firms and sub-manufacturing sectors are provided in Section 6.3, Chapter 6.

Focusing on hypothesis 1 (leverage and liquidity) the leverage ratio represented by the ratio of total debts to total assets (the D/A ratio) is used to capture financial constraints (leverage) for this hypothesis (Sena, 2006; Mok et al., 2007). This debt ratio captures how much a firm is constrained in its expansion (Sena, 2006). The interest coverage ratio (earnings before interest and taxes (EBIT) / total interest expense) is not applicable for this study, since an inefficiency effects model using FRONTIER 4.1 is not applicable for such a negative value of the interest coverage ratios. The interest coverage ratios are also found to be widely dispersed among Thai listed manufacturing enterprises.

In addition, liquidity can be represented either by the current ratio (current assets / current liabilities) or the quick ratio ((current assets – inventories) / current liabilities). Goldar et al. (2003) applied the quick ratio to examine the liquidity of Indian engineering firms on their technical efficiency. The current ratio (current assets/current liabilities), however, is used for this study to examine the effect of a firm's liquidity on its technical efficiency. The current ratio captures the ability of a firm to meet its short-term liabilities, which is quite similar to the quick ratio, except inventories are included in current assets in the current ratio. Moreover, the debt to asset and current ratios can be calculated from listed firms' balance sheets.

Focusing on hypothesis 2, a dummy variable is used for internal financing. The number "1" is assigned when a listed manufacturing firm has short-term and long-term loans from related parties (i.e., executives, major shareholders, related and subsidiary firms), and the number "zero" is assigned when a listed manufacturing firm does not have any loan from related parties. The reason that the real value of internal loans cannot be used for hypothesis 2 is because this item cannot be observed for many listed manufacturing firms over the period 2000 to 2008, while high volumes of internal loans are also observed in a number of listed manufacturing firms. In other words, the raw observations obtained from the balance sheets of listed manufacturing firms are widely dispersed, and therefore the dummy variable used for internal financing is a good proxy in examining this hypothesis. For external financing, Kim (2003) used interest expense as represented by the ratio of total interest payments on borrowed capital to total capital for external financing.

Therefore, interest expenses deflated by the general Producer Price Index (PPI) is used for external financing for hypothesis 2, which can be obtained from listed manufacturing firms' statement of incomes.

(ii) Variables used for research and development (R&D) (hypothesis 3)

Empirical studies such as that of Sheu and Yang (2005) and Kim (2003) used R&D expenditure and the ratio of R&D spending to total output, respectively, as proxies for research and development (R&D). Dilling - Hansen et al. (2003) used a dummy variable as a proxy for R&D activity. However, there is some difficulty in obtaining R&D expenditure for this hypothesis, since only some of the listed manufacturing firms provided annual R&D expenditures in Form 56-1. Moreover, some listed manufacturing firms did not report their annual R&D expenditures continuously over the period 2000 to 2008. The information that can be obtained in the R&D section of the Form 56-1 is R&D activities in new products and new processes only for each year. To solve this problem, a dummy variable is applied for R&D activities[68]. The number "1" is given to Thai listed manufacturing firms which engage in R&D, but the number "0" is given to those firms which do not participate in R&D.

(iii) Variables used for ownership structure (hypotheses 4 and 5)

Controlling ownership (hypothesis 4)

In the literature, controlling ownership has been measured by the percentage of equity owned by the five largest shareholders (Wiwanttanakantang, 2001; Yammeesri and Lodh, 2003; Zeitun and Tian, 2007). This is the approach adopted in this study. The list of shareholders for each listed manufacturing firm is used to calculate this variable by summing up the equity owned by the five largest shareholders expressed as a percentage of total equity.

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[68] R&D may have a lagged effect on a firm's technical efficiency, since it takes some time to increase the firm's technical efficiency. Due to data limitation a R&D dummy variable is used instead of R&D expenditure. In addition, most listed manufacturing firms engaged in R&D, were unlikely to report their R&D activities consecutively. For example, if the firm engages in R&D activities, "1" will be given over the years. Therefore, a lagged R&D variable is not applicable for this study.

Variables used for managerial ownership (hypothesis 5)

The variable for managerial ownership can be obtained by combining the percentage of equity owned by board members and top executives (Wiwattanakantang, 1999; Yammeesi and Lodh, 2003; Liao et al., 2010). From Form 56-1 board members consist of (i) executive board members, (ii) non-executive board members, and (iii) audit committees. In addition, executive board members normally have control over their listed firms. The variable for managerial ownership can be obtained from the "management" section of Form 56-1. This section normally provides the percentage of equity owned by each board member and top executives. However, some listed manufacturing firms only provide the number of stocks owned by board members and top executives. In this case the percentage of equity owned by board members and top executives can be calculated as the ratio of equity owned by top executives and board members to a listed firm's total paid equity multiplied by a hundred.

(iv) Variable used for executive remuneration (hypothesis 6)

The variable used for executive remuneration only focuses on monetary (cash) rewards for top executives and board members including (i) salaries, (ii) bonuses, and (iii) other remunerations (i.e., meeting allowances, superannuation, and medical allowances). Other non-cash rewards are excluded from this variable, such as (i) warrants issued for top executives and board members, and (ii) properties (i.e., cars and houses given to top executives during their period of employment). The reasons that non-cash rewards are excluded from this variable are as follows: (i) Even though warrants are given to executives and board members they must still pay cash to convert warrants into listed firms' shares. As a result some top executives and board members may not have converted warrants to their listed companies' stocks. (ii) Properties normally belong to listed firms, but are given to top executives or board members only for the period of their employment. As a result the variable representing executive remuneration excludes non-cash items. Executive remuneration is then calculated by the ratio of top executive and board remunerations to total employee expenditures. Information used to calculate this variable is obtained from the "management" section of Form 56-1.

(v) Variables used for types of owned firms (hypothesis 7)

Focusing upon different types of owned firms a dummy variable is used to classify each type of ownership Claessens et al. (2000) defined the controlling shareholder (ultimate owner) by adopting cut-off shareholding levels of 10 percent and 20 percent to study ultimate control for businesses in nine Asian countries such as Hong Kong, Indonesia, Japan, Korean, Malaysia, Philippines, Singapore, Taiwan, and Thailand.

However, according to the Public Limited Companies Act B.E. 2535 of Thailand (Section 31)[69], shareholders must have at *least 75 percent* of their voting rights to obtain the absolute power over the public limited firm. In addition, Wiwattanakantang (2001) and Yammeesri and Lodh (2003) used the cut-off shareholding level of at least 25 percent for Thai listed enterprises. Hence, it is much more appropriate to adopt a cut-off shareholding level of 25 percent for Thailand. The Form 56-1 and the list of shareholders are used to classify these ownership variables. The dummy variable used for family - owned firms can be constructed by examining the family relationship among the executive board members, top executives, and shareholders. In addition, some insolvent family-owned firms are controlled by the planner appointed by the Bankruptcy Court. These firms are also excluded from this firm category, since they do not have the control over their firms. The sections of "management" and "reference information" provided in the Form 56-1 normally provide the information with respect to the family relationship among board members and executive shareholders.

In some cases, private companies are major shareholders. If these private companies are owned by the same top executives or board members, a listed firm is normally required to declare this related ownership transaction in the "capital

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[69] According to the Public Limited Companies Act B.E. 2535 of Thailand, Section 31, "The company may amend the memorandum or the articles of association of the company only when a resolution therefore has been passed at the meeting of shareholders by ***not less than three-fourths of the total number of votes of shareholders*** attending the meeting and having the right to vote. For amending the memorandum of association or the articles of association of the company, the company shall apply to register the amendment within fourteen days as from the date on which the resolution was passed at the meeting" (source: http://www.lawreform.go.th/lawreform/images/th/legis/en/act/1992/12878.pdf (24/03/2009)).

structure" section of the Form 56-1[70]. However, it is possible that they do not report this transaction in the Form 56-1. The Business Online (BOL)'s database is also used to trace the owners of private companies. Similarly, the dummy variable for foreign - owned firms can also be conducted by the same procedure. In addition, a dummy variable can be used for hybrid-owned firms if dispersed shareholders (who hold less than a 25 percent shareholding) are observed in any listed manufacturing firm. A dummy variable can be used for domestic-owned firms where another type of ownership entity (i.e., government, banks, the crown property bureau, and firms under the Bankruptcy Court)[71] holds at least a 25 percent shareholding level. A dummy variable is used for jointly-owned firms where Thai shareholders, or a group of foreigners, control the listed manufacturing firms. However, each partner must obtain at least a 25 percent shareholding level.

(vi) Variables used for the learning-by-exporting and self-selection hypotheses (hypothesis 8)

The variable used to capture the learning-by-exporting hypothesis is the ratio of total exports to total sales, expressed as a percentage. Export sales can be obtained from "notes to financial statements" of the financial reports, or the "business operations of the firm" section of the Form 56-1. However, export sales obtained from financial reports are preferable, since they cover export sales among related or subsidiary firms. For the self-selection hypothesis two main variables are required: (i) technical efficiency scores obtained from both the Stochastic Frontier Analysis (SFA) and the two-stage Data Envelopment Analysis (DEA) approaches are required as the independent variables, and (ii) the dummy variable for export participation is required as the dependent variable (see Table 5.3).

Both SFA and DEA technical efficiency scores will be obtained for this study, and, therefore, they can be used to confirm that the self-selection hypothesis exists for the case of Thai listed manufacturing enterprises. Besides examining the self selection hypothesis as show in Table 5.3, there are a number of variables that

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[70] The identities of the ultimate beneficial owners of those shareholdings and related party transactions must be disclosed by the SEC regulations (World Bank, 2005, p3).

[71] The reason that these ownership entities are combined together as domestic-owned firms is that they represent only a small number of firms.

affect a firm's export participation such as firm size, firm age, leverage, and foreign investment.

Table 5.3: Summary of variables used for hypothesis 8 (the self-selection hypothesis*)

Variables	Data Description	Hypothesis	Expected
Dependent variable			
Export participation	Dummy variable (1= Export Participation, 0 = otherwise)		
Independent variables:			
Technical inefficiency scores	Technical inefficiency scores obtained from the SFA approach	H8	(+)
	Technical inefficiency scores obtained from the DEA approach	H8	(+)
Other independent variables:			
Firm size	Total assets (logarithm)		
Firm age	The number of operating years (logarithm)		
Leverage	The ratio of total debt to total assets (D/A ratio)		
Foreign investment	The percentage of equity owned by foreigners		

Source: Author
Note: *The Probit model is conducted in examining the self-selection hypothesis.

Total assets are used as a proxy of firm size. The number of operating years is used as a proxy of firm age. It is also very interesting to study the effect of financial constraints (leverage) on a firm's export participation, since very few empirical studies have examined the relationship between financial constraints (leverage) and a firm's export participation (Greenaway et al., 2007; Bellone et al., 2010). The ratio of total debt to total assets (D/A ratio) is used as a proxy of firm leverage. Finally, the effect of foreign investment on a firm's export participation is also investigated, and the percentage of equity owned by foreigners is used as a proxy of foreign investment.

(vii) Variables used for other firm-specific and business environment factors

Besides the business environment and firm-specific variables used for the previous eight hypotheses, from Table 5.2 there are a number of variables that affect a firm's technical efficiency[72], such as (i) firm size, (ii) firm age, (iii) government assistance, and (iv) foreign cooperation (see Section 3.9, Chapter 3). These variables can be explained as follows:

[72] According to Kohpaiboon (2006, p148) the effect of any possible exogenous factors on "*industry productivity* (labour productivity)" would be conditioned by the degree of market competition (e.g.,

(i) Firm size

The variable used to capture the effect of firm size on its technical efficiency can be represented as either (i) total assets (Kim, 2003; Sheu and Yang, 2005; Liao et al., 2010), (ii) the number of employees (Bottasso and Sembenelli, 2004), or (iii) intermediate inputs (Lundvall and Battese, 2000; Hossain and Karunaratne, 2004; Oczkowski and Sharma, 2005). Total assets[73] are used as the proxy for firm size for this study, since the number of workers is not completely available as discussed in Section 5.4.1. This variable can be collected from the balance sheets of listed firms.

(ii) Firm age

The variable used for firm age is represented by the number of operating years (Lundvall and Battese, 2000). This variable can be obtained from the "nature of business operation" section of Form 56-1.

(iii) Government assistance

A dummy variable for government assistance will be used in this study. Government assistance is based on promotional privileges received from the Board of Investment (BOI)[74]. According to financial reports provided, promotional privileges can be any of the following promotional privileges or a combination of these promotional privileges, such as (i) exemption from corporate income tax on net

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the sum of the five largest firms (CR5) and the Herfindahl-Hirshman index of concentration (HHI)) under the assumption that two industries with "*the same technical efficiency*" may indicate different levels of labour productivity. These variables, however, are not suitable in the context of Thai listed manufacturing firms as follows (i) the 178 Thai listed manufacturing firms used in this study are fairly "*homogeneous*", since their sizes are all large due to the SET's listing criteria. Kohpaiboon (2006), however, used 15,624 firms which are "heterogeneous", consisting of micro, small, medium, and large enterprises; (ii) this thesis aims to examine the effects of firm-specific and business variables on technical efficiency at the firm level focusing upon only 4 manufacturing sub-sectors. Kohpaiboon (2006), however, examined the factors affecting labour productivity for the entire Thai manufacturing sector, including locally owned industry in aggregate across 105 industries.

[73] The standard deviation of Thai listed firms' total assets is very large. Therefore, the logarithm form for total assets is introduced in this model.

[74] Government assistance can have a lagged effect on a firm's technical efficiency, since it takes some time to increase the firm's technical efficiency. Due to data limitation a dummy variable is used as a proxy for government assistance instead of government assistance expenditure. A lagged dummy variable for government assistance, therefore, is not applicable for this analysis. The reasons are as follows: (i) most of the listed manufacturing firms which received BOI privileges were likely to report this transaction consecutively in their annual reports, according to the period of the BOI privileges granted. For example, if the firm receives BOI privileges, "1" will be given over the years; (ii) unlike other types of government assistance (e.g., providing training courses) BOI privileges mainly focus on financial assistance (e.g., the corporate income tax exemption and the import duty exemption on machinery), which can be used to increase the firm's revenue immediately.

income from the promoted activities, (ii) a 50 percent reduction of corporate income tax on net income from the promoted activities, (iii) exemption from import duty on machinery, and (iv) exemption from import duty on essential raw materials and supplies imported for manufacturing products for export sales.

(iv) Foreign cooperation

A dummy variable for foreign cooperation is also considered for this study, which includes (i) technical assistance from foreign partners (e.g., providing new knowledge or a new technique in operating the businesses of Thai listed manufacturing firms) and (ii) assistance from foreign partners in exporting to new foreign markets (e.g., providing new foreign customers via their networking). The "business operations of the company" section of Form 56-1 can provide this information. In some cases foreign technical assistance is also recorded in financial reports, since listed manufacturing firms have the obligation to pay for such technical assistance. Therefore, a dummy variable is used in this study to capture foreign cooperation.

5.5 Conclusions

This chapter has provided the context for the eight hypotheses to be examined in Chapter 6. These eight hypotheses specifically aim to investigate the relationship between business environment and firm-specific variables and firm technical efficiency (see Section 5.2). The raw data used to conduct the empirical analysis in Chapter 6 have been obtained from the Stock Exchange of Thailand (SET), which consists of (i) the list of board of directors and major shareholders, (ii) financial reports, and (iii) annual reports of Thai listed companies (the Form 56-1). With regard to the International Standard Industrial Classification of all economic activities (ISIC), some listed firms that are not classified as manufacturing firms are removed from the study. In addition, some listed manufacturing firms that had been delisted from the SET during 2000 to 2008 are also included in the study. As a result, 178 listed manufacturing firms over the period 2000 to 2008 are used to conduct the empirical analysis in Chapter 6. From Table 5.1 there are six sub-manufacturing sectors, such as Agro and Food Industry, Consumer products, Industrials, Publishing, Construction Materials, and Technology. However, publishing, construction materials, and technology are grouped as "Other Sectors" due to the small number of firms in each sector.

With respect to the hypotheses discussed in Section 5.2, firm technical inefficiency effects (scores) to be used as the dependent variable can be predicted by the Stochastic Frontier Analysis (SFA) approach through an estimated stochastic frontier production function, and via the first step of the two-stage Data Envelopment Analysis (DEA) approach. More specifically, technical inefficiency effects (scores) are predicted by employing one output and three inputs. Annual sales revenue deflated by the manufacturing Producer Price Index (PPI) is used as the output. Net fixed productive assets deflated by the PPI for capital goods, total employee expenditures deflated by manufacturing PPI, and intermediate inputs deflated by PPI for intermediate goods, are used as the capital, labour, and intermediate inputs, respectively. A time trend is also introduced to capture technological progress for the unbalanced panel data used in this study.

Business environment and firm-specific variables (independent variables) can be grouped into seven categories such as (i) finance, (ii) research and development (R&D), (iii) ownership structure, (iv) types of owned firms (ownership), (v) executive remuneration, (vi) exports, and (vii) other business environment and firm-specific factors. Finance can be sub-grouped into two categories: (i) financial constraints (leverage) and liquidity (hypothesis 1) and (ii) external financing and internal financing (hypothesis 2). First, the debt to asset and the current ratios are used for financial constraints (leverage) and liquidity, respectively (see hypothesis 1). Second, a dummy variable is used to capture internal financing and interest payment deflated by the general Producer Price Index is used to capture external financing for hypothesis 2. In addition, a dummy variable is used to represent R&D activities for hypothesis 3. For ownership structure, controlled and managerial ownerships are captured by the percentage of equity owned by the five largest shareholders and the percentage of equity owned by top executives and board members, respectively (see hypotheses 5 and 6). Moreover, the ratio of top executive and board member remunerations to total employee expenditures is used as the proxy for executive remuneration (see hypothesis 6).

Types of owned firms are classified into (i) family-owned firms, (ii) foreign-owned firms, (iii) domestic-owned firms, (iv) hybrid-owned firms, and (v) joint-owned firms. A cut-off shareholding level of 25 percent is adopted to classify these types of owned firms. Family and foreign owned firms are mainly focused upon in this study. The effects of family and foreign owned firms on a firm's technical efficiency are examined by hypothesis 7. For hypothesis 8 there are two sub hypotheses: (i) the learning-by-exporting hypothesis and (ii) the self - selection hypothesis. The classification of these ownership types as well as controlling and managerial ownerships are based on the finance literature (see Section 3.5, Chapter 3), and therefore it leads to the uniqueness of this thesis when linking these ownership variables with technical efficiency.

Focusing on the learning-by-exporting hypothesis, the independent variable is represented by the export revenue to total sales revenue ratio and the SFA and DEA technical inefficiency scores are used as the dependent variables. For the self-selection hypothesis a dummy variable is used to capture export participation as the dependent variable while the SFA and DEA technical inefficiency scores are applied as the independent variables (see Table 5.3). In the following chapter the results from an empirical analysis of the eight hypotheses is presented.

CHAPTER 6

EMPIRICAL MODELS AND RESULTS

6.1 Introduction

The objective of this chapter is to conduct an empirical analysis with respect to the hypotheses discussed in Chapter 5. This chapter employs both the Stochastic Frontier Analysis (SFA) and two-stage Data Envelopment Analysis (DEA) approaches, since both estimation approaches have advantages and disadvantages as discussed in Chapter 4. Therefore, there is no reason to favour one estimation technique over the other, and it is reasonable to analyse the firm's technical efficiency using both estimation techniques to "cross-check" the results as suggested in a number of contributions in the efficiency literature (Bauer et al., 1998; Stone, 2002; Jacobs et al., 2006; Miranda et al., 2010).

This study uses unbalanced panel data for 178 Thai listed manufacturing enterprises covering the period 2000 to 2008. For the SFA approach the Battese and Coelli (1995) model is applied by estimating (i) a stochastic frontier production function which is selected by using likelihood-ratio test statistics (see Section 6.4), and (ii) an inefficiency effects model simultaneously using FRONTIER Version 4.1. In other words technical inefficiency effects, which are predicted through estimates of the stochastic frontier production function, are regressed with business environment and firm-specific variables simultaneously. For the two-stage DEA approach the first stage is to predict technical inefficiency scores using variable returns to scale (VRS) linear programming as analysed by the Data Envelopment Analysis (Computer) Program (DEAP) Version 2.1. In the second stage the maximum likelihood Tobit model is applied, in which technical inefficiency scores[75] are regressed with business environment and firm-specific variables. Moreover, the maximum likelihood Probit model is used to investigate the effect of a firm's

[75] Technical inefficiency scores are obtained by subtracting the efficiency score predicted by DEAP Version 2.1 from "unity" (Sirasoontorn, 2004).

technical efficiency on its export participation (the self-selection hypothesis) as discussed in Chapter 5.

The organization of this chapter is as follows: Section 6.2 provides an overview of the empirical models to be utilized in this study consisting of the stochastic frontier production function model (Section 6.2.1) and the two-stage Data Envelopment Analysis (DEA) model (Section 6.2.2). Data statistics are provided in Section 6.3. Hypothesis tests are conducted in Section 6.4. Section 6.5 is divided into three sub sections as follows: The empirical results obtained from the Stochastic Frontier Analysis (SFA) approach are provided in Section 6.5.1 Section 6.5.2 illustrates the empirical results obtained from the two-stage Data Envelopment Analysis (DEA) approach. Section 6.5.3 compares the empirical results between the Stochastic Frontier Analysis (SFA) and two-stage Data Envelopment Analysis (DEA) approaches. In addition, the self-selection hypothesis for Thai listed manufacturing enterprises, as discussed in Chapter 5 (part of hypothesis 8), is examined in Section 6.6, by applying the maximum likelihood Probit model. Finally, the conclusions for this chapter are provided in Section 6.7.

6.2 Empirical models

This section aims to explain the parametric and non-parametric models used in this chapter, specifically the Stochastic Frontier Analysis (SFA) and the Two-stage Data Envelopment Analysis (DEA) approaches. As discussed in Chapter 4 there are important differences between the SFA and the DEA approaches. SFA requires functional forms for the production frontier and assumes that firms may deviate from the production frontier not only due to technical inefficiency but also from measurement errors, statistical noise or other non-systematic influences (Admassie and Matambalya, 2002). In addition, SFA requires strong distributional assumptions of both statistical random errors (i.e., normal distribution) and non-negative technical inefficiency random variables (i.e., half-normal distribution for time-invariant inefficiency model (Pitt and Lee, 1981), and truncated normal distribution for both the time-invariant inefficiency model (Battese and Coelli, 1988) and the time-variant inefficiency model (Battese and Coelli, 1992, 1995). The DEA approach, however, does not impose functional forms, and uses linear programming to construct a frontier that envelops the observations of all firms. Hence, all firms are compared relative to the "best" performing firms. It also overcomes restrictions on the production and distribution of various residuals.

6.2.1 The stochastic frontier production function model

According to Schmidt and Sickles (1984) and Kumbhakar and Lovel (2000) as previously discussed in Section 4.3.1 (iii), Chapter 4, the preferred model for capturing firm inefficiency is the stochastic frontier production function model based on the time-variant efficiency model of Battese and Coelli (1995).

The model of Battese and Coelli (1995) allows the technical efficiency levels to change over time, since firms expect to learn from their learning-by-doing experience. As the panel becomes larger the technical efficiency effects would change. The model consists of two main components. The first component is to estimate the time-varying stochastic frontier production function which contains two random errors: (i) random errors (V_{its}) and non-negative random variables (U_{its}). The first random errors, which are assumed to be independently and identically distributed normal random variables with zero means and variances, σ_v^2 ($V_{it} \sim iid\ N(0, \sigma_v^2)$), can be observed, for example, when the problems of omitted variables and model misspecification arise. The second non-negative random variables which are assumed to be independently and identically distributed normal random variables as truncations at zero with $Z_{it}\delta$ means and variances σ_u^2 ($U_{it} \sim iid\ N(0, \sigma_u^2)$) are known as the technical inefficiency effects. In addition, these two random variables are assumed to be independently distributed for all time periods (t=1,2,…..,T) and all firms (i=1,2,….,N).

The second component links business environment and firm-specific variables (i.e., types of firm ownership, government assistance, firm age, and firm size) with the inefficiency effects or the non-negative random variables. In other words, this part aims to examine what business environment and firm-specific variables significantly affect the firm's inefficiency. The stochastic frontier production function and the inefficiency effects will be simultaneously estimated by the method of maximum likelihood (ML) [76] which has desirable large sample (or asymptotic) properties. More specifically, the ML estimator is consistent and asymptotically efficient (Coelli, 2005, p218).

FRONTIER Version 4.1 is used to conduct a single - step process[77] in which the stochastic frontier production and the model of technical inefficiency effects are estimated simultaneously by the method of maximum likelihood estimation (Quasi-Newton methods) (Coelli, 1996a). This software utilizes the parameterisation from Battese and Corra (1977) by replacing σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\Upsilon = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$. The technical inefficiency for the i^{th} firm in the Battese and Coelli (1995) model is given by TE_{it} = exp (-U_{it},) = exp (-$Z_{it}\delta$ - W_{it}). Applying the model of Battese and Coelli (1995), the stochastic frontier production functions in the Cobb-Douglas and Translog functional forms are tested for adequate functional form. The Cobb-Douglas functional form can be written as:

$$Ln(Y_{it}) \ = \beta_0 + \beta_1 \ \ln(L_{it}) + \beta_2 \ \ln(K_{it}) + \beta_3 \ \ln(IM_{it}) + \beta_4 \ (t) + \ V_{it} - U_{it} \quad (6.1)$$

The Translog functional form can be written as:

$$\begin{aligned} Ln(y_{it}) = {} & \beta_0 + \beta_1 \ \ln(L_{it}) \ + \beta_2 \ \ln(K_{it}) \ + \beta_3 \ \ln(IM_{it}) + \beta_4 \ (t) + \tfrac{1}{2}\beta_5 \ \ln(L_{it}^2) \ + \\ & \tfrac{1}{2}\beta_6 \ \ln(K_{it}^2) \ + \tfrac{1}{2}\beta_7 \ \ln(IM_{it}^2) \ + \tfrac{1}{2}\beta_8 \ (t^2) + \beta_9 \ \ln(L_{it}) * \ln(K_{it}) + \\ & \beta_{10} \ \ln(L_{it}) * \ln(IM_{it}) + \beta_{11} \ \ln(L_{it}) * (t) + \beta_{12} \ \ln(K_{it}) * \ \ln(IM_{it}) + \\ & B_{13}(K_{it}) * (t) + B_{14}(IM_{it}) * (t) + V_{it} - \ U_{it} \qquad (6.2) \end{aligned}$$

Where:

Y_{it} = Sales revenue deflated by the manufacturing Producer Price Index (PPI) of firm *i* at time *t*

L_{it} = Employee expenses deflated by the manufacturing Producer Price Index (PPI) of firm *i* at time *t*

[76] According to Coelli *et al.* (2005, p245), the method of maximum likelihood is preferred to other estimation techniques in computing measures of technical efficiency, such as ordinary least squares (OLS) and corrected ordinary least squares (COLS). The OLS estimates cannot be used to compute the firm's technical efficiency, since the estimated "intercept" coefficient obtained from the OLS is "biased downwards" even though the estimated "slope" coefficients are consistent.

[77] See footnote 48 in Chapter 4 for the reason why the one-stage process is more preferred than the two-stage process.

K_{it} = Net productive fixed assets deflated by the Producer Price Index (PPI) of capital goods of firm *i* at time *t*

IM_{it} = Intermediate inputs deflated by the Producer Price Index (PPI) of intermediate inputs of firm *i* at time *t*

V_{it} = Random error ($V_{it} \sim N(0, \sigma_V^2)$)

U_{it} = Non-negative random variable (or technical inefficiency) ($U_{it} \sim N(Z_{it}\delta, \sigma_u^2)$)

The Inefficiency Effects Model for this study can be written as follows:

$$\begin{aligned} U_{it} = {} & \sigma_0 + \sigma_1 LEV_{it} + \sigma_2 LIQ_{it} + \sigma_3 INF_{it} + \sigma_4 EXF_{it} + \sigma_5 EXC_{it} + \sigma_6 TOP5_{it} \\ & + \sigma_7 MGR_{it} + \sigma_8 EXP_{it} + \sigma_9 R\&D_{it} + \sigma_{10} GOVT_{it} + \sigma_{11} FCO_{it} \\ & + \sigma_{12} SIZE_{it} + \sigma_{13} AGE_{it} + \sigma_{14} FAM_{it} + \sigma_{15} FGR_{it} + \sigma_{16} DOM_{it} \\ & + \sigma_{17} HYD_{it} + W_{it} \end{aligned} \tag{6.3}$$

All of the below variables are described in detail in Section 5.4 of Chapter 5.

Where:

LEV_{it} = Leverage of firm *i* at time *t*, represented by the ratio of total debt to total assets (the D/A Ratio)

LIQ_{it} = Liquidity of firm *i* at time *t*, represented by the ratio of current assets to current liabilities (the Current Ratio)

INF_{it} = Dummy for internal financing;

INF_{it} = 1 if firm *i* at time *t* borrows from related parties.
= 0, otherwise

EXF_{it} = External financing, represented by total interest expenses deflated by the general Producer Price Index (PPI)

EXC_{it} = Executive Remuneration of firm *i* at time *t,* represented by the ratio of top executive and board member remunerations to total employee expenses

$TOP5_{it}$ = Controlling ownership of firm *i* at time *t*, represented by the percentage of equity owned by the five largest shareholders

MGR_{it} = Managerial ownership of firm *i* at time *t,* represented by the percentage of equity owned by top executives and board members[78]

EXP_{it} = Exports of firm *i* at time *t,* represented by the ratio of export revenue to total sales revenue

$R\&D_{it}$ = Dummy for research and development:

$R\&D_{it}$ = 1 if firm *i* at time *t* has R&D.
= 0, otherwise

$GOVT_{it}$ = Dummy for Government assistance

$GOVT_{it}$ = 1 if firm *i* at time *t* receives Board of Investment (BOI) support.
= 0, otherwise

FCO_{it} = Dummy for foreign cooperation

FCO_{it} = 1 if firm *i* at time *t* engages in foreign cooperation
= 0, otherwise

$SIZE_{it}$ = Size of firm *i* at time *t*, represented by total assets in the natural logarithm form

AGE_{it} = Age of firm *i* at time *t,* represented by the number of operating years

FAM_{it} = Dummy for a family-owned firm:

FAM_{it} = 1 if firm *i* at time *t* is a family-owned firm.
= 0, otherwise

FGR_{it} = Dummy for a foreign-owned firm:

FGR_{it} = 1 if firm *i* at time *t* is a foreign-owned firm.
= 0, otherwise

[78] There might be some concern regarding the high correlation between controlling ownership and managerial ownership variables, since they might be inter-related and their impacts on a firm's technical efficiency are not mutually exclusive. The result of the correlation test shows that both explanatory variables have a negative relationship and they are not correlated (r = -0.009578). More importantly, the maximum likelihood (ML) estimation is used for this thesis, and therefore the assumptions underlying OLS (e.g., no multicollinearity) are not considered for the ML estimation (see Wooldridge, 2006, pp347-354).

DOM_{it} = Dummy for a domestic-owned firm:

DOM_{it} = 1 if firm i at time t is a domestically-owned firm.

= 0, otherwise

HYD_{it} = Dummy for a hybrid-owned firm:

HYD_{it} = 1 if firm i at time t is a hybrid-owned firm.

= 0, otherwise

W_{it} = Random error ($W_{it} \sim N(0, \sigma_W^2)$)

6.2.2 Two-stage Data Envelopment Analysis (DEA)

As previously discussed in Section 4.3.2, Chapter4, this study applies the variable returns to scale (VRS) linear programming problem to predict the technical efficiency for the first-stage of the two-stage DEA approach (F$\ddot{a}$re, et al., 1983; Banker, et al. 1984). The VRS assumes that firms are not operating at an optimal scale due to imperfect competition, government intervention, and financial constraints (Coelli et al., 2005). In addition, the output orientated model is used assuming fixed input amounts and maximized output production. The VRS linear programming program under the output orientated model can be written as follows (Coelli et al., 2005, p180):

$$
\begin{aligned}
& Max_{\varphi,\lambda} \quad \varphi, \\
\text{st} \quad & -\varphi y_i + Y\lambda \geq 0, \quad \text{i=1,2,....,n,} \\
& x_i - X\lambda \geq 0, \\
& \mathrm{I}1'\lambda \leq 1, \\
& \lambda \geq 0,
\end{aligned} \tag{6.4}
$$

Where:

φ is a scalar. $1 \leq \varphi < 0,$ and $\varphi - 1$ is the proportional increase in outputs (y_i) which can be obtained for the i^{th} firm, while holding input amounts (x_i) constant.

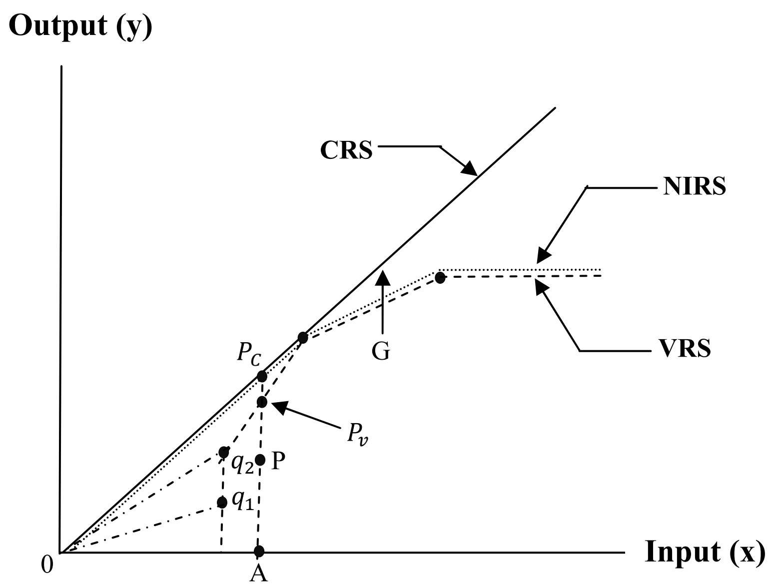
$\frac{1}{\varphi}$ is the efficiency score for the i^{th} firm.

x_i is an input vector for the i^{th} firm. $\boldsymbol{\lambda}$ is a vector of constants.

$\mathrm{I}1'\lambda \leq 1$ defines non-increasing returns to scale (NIRS).

The DEA problem under Equation (6.4), for example, takes the firm i, and radially expands the output vector of the firm i (y_i) as much as possible, while still remaining within the feasible output set. The inner-boundary of this output set is a piece-wise linear production possibility curve which is determined by all the firms in the sample (see Figure 6.1). The DEA model in linear programming (6.4) also replaces the convexity constraint which is imposed for the VRS: $I1'\lambda = 1$ for $I1'\lambda \leq 1$. The modified $I1'\lambda \leq 1$ indicates that the VRS can only be non-increasing. In other words, the constraint: $I1'\lambda \leq 1$ is set to ensure that the i^{th} firm is compared with firms that are smaller than it (Coelli et al., 2005, p174). The linear programming problem (6.4) can also be illustrated in Figure 6.1 as follows:

Figure 6.1: Efficiency measurement under the output-orientated DEA model



Source: Author

Note: Figure 6.1 is modified from Figures 3.7 and 6.3 of Coelli et al. (2005, p 55, 171). The original figures described input- and output- orientated technical efficiency measures and Returns to Scale (Figure 3.7), and the scale efficiency measurement under the input-orientated DEA model (Figure 6.3).

Figure 6.1 only explains the case of one output and one input as an example. The VRS technical inefficiency is expressed, for example, by the distance between P to P_V. The CRS technical inefficiency is expressed by the distance between P to P_c . The difference between the CRS and VRS technical inefficiencies, which is given by the distance between P_c to P_V, indicates scale inefficiency. In addition, the VRS technical efficiency can be expressed by the distance ratio AP_v to AP, while the CRS technical efficiency can be expressed by the ratio AP_c to AP The scale efficiency is simply the ratio of the CRS technical efficiency to the VRS technical efficiency (AP_c/ AP_v). However, the disadvantage of this measure of scale efficiency is that it does not indicate whether a firm is operating under increasing, constant, or decreasing returns to scale. The term, non-increasing returns to scale ($I1'\lambda \leq 1$) technical efficiency is imposed in conducting further analysis for increasing, constant, and decreasing returns to scale. If the non-increasing returns to scale (NIRS) technical efficiency score is equal to the VRS technical efficiency score, for example, as is the case for point G, then decreasing returns to scale exist. If the NIRS technical efficiency score and the VRS technical efficiency score are not equal (as is the case for point P), then increasing returns to scale apply (F$\ddot{a}$re et al., 1983). If the CRS technical efficiency is equal to VRS technical efficiency, constant returns to scale apply.

One problem of the piece-wise linear frontier in DEA is that firms operating parallel to the axes causes the problem of “slacks”. For the output-orientated model shown in Figure 6.1 this problem is also known as “output slack” (or output excess), since a firm’s production can be increased without using any more inputs. There are a number of methods that can be used to treat the problem of slack (e.g., one-stage DEA, two-stage DEA, and multi-stage DEA). As previously discussed in Section 4.3.2 (i) of Chapter 4, multiple-stage DEA can be useful, since it is invariant to units of measurement and its efficient projected points have input and output mixes that are similar to those of the inefficient points as strongly recommended by Coelli et al. (2005). Hence, multi-stage DEA will be selected in this study to predict the VRS technical efficiency as well as the CRS technical efficiency for the first-stage of the two-stage DEA model. The second stage of the two-stage DEA model is conducted by regressing business environment and firm-specific variables on the firm’s VRS technical inefficiency scores which are predicted from the first step of the two-stage DEA model. The firm’s technical inefficiency scores are used as the dependent variable, which is obtained by subtracting the efficiency scores estimated from the DEA model from “unity”.

The set of business environment and firm-specific variables are used as independent variables for the two-stage DEA model. The estimated inefficiency scores are normally bounded between zero and one. Applying the method of Ordinary Least Squares (OLS) with such a dependent variable that its values are bounded between zero and one will lead to biased and inconsistent estimators, since the OLS method is likely to predict inefficiency scores which are greater than one (Kumbhakar and Lovell, 2000; Coelli et al., 2005).

Therefore, the Maximum Likelihood estimation for a two-limit Tobit model[79] is adopted (Hoff, 2006; McDonald, 2009), which is given as follows:

$$(1-\theta_{it})^{*} = \sigma_0 + \sum_{j=1}^{j=17} \sigma_{jt}\, z_{jt} + \varepsilon_{it} \qquad (6.5)$$

$$(1-\theta_{it}) = \begin{cases} (1-\theta_{it})^{*} & if\ \ 0 < (1-\theta_{it})^{*} < 1 \\ 0 & if\ (1-\theta_{it})^{*} \leq 0 \\ 1 & if\ (1-\theta_{it})^{*} \geq 1 \end{cases}$$

Where:

$(1-\theta_{it})^{*}$ = Unobserved inefficiency scores of firm *i* at time *t*.

$(1-\theta_{it})$ = Observed inefficiency scores of firm *i* at time *t*.

σ_{jt} = Unknown parameter to be estimated for each business environment or firm-specific variable *j* at time *t*

z_{jt} = Business environment or firm-specific variables *j* at time *t*

ε_{it} = Random error ($\varepsilon_{it} \sim N(0, \sigma_{\varepsilon}^{2})$)

6.3 Data Statistics

Basic data statistics for all of the variables used to conduct the empirical analysis in this chapter are summarized in Table 6.1.

[79] The interval of predicted efficiency scores is $[0; 1]$. Efficiency scores normally concentrate at or close to 1 (or have a positive pileup at or close to 1 at the right hand side of the interval), but often none of them are at or close to 0 (McDonald, 2009). For this study inefficiency scores, however, are used instead, and therefore inefficiency scores are skewed at or close to 0, but none of them are at or close to 1.

Table 6.1: Summary statistics of Thai listed manufacturing firms

Variables	Unit of Variables	Mean	Median	Max	Min	Std. Dev.	Obs.
Output							
Sales revenue (level)	000 Baht	6203706	1953962	210000000	24202	17190172	1309
Sales revenue (logarithm)	Natural Logarithm	9.95	9.88	14.56	5.49	1.36	1309
Inputs:							
Labour expenses (level)	000 Baht	433724	205636	11745483	4074	1005995	1309
Labour expenses (logarithm)	Natural Logarithm	7.64	7.66	11.84	3.71	1.15	1309
Fixed productive assets (level)	000 Baht	2832218	590693	81233000	3561	8409219	1309
Fixed productive assets (logarithm)	Natural Logarithm	8.84	8.68	13.61	3.57	1.56	1309
Intermediate inputs (level)	000 Baht	4542167	1180994	156000000	19697	12963246	1309
Intermediate inputs (logarithm)	Natural Logarithm	9.51	9.40	14.26	5.28	1.45	1309
Time trend	No. of years	5	5	9	1	2.58	1309
Finance:							
Leverage	Ratio	2.40	1.57	46.20	0.00	2.81	1309
Liquidity	Ratio	0.57	0.43	29.13	0.01	1.50	1309
Internal financing	Dummy	0.35	0	1	0	0.48	1309
External financing	000 Baht	174663	20282	14030418	0	772070	1309
R&D	Dummy	0.80	1	1	0	0.40	1309
Ownership structure:							
Controlling ownership	%	58.81	58.82	99.69	5.44	16.50	1309
Managerial ownership	%	20.53	12.63	96.53	0	21.67	1309
Types of owned firms:							
Family-owned firm	Dummy	0.53	1	1	0	0.50	1309
Foreign-owned firm	Dummy	0.19	0	1	0	0.39	1309
Domestic-owned firm	Dummy	0.12	0	1	0	0.32	1309
Joint-owned firm	Dummy	0.07	0	1	0	0.26	1309
Hybrid-owned firm	Dummy	0.09	0	1	0	0.29	1309
Executive remuneration	Ratio	0.14	0.09	6.83	0	0.32	1309
Exports	%	32.68	19.32	100	0	33.53	1309
Other factors:							
Total assets (level)	000 Baht	13689745	2273483	286000000	145806	40676518	1309
Total assets (logarithm)	Natural Logarithm	14.76	14.54	19.47	11.73	1.27	1309
Firm age	No. of years	26	24	95	0	12	1309
Government assistance	Dummy	0.62	1	1	0	0.49	1309
Foreign cooperation	Dummy	0.31	0	1	0	0.54	1309
Additional variables used for the self-selection hypothesis							
Foreign investment (ownership)	%	17.26	8.34	96.95	0.00	21.93	1309
Technical inefficiency scores (SFA)*	Number	0.188	0.156	0.997	0.045	0.123	1309
Technical inefficiency scores (DEA)*	Number	0.113	0.114	0.50	0.000	0.065	1309

Note: *indicate SFA and DEA Technical inefficiency scores respectively which are calculated by taking technical efficiency scores predicted by FRONTIER 4.1 and DEAP 2.1, respectively subtracted from "unity".

There are 1,309 observations covering the period 2000 to 2008. Variables for inputs and outputs are expressed in natural logarithm form due to the use of production functions (i.e., Cobb-Douglas and Translog production functions).

Business environment and firm specific variables are expressed in a variety of units such as dummy variable, ratio, percentage, and real value. Descriptive statistics (i.e., mean, median, max, min, and standard deviation) are also provided for each variable.

From Table 6.1 the average age of Thai listed manufacturing enterprises is 26 years. Thai listed manufacturing enterprises export approximately 32.68 percent of their total sales. The average leverage of Thai listed manufacturing enterprises is quite low as given by the average of the debt to asset ratio (0.57), indicating that they have strong financial health. This is because they have to meet certain listing criteria set by the Stock Exchange of Thailand (SET) before their securities can resume trading, and they have to maintain their financial health in order to retain their listing status in the SET. The top 5 major shareholders of Thai listed manufacturing firms hold approximately 58.81 percent of a firm's total shares on average. In addition, 20.55 percent of a firm's total shares are held by top executives and board members on average. Focusing on types of firm ownership, family ownership (53 percent[80]) is the major type of ownership, followed by foreign ownership (19 percent), domestic ownership (12 percent), hybrid ownership (9 percent), and joint ownership (7 percent). In terms of the percentage of foreign investment (ownership) for each listed manufacturing firm, foreign investors hold approximately 17.26 percent on average of a firm's total shares. Finally, SFA and DEA inefficiency scores obtained from FRONTIER 4.1 and DEAP 2.1, respectively, are 0.19 and 0.11. Technical inefficiency scores from both estimation approaches are very low, and their mean values are very close. In addition, basic data statistics for sub-manufacturing sectors such as (i) the Agro and Food Industry, (ii) the Consumers Product, (iii) the Industrials, and (iv) the Other Sectors are also summarized and provided in Tables 6.2, 6.3, 3.4, and 3.5, respectively.

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[80] Claessens et al. (2000, p103) also revealed the percentage of publicly listed and family-owned firms among East Asian countries in 1996. They revealed that the percentage share of publicly listed and family-owned firms was 61.6 percent for Thailand, 48.2 percent for Taiwan, 55.4 percent for Singapore, 44.6 percent for the Philippines, 67.2 percent for Malaysia, 48.4 percent for Korea, 9.7 percent for Japan, 71.5 percent for Indonesia, and 66.7 percent for Hong Kong.

Table 6.2: Summary statistics of the Agro and Food Industry sector

Variables	Unit of Variables	Mean	Median	Max	Min	Std. Dev.	Obs.
Output							
Sales revenue (level)	000 Baht	7189315	2790878	110000000	91910	15735308	323
Sales revenue (logarithm)	Natural Logarithm	10.28	10.24	13.91	6.82	1.18	323
Inputs:							
Labour expenses (level)	000 Baht	583642	222749	11745483	7710	1499821	323
Labour expenses (logarithm)	Natural Logarithm	7.87	7.72	11.84	4.35	1.04	323
Fixed productive assets (level)	000 Baht	1651510	686668	35755783	123533	4290412	323
Fixed productive assets (logarithm)	Natural Logarithm	8.92	8.83	12.79	7.12	1.02	323
Intermediate inputs (level)	000 Baht	5792386	2171342	82592520	82698	12548765	323
Intermediate inputs (logarithm)	Natural Logarithm	10.03	9.99	13.62	6.72	1.23	323
Time trend	No. of years	5	5	9	1	2.59	323
Finance:							
Leverage	Ratio	2.10	1.35	10.67	0.00	1.83	323
Liquidity	Ratio	0.46	0.42	4.70	0.03	0.42	323
Internal financing	Dummy	0.30	0	1	0	0.46	323
External financing	000 Baht	1263	188	45862	0	3985.85	323
R&D	Dummy	0.87	1	1	0	0.34	323
Ownership structure:							
Controlling ownership	%	57.45	55.46	98.53	8.63	17.42	323
Managerial ownership	%	25.20	19.86	96.53	0.00	22.46	323
Types of owned firms:							
Family-owned firm	Dummy	0.64	1	1	0	0.48	323
Foreign-owned firm	Dummy	0.18	0	1	0	0.38	323
Domestic-owned firm	Dummy	0.04	0	1	0	0.20	323
Joint-owned firm	Dummy	0.01	0	1	0	0.10	323
Hybrid-owned firm	Dummy	0.13	0	1	0	0.34	323
Executive remuneration	Ratio	0.10	0.08	0.93	0.01	0.08	323
Exports	%	47.78	41.00	99.77	0.00	37.90	323
Other factors:							
Total assets (level)	000 Baht	5498545	2139002	108000000	479127	13411746	323
Total assets (logarithm)	Natural Logarithm	14.71	14.58	18.49	13.08	1.03	323
Firm age	No. of years	25	23	56	5	9	323
Government assistance	Dummy	0.77	1	1	0	0	323
Foreign cooperation	Dummy	0.15	0	1	0	0	323
Additional variables used for the self-selection hypothesis							
Foreign investment (ownership)	%	11.75	7.20	49.00	0.00	12.78	323
Technical inefficiency scores (SFA)*	Number	0.16	0.14	0.42	0.09	0.05	323
Technical inefficiency scores (DEA)*	Number	0.11	0.12	0.29	0.00	0.05	323

Note: *indicate SFA and DEA Technical inefficiency scores respectively which are calculated by taking technical efficiency scores predicted by FRONTIER 4.1 and DEAP 2.1, respectively subtracted from "unity".

Table 6.3: Summary statistics of the Consumer Products sector

Variables	Unit of Variables	Mean	Median	Max	Min	Std. Dev.	Obs.
Output							
Sales revenue (level)	000 Baht	2222515	1482518	18180793	120479	2818906	252
Sales revenue (logarithm)	Natural Logarithm	9.53	9.60	12.11	7.09	0.98	252
Inputs:							
Labour expenses (level)	000 Baht	367573	225646	2525467	19873	413528.3	252
Labour expenses (logarithm)	Natural Logarithm	7.80	7.74	10.22	5.47	0.93	252
Fixed productive assets (level)	000 Baht	769543.7	484824	6230780	24105	974515	252
Fixed productive assets (logarithm)	Natural Logarithm	8.38	8.49	11.04	5.49	1.08	252
Intermediate inputs (level)	000 Baht	1557376	1020563	15204191	23287	2190827	252
Intermediate inputs (logarithm)	Natural Logarithm	9.26	9.26	11.93	6.72	0.99	252
Time trend	No. of years	5	5	9	1	2.61	252
Finance:							
Leverage	Ratio	3.21	2.12	46.20	0.12	3.89	252
Liquidity	Ratio	0.39	0.32	2.98	0.01	0.36	252
Internal financing	Dummy	0.39	0	1	0	0.49	252
External financing	000 Baht	28875	10759	446610	0	53900	252
R&D	Dummy	0.78	1	1	0	0.42	252
Ownership structure:							
Controlling ownership	%	57.39	58.45	97.86	17.82	15.26	252
Managerial ownership	%	19.26	12.615	74.6	0	17.97	252
Types of owned firms:							
Family-owned firm	Dummy	0.56	1	1	0	0.50	252
Foreign-owned firm	Dummy	0.13	0	1	0	0.34	252
Domestic-owned firm	Dummy	0.05	0	1	0	0.21	252
Joint-owned firm	Dummy	0.17	0	1	0	0.38	252
Hybrid-owned firm	Dummy	0.09	0	1	0	0.29	252
Executive remuneration	Ratio	0.11	0.09	0.45	0.01	0.07	252
Exports	%	46.69	43.16	100	0	31.45	252
Other factors:							
Total assets (level)	000 Baht	2665295	1555191	20730355	239644	3600346	252
Total assets (logarithm)	Natural Logarithm	14.34	14.26	16.85	12.39	0.89	252
Firm age	No. of years	29.56	29	58	11	10.65	252
Government assistance	Dummy	0.53	1	1	0	0.50	252
Foreign cooperation	Dummy	0.44	0	1	0	0.50	252
Additional variables used for the self-selection hypothesis							
Foreign investment (ownership)	%	18.23	8.2	96.95	0	22.51	252
Technical inefficiency scores (SFA)*	Number	0.23	0.19	0.97	0.11	0.15	252
Technical inefficiency scores (DEA)*	Number	0.15	0.14	0.35	0	0.06	252

Note: *indicate SFA and DEA Technical inefficiency scores respectively which are calculated by taking technical efficiency scores predicted by FRONTIER 4.1 and DEAP 2.1, respectively subtracted from "unity".

Table 6.4: Summary statistics of the Industrials sector

Variables	Unit of Variables	Mean	Median	Max	Min	Std. Dev.	Obs.
Output							
Sales revenue (level)	000 Baht	4878203	2057071	59404533	27867	7782736	397
Sales revenue (logarithm)	Natural Logarithm	9.89	9.93	13.29	5.63	1.41	397
Inputs:							
Labour expenses (level)	000 Baht	215330	163960	2079096	4074	247388	397
Labour expenses (logarithm)	Natural Logarithm	7.21	7.41	10.12	3.71	1.07	397
Fixed productive assets (level)	000 Baht	3218592	470835	79008697	3561	7460036	397
Fixed productive assets (logarithm)	Natural Logarithm	8.65	8.46	13.58	3.57	1.97	397
Intermediate inputs (level)	000 Baht	3054417	709558	35449116	19697	5442074	397
Intermediate inputs (logarithm)	Natural Logarithm	9.11	8.87	12.78	5.28	1.57	397
Time trend	No. of years	5	6	9	1	3	397
Finance:							
Leverage	Ratio	2.12	1.46	23.15	0.02	2.24	397
Liquidity	Ratio	0.82	0.47	29.13	0.04	2.64	397
Internal financing	Dummy	0.31	0	1	0	0.46	397
External financing	000 Baht	176967	30698	6075890	0	574430	397
R&D	Dummy	0.796	1	1	0	0.40	397
Ownership structure:							
Controlling ownership	%	60.87	61.82	99.69	5.44	16.59	397
Managerial ownership	%	20.65	8.92	94.17	0.00	23.75	397
Types of owned firms:							
Family-owned firm	Dummy	0.49	0	1	0	0.50	397
Foreign-owned firm	Dummy	0.24	0	1	0	0.43	397
Domestic-owned firm	Dummy	0.18	0	1	0	0.38	397
Joint-owned firm	Dummy	0.02	0	1	0	0.15	397
Hybrid-owned firm	Dummy	0.07	0	1	0	0.25	397
Executive remuneration	Ratio	0.20	0.11	6.83	0.02	0.56	397
Exports	%	19.97	10.70	94.00	0.00	23.16	397
Other factors:							
Total assets (level)	000 Baht	7838694	2190888	152000000	124793	15498386	397
Total assets (logarithm)	Natural Logarithm	14.87	14.60	18.84	11.73	1.37	397
Firm age	No. of years	24	23	56	0	11.93	397
Government assistance	Dummy	0.62	1	1	0	0.48	397
Foreign cooperation	Dummy	0.30	0	1	0	0.46	397
Additional variables used for the self-selection hypothesis							
Foreign investment (ownership)	%	17.57	9.55	94.95	0.00	20.23	397
Technical inefficiency scores (SFA)*	Number	0.17	0.13	1.00	0.04	0.15	397
Technical inefficiency scores (DEA)*	Number	0.09	0.08	0.50	0.00	0.07	397

Note: *indicate SFA and DEA Technical inefficiency scores respectively which are calculated by taking technical efficiency scores predicted by FRONTIER 4.1 and DEAP 2.1, respectively subtracted from “unity”.

Table 6.5: Summary statistics of the "Other Sectors" sector

Variables	Unit of Variables	Mean	Median	Max	Min	Std. Dev.	Obs.
Output							
Sales revenue (level)	000 Baht	9797572	1734844	210000000	24202	28423392	337
Sales revenue (logarithm)	Natural Logarithm	10.01	9.76	14.56	5.49	1.59	337
Inputs:							
Labour expenses (level)	000 Baht	596778	221618	10735169	8929	1214971	337
Labour expenses (logarithm)	Natural Logarithm	7.80	7.74	11.76	4.63	1.33	337
Fixed productive assets (level)	000 Baht	5051127	886631	81233000	16386	13479520	337
Fixed productive assets (logarithm)	Natural Logarithm	9.31	9.09	13.61	5.10	1.62	337
Intermediate inputs (level)	000 Baht	7328468	1256944	156000000	22949	21123245	337
Intermediate inputs (logarithm)	Natural Logarithm	9.67	9.44	14.26	5.44	1.61	337
Time trend	No. of years	5	5	9	1	3	337
Finance:							
Leverage	Ratio	2.42	1.66	28.67	0.02	3.09	337
Liquidity	Ratio	0.52	0.48	2.84	0.02	0.37	337
Internal financing	Dummy	0.42	0	1	0	0.49	337
External financing	000 Baht	327273	22228	14030418	0	1317436	337
R&D	Dummy	0.76	1	1	0	0.43	337
Ownership structure:							
Controlling ownership	%	58.75	59.97	97.63	17.54	16.19	337
Managerial ownership	%	16.87	6.67	90.28	0.00	20.09	337
Types of owned firms:							
Family-owned firm	Dummy	0.45	0	1	0	0.50	337
Foreign-owned firm	Dummy	0.17	0	1	0	0.37	337
Domestic-owned firm	Dummy	0.16	0	1	0	0.37	337
Joint-owned firm	Dummy	0.12	0	1	0	0.33	337
Hybrid-owned firm	Dummy	0.10	0	1	0	0.30	337
Executive remuneration	Ratio	0.11	0.10	0.44	0.00	0.08	337
Exports	%	22.72	4.23	100.00	0.00	31.17	337
Other factors:							
Total assets (level)	000 Baht	13689745	2273483	286000000	145806	40676518	337
Total assets (logarithm)	Natural Logarithm	14.98	14.64	19.47	11.89	1.49	337
Firm age	No. of years	26	23	95	0	16	337
Government assistance	Dummy	0.54	1	1	0	0.50	337
Foreign cooperation	Dummy	0.31	0	1	0	0.46	337
Additional variables used for the self-selection hypothesis							
Foreign investment (ownership)	%	21.45	8.38	95.73	0.00	28.42	337
Technical inefficiency scores (SFA)*	Number	0.21	0.18	0.70	0.08	0.10	337
Technical inefficiency scores (DEA)*	Number	0.12	0.12	0.31	0.00	0.06	337

Note: *indicate SFA and DEA Technical inefficiency scores respectively which are calculated by taking technical efficiency scores predicted by FRONTIER 4.1 and DEAP 2.1, respectively subtracted from "unity".

6.4 Hypotheses tests

There are a number of null hypotheses that will be tested for estimation of the stochastic frontier production function (i.e., (i) the validation of the Cobb-Douglas production function, (ii) the absence of technical progress, (iii) the absence of neutral technical progress), and for estimation of the model of inefficiency effects (i.e., (iv) the absence of inefficiency effects, (v) the absence of stochastic inefficiency effects, (vi) the insignificance of joint inefficiency variables). These results are reported in Table 6.6. A likelihood-ratio test statistic (LR statistic) is used to test these hypotheses, which can be conducted as follows:

$$\lambda = -2\{\log [L(H_0)] - \log [L(H_1)]\} \tag{6.6}$$

Where, $\log [L(H_0)]$ and $\log [L(H_1)]$ are obtained from the maximized values of the log-likelihood function under the null hypothesis (H_0) and the alternative hypothesis (H_a), respectively. The LR test statistic has an asymptotic chi-square distribution with parameters equal to the number of restricted parameters imposed under the null hypothesis (H_0), except for hypotheses (iv) and (v) that have a "mixed" chi-square distribution (Kodd and Palrm, 1986). Hypotheses (iv) and (v) involve the restriction that γ is equal to zero, which defines a point on the boundary of the parameter space (Coelli, 1996a, p6).

(i) Validation of the Cobb-Douglas production function

Both Cobb-Douglas and Translog production functions can be estimated by FRONTIER 4.1, and then selected by conducting the likelihood-ratio test statistic (LR statistic) for an adequate functional form. The reason is that FRONTIER 4.1 does not provide a diagnostic test for such an adequate functional form. As a result, the null hypothesis that the Cobb-Douglas production function is an adequate functional form for the data is tested against the alternative hypothesis that the specification of the Translog production function is an adequate functional form. From Equation (6.2) the null hypothesis ($H_0 : \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = \beta_{13} = \beta_{14} = 0$) is strongly rejected at the 5 percent level of significance for the SET's manufacturing sector including all sub-manufacturing sectors, since all the LR test statistics are greater than the critical value at the 5 percent level of significance (see Table 6.6). Therefore, the Cobb-Douglas production function is not an adequate specification for the case of the SET's manufacturing sector including all sub-manufacturing sectors, compared with the specification of the Translog production function model. This also indicates that input and substitution elasticities are not constant among firms (Lundvall and Battese, 2000).

(ii) The absence of technical progress

In dealing with panel data it is crucial to investigate whether technical progress (technological change) exists for the study. This can be examined by applying unrestricted and restricted models and then conducting the LR test statistic. As a result, the null hypothesis that there is no technical progress is conducted against the alternative hypothesis that there is technical progress. From Table 6.6 the LR test statistics are greater than the critical value at the 5 percent level of significance for the SET's manufacturing sector including sub-manufacturing sectors, except for the Agro and Food Industry. Hence, the second null hypothesis that there is no technical progress (H_0: $\beta_4 = \beta_8 = \beta_{11} = \beta_{13} = \beta_{14} = 0$) is rejected at the 5 percent level of significance for the SET's manufacturing sector including sub-manufacturing sectors, except for the Agro and Food Industry.

(iii) The absence of neutral technical progress

The third hypothesis test takes a further step from the second hypothesis test in examining for the existence of neutral technical progress. In examining this hypothesis test, the null hypothesis test that technical progress is neutral is tested against the alternative hypothesis that there is no neutral technical progress. From Table 6.6 the LR test statistics are greater than the critical value at the 5 percent level of significance for the SET's manufacturing sector including sub-manufacturing sectors. For this hypothesis the Agro and Food Industry is not tested, since technical progress does not exist in this sector. Therefore, the null hypothesis that technical progress is neutral ($H_0 : \beta_{11} = \beta_{13} = \beta_{14} = 0$) is rejected at the 5 percent level of significance for the SET's manufacturing sector including other sub manufacturing sectors such as Consumer Products, Industrials, and Other Sectors. This indicates that technical change not only merely affects average output, but also changes marginal rates of technical substitution. In other words the marginal rate of substitution is not dependent on time, indicating that *Hicks* neutral technology does not exist for the SET's manufacturing sector including Consumer Products, Industrials, and Other Sectors.

(iv) The absence of inefficiency effects

The fourth hypothesis test aims to investigate for the existence of the inefficiency effects model. The null hypothesis that inefficiency is absent from the model is tested against the alternative hypothesis that the inefficiency effects model exists for the model. From Table 6.6 the LR test statistics are greater than the critical value at the 5 percent level of significance for the SET's manufacturing sector including all sub-manufacturing sectors. As a result the null hypothesis (iv) which specifies that the inefficiency effects are absent from the model $(\gamma = \delta_0 = \delta_1 \ldots = \delta_{17} = 0)$ is strongly rejected at the 5 percent level of significance, which implies that the model of inefficiency effects exists for the case of the SET's manufacturing sector including all sub-manufacturing sectors.

(v) The absence of "stochastic" inefficiency effects

The fifth hypothesis test aims to investigate whether an inefficiency effects model is "stochastic" or not. To examine this hypothesis test the null hypothesis that the inefficiency effects are not "stochastic" $(\gamma = 0)$ is tested against the alternative hypothesis that the inefficiency effects are "stochastic. From Table 6.6 the LR test statistics are greater than the critical value at the 5 percent level of significance for the SET's manufacturing sector including all sub-manufacturing sectors. Therefore, the null hypothesis that the inefficiency effects are not "stochastic" $(\gamma = 0)$[81] is strongly rejected, implying that the model of inefficiency effects is not reduced to a traditional mean response function (Battese and Coelli, 1995). In other words, all the explanatory variables in the inefficiency effects model are not included in the production function, implying that the inefficiency effects model exists and therefore the estimated parameters can be identified in the model of inefficiency effects. In

[81] If the parameter γ is equal to zero, then the variance of the inefficiency effects is zero, and, therefore, the inefficiency effects model reduces to a traditional mean response function in which inefficiency variables (or firm-specific and business environment variables) are included in the production function. As a result inefficiency variables are not identified (Battese and Coelli, 1995, p 330).

addition, if the estimate of the variance parameter (γ) is close to one, it indicates that overall residual variation ($U_{it}s$ and $V_{it}s$) is highly related to the inefficiency components ($U_{it}s$).

(vi) The insignificance of joint inefficiency variables

The last hypothesis test aims to investigate the significance of the joint inefficiency variables (business environment and firm-specific variables) for the model. To conduct this hypothesis test the null hypothesis that inefficiency effects are not a linear function of all explanatory variables is tested against the alternative hypothesis that inefficiency effects are a linear function of all explanatory variables. In other words the null hypothesis specifying that all parameters of the explanatory variables are equal to zero is tested against the alternative hypothesis that the explanatory variables are not equal to zero. From Table 6.6 the LR statistic tests are all greater than the critical value of approximately chi-square distribution at the 5 percent level of significance, implying that the null hypothesis that all coefficients of the explanatory variables are equal to zero ($H_0 : \delta_1 = \delta_2 = \cdots = \delta_{16} = \delta_{17} = 0$) is strongly rejected at the 5 percent level of significance for the SET's manufacturing sector including all sub-manufacturing sectors, given the specification of the Translog stochastic frontier and the model of inefficiency effects.

According to the rejection of the last null hypothesis test, the model of inefficiency effects of the SET's manufacturing sector including all sub-manufacturing sectors can be assumed to be independently and identically distributed as truncations at zero of the normal distribution with mean, $Z_{it}\delta$ and variance, σ_u^2 (Battese and Coelli, 1995). Similarly, the last hypothesis test can be conducted for the two-stage Data Envelopment Analysis (DEA). Unrestricted and restricted models are conducted and then used to conduct the LR test statistics (see Table 6.13).

As a result, the null hypothesis that all parameters of the explanatory variables are equal to zero is also rejected at the 5 level of significance for the SET's manufacturing sector including all sub-manufacturing sectors. In addition, the majority of the estimates of the Translog production frontier parameters are statistically significant at the 5 percent level of significance for the SET's manufacturing sector including sub-manufacturing sectors (see Table 6.7). It is also common to observe that some of the individual coefficients of the Translog stochastic frontier are not statistically significant due to high multicollinearity among the inputs (Lundvall and Battese, 2000; Oczkowski and Sharma, 2005).

6.5 Results from the Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA) approaches

This section compares the empirical results obtained from the Stochastic Frontier Analysis (SFA) and the two-stage Data Envelopment Analysis (DEA) approaches for the SET's manufacturing sector including sub-manufacturing sectors. For the SFA approach, as described in Section 6.5.1, the empirical evidence can be divided into two parts: (i) the empirical results obtained from the estimates of a Translog frontier production function and (ii) the empirical results obtained from an estimated inefficiency effects model. For the DEA approach, as described in Section 6.5.2, the empirical evidence can be classified into two parts: (i) the empirical results from the estimates of DEA technical efficiency using DEAP Version 2.1 and (ii) the empirical results from estimates of the maximum likelihood Tobit model. Section 6.5.3 compares the empirical evidence from both the Stochastic Frontier Analysis (SFA) and two - stage Data Envelopment Analysis (DEA) approaches for robustness of the results.

6.5.1 Results from the Stochastic Frontier Analysis (SFA) approach

This section presents the empirical results estimated by the Stochastic Frontier Analysis (SFA) approach. The Battese and Coelli (1995) model is used for this part by using FRONTIER 4.1. With respect to Section 6.4 (i) the Translog frontier production function is used for the empirical analysis in Section 6.5.1 (i), since it is found to be an adequate functional form for the SET's manufacturing sector including all sub-manufacturing sectors. Furthermore, an inefficiency effects model is conducted in Section 6.5.1 (ii) to investigate the effects of business environment and firm-specific variables on the technical inefficiency effects for Thai listed manufacturing enterprises.

(i) Results from estimates of a stochastic frontier production function

Table 6.7 shows the empirical results obtained from the Battese and Coelli (1995) model using FRONTIER 4.1. The estimates of the labour (β_1) and capital (β_2) inputs are found to be significantly positive and negative, respectively, for Thai listed manufacturing enterprises. The estimate of the intermediate input (β_3) is found to be significant and positive at the 5 percent level of significance. The expected sign of the capital coefficient should be positive.

Unlike the Cobb-Douglas production function, a negative sign of the input coefficients in the Translog production function can be observed due to the common problem of a high degree of collinearity (Coelli, 1995; Shing, 1997). This negative result can also be observed in other SFA studies applying the Translog production function in their analysis (Kim, 2003; Tran et al., 2008). For sub-manufacturing sectors the estimate of the labour (β_1) input is found to be significantly positive in the Agro and Food Industry and Other Sectors. The estimate of the capital input (β_2) is significantly positive for the Consumer Products, Industrials, and Other Sectors. In addition, the estimate of the intermediate input (β_3) is found to be significantly positive for the Agro and Food Industry, Consumer Products, and Other Sectors, but is found to be significantly negative in the Industrials sector.

However, the estimate for an individual input are not readily interpretable in the Translog production function (Kim, 1992). Therefore, the production elasticities of input, returns to scale, and the rate of technical change provide more useful economic interpretation.

Returns to scale and technical change

Returns to scale can be estimated as the sum of the output elasticities with respect to each input. For the case of three inputs (capital, labour, and intermediate inputs) returns to scale can be calculated as the sum of the elasticities of output with respect to capital, labour, and intermediate inputs ($e = e_k + e_l + e_{im}$). This can be used to examine how much output will increase when the level of an input increases.

Table 6.6: Statistics for the hypotheses tests of the stochastic frontier and inefficiency effect models for the SET's manufacturing sectors

	All manufacturing			Agro and Food Industry			Consumer Products			Industrials			Other Sectors[a]		
Null Hypothesis	**LR Statistics**	**Critical Value**	**Decision**	**LR Statistics**	**Critical Value**	**Decision**	**LR Statistics**	**Critical Value**	**Decision**	**LR Statistics**	**Critical Value**	**Decision**	**LR Statistics**	**Critical Value**	**Decision**
(i) Cobb-Douglas $(H_0: \beta_5 = \beta_6 = \beta_7 = \beta_8 = \beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = \beta_{13} = \beta_{14} = 0)$	210.37	18.31	Reject H_0	82.25	18.31	Reject H_0	104.30	18.31	Reject H_0	98.07	18.31	Reject H_0	127.50	18.31	Reject H_0
(ii) No technical progress $(H_0: \beta_4 = \beta_8 = \beta_{11} = \beta_{13} = \beta_{14} = 0)$	26.42	11.07	Reject H_0	5.00	11.07	Do not reject H_0	54.88	11.07	Reject H_0	77.46	11.07	Reject H_0	22.69	11.07	Reject H_0
(iii) Neutral technical change $(H_0 : \beta_{11} = \beta_{13} = \beta_{14} = 0)$	32.49	7.81	Reject H_0	-	-	-	33.56	7.81	Reject H_0	53.91	7.81	Reject H_0	12.67	7.81	Reject H_0
(iv) No inefficiency effects $(H_0: \gamma = \delta_0 = \delta_1 \ldots = \delta_{17} = 0)$	628.72	29.55*	Reject H_0	217.75	29.55*	Reject H_0	531.76	29.55*	Reject H_0	366.91	29.55*	Reject H_0	118.48	29.55*	Reject H_0
(v) Non stochastic inefficiency $(H_0: \gamma = 0)$	207.04	2.71*	Reject H_0	196.37	2.71*	Reject H_0	664.65	2.71*	Reject H_0	262.83	2.71*	Reject H_0	308.68	2.71*	Reject H_0
(vi) No inefficiency $(H_0: \delta_1 = \delta_2 \ldots \delta_{16} = \delta_{17} = 0)$	294.14	27.59	Reject H_0	151.29	27.59	Reject H_0	247.26	27.59	Reject H_0	290.15	27.59	Reject H_0	80.24	27.59	Reject H_0

Source: Author's estimates

Note: All critical values of the test statistics are subject to the 5% level of significance; * indicates a mixture of χ^2 distribution (Kodde and Palrm, 1986); [a] includes Publishing, Construction Materials, and Technology (Electronic components); Hypotheses (i) - (iii) refer to Equation (6.2), and hypotheses (iv) – (vi) refer to Equation (6.3).

Table 6.7: Maximum-likelihood estimates for parameters of the Translog frontier production function

Variable Stochastic frontiers	All Manufacturing	Agro & Food Industry	Consumer Products	Industrials	Other Sectors[a]
Constant	3.8006*	1.0833*	-1.5394*	22.5773*	0.7657**
	(0.5481)	(0.3057)	(0.5932)	(2.0202)	(0.4569)
log(L)[b]	1.0182*	0.6049*	0.3247	-0.2765	0.5256*
	(0.1339)	(0.0946)	(0.2212)	(0.3880)	(0.1151)
log(K)[b]	-0.7088*	0.1253	0.5457*	1.0018*	0.1298**
	(0.1076)	(0.0861)	(0.1525)	(0.4624)	(0.0727)
log(IM)[b]	0.2519**	0.2882*	0.6910*	-3.5993*	0.3823*
	(0.1519)	(0.0787)	(0.2526)	(0.6744)	(0.0984)
t	0.0911*	-	0.0286	-0.2646*	0.0596**
	(0.0432)	-	(0.0394)	(0.1131)	(0.0330)
½ (log(L)^2)	0.0777*	0.0870*	-0.1029**	0.2178*	0.0948*
	(0.0216)	(0.0243)	(0.0590)	(0.0453)	(0.0347)
½ (log(K)^2)	-0.0996*	0.0211	-0.0492	-0.1546	-0.0493*
	(0.0259)	(0.0220)	(0.0306)	(0.1295)	(0.0173)
½ (log(IM)^2)	0.1301*	0.1652*	0.1423*	0.7253*	0.1868*
	(0.0277)	(0.0126)	(0.0570)	(0.2230)	(0.0189)
½ (t^2)	-0.0051	-	-0.0023	0.0008	-0.0091*
	(0.0046)	-	(0.0024)	(0.0097)	(0.0035)
log(L)*log(K)	0.0886*	0.0022	0.1279*	0.1627*	0.0563*
	(0.0226)	(0.0247)	(0.0369)	(0.0800)	(0.0184)
log(L)*log(IM)	-0.2125*	-0.1151*	-0.0485	-0.2495*	-0.1725*
	(0.0258)	(0.0139)	(0.0323)	(0.0922)	(0.0194)
log(L)* *t*	-0.0198*	-	0.0082	-0.0219	0.0105**
	(0.0078)	-	(0.0056)	(0.0184)	(0.0060)
log(K)*log(IM)	0.0888*	-0.0275**	-0.1074*	-0.1234	-0.0041
	(0.0192)	(0.0150)	(0.0285)	(0.1595)	(0.0158)
log(K)t***	0.0164*	-	-0.0154*	0.0032	-0.0017
	(0.0058)	-	(0.0040)	(0.0230)	(0.0043)
log(M)t***	-0.0040	-	0.0054	0.0457	-0.0073
	(0.0071)	-	(0.0063)	(0.0305)	(0.0053)

Source: Author's estimates using FRONTIER 4.1

Note: Standard Errors (S.E.) are in parentheses; * and ** indicate that the coefficients are statistically significant at the 5% and 10 % levels, respectively. [a] includes Publishing, Construction Materials, and Technology (Computer components); [b] L is the labour input, K is the capital input, and IM is intermediate input (see Equation (6.2)); The empirical results refer to Equation 6.3.

For the Cobb-Douglas production function the sum of input coefficients (elasticities) can measure whether the production function indicates constant, increasing, or decreasing returns to scale (Coelli et al., 2005; Maity and Chatterjee, 2010). Unlike the Cobb-Douglas production function the estimation of returns to scale for the Translog production function is more complicated, since the sum of individual estimated parameters (e.g., labour, capital, and intermediate inputs) of the Translog production function cannot be used to measure the returns to scale. The elasticities of output with respect to each input must be calculated and then added up together as follows (Kim, 1992; Margono and Sharma, 2004):

The elasticity of output with respect to capital (e_k) can be estimated by

$e_k = \partial lny/\partial \ln k_{it}$ or

$$e_k = \beta_k + \beta_{kk} * \ln(k_{it}) + \beta_{kl} * \ln(l_{it}) + \beta_{kim} * \ln(im_{it}) + \beta_{kt} * \mathrm{t} \quad (6.7)$$

Whereas the elasticity of output with respect to labour (e_l) can be estimated by

$e_l = \partial lny/\partial \ln l_{it}$ or

$$e_l = \beta_l + \beta_{ll} * \ln(l_{it}) + \beta_{kl} * \ln(k_{it}) + \beta_{lim} * \ln(im_{it}) + \beta_{lt} * \mathrm{t} \quad (6.8)$$

Whereas the elasticity of output with respect to intermediate inputs can be estimated by $e_{im} = \partial lny/\partial \ln im_{it}$ or

$$e_{im} = \beta_{im} + \beta_{imim} * \ln(im_{it}) + \beta_{iml} * \ln(l_{it}) + \beta_{kim} * \ln(k_{it}) + \beta_{imt} * \mathrm{t} \quad (6.9)$$

Finally, a measure of returns to scale is given by $e = e_k + e_l + e_{im}$. All estimated parameters can be obtained from an estimated Translog production function. The value of each input expressed by the natural logarithm form can be obtained by its mean value. If $e = e_k + e_l + e_{im}$ is equal to one, there is constant returns to scale. If $e = e_k + e_l + e_{im}$ is less than one, there is decreasing returns to scale. If $e = e_k + e_l + e_{im}$ is greater than one, there is increasing returns to scale. In addition, the rate of technical change can be obtained as follows (Kim, 1992):

$$\partial lny/\partial t = \beta_t + \beta_{tt} * t + \beta_{lt} * \ln(l_{it}) + \beta_{kt} * \ln(k_{it}) + \beta_{imt} * \ln(im_{it}) \quad (6.10)$$

The calculations of returns to scale for Thai listed manufacturing firms and all manufacturing sub-sectors are calculated and summarized in Tables 6.8 and 6.9.

Table 6.8: The calculations of returns to scale and technical change of Thai listed manufacturing sector and sub-manufacturing sectors

Sectors		Output Elasticity	Estimated parameters and mean value of inputs									
All Manufacturing	Capital	$e_k = \partial lny/\partial \ln k_{it}$	β_k	β_{kk}	*ln(k_it)*	β_{kl}	*ln(l_it)*	β_{kim}	*ln(im_it)*	β_{kt}	*t*	Estimated *e*
			-0.7088	*-0.0996*	*8.835966*	*0.0886*	*7.63786*	*0.0888*	*9.511215*	*0.0164*	*5.14133*	0.016766
	Labour	$e_l = \partial lny/\partial lnl_{it}$	β_l	β_{ll}	*ln(l_it)*	β_{kl}	*ln(k_it)*	β_{lim}	*ln(im_it)*	β_{lt}	*t*	
			1.0182	*0.0777*	*7.637858*	*0.0886*	*8.83597*	*-0.2125*	*9.511215*	*-0.0198*	*5.14133*	0.271597
	Intermediate	$e_{im} = \partial lny/\partial lnim_{it}$	β_{im}	β_{imim}	*ln(im_it)*	β_{iml}	*ln(l_it)*	β_{kim}	*ln(k_it)*	β_{imt}	*t*	
			0.2519	*0.1301*	*9.511215*	*-0.2125*	*7.63786*	*0.0888*	*8.835966*	*-0.004*	*5.14133*	0.630333
	Returns to	$e = e_k + e_l + e_{im}$										0.918695
	Tech. Change	$\partial lny/\partial t$	β_t	β_{tt}	*t*	β_{lt}	*ln(l_it)*	β_{kt}	*ln(k_it)*	β_{imt}	*ln(im_it)*	
			0.0911	*-0.0051*	*5.14133*	*-0.0198*	*7.63786*	*0.0164*	*8.835966*	*-0.004*	*9.51122*	0.020515
Agro & Food Industry	Capital	$e_k = \partial lny/\partial \ln k_{it}$	β_k	β_{kk}	*ln(k_it)*	β_{kl}	*ln(l_it)*	β_{kim}	*ln(im_it)*			Estimated *e*
			0.1253	*0.0211*	*8.922412*	*0.0022*	*7.86581*	*-0.0275*	*10.0255*			0.055166
	Labour	$e_l = \partial lny/\partial lnl_{it}$	β_l	β_{ll}	*ln(l_it)*	β_{kl}	*ln(k_it)*	β_{lim}	*ln(im_it)*			
			0.6049	*0.087*	*7.865809*	*0.0022*	*8.92241*	*-0.1151*	*10.0255*			0.15492
	Intermediate	$e_{im} = \partial lny/\partial lnim_{it}$	β_{im}	β_{imim}	*ln(im_it)*	β_{iml}	*ln(l_it)*	β_{kim}	*ln(k_it)*			
			0.2882	*0.1652*	*10.0255*	*-0.1151*	*7.86581*	*-0.0275*	*8.922412*			0.793692
	Returns to	$e = e_k + e_l + e_{im}$										1.003778
Consumer Products	Capital	$e_k = \partial lny/\partial \ln k_{it}$	β_k	β_{kk}	*ln(k_it)*	β_{kl}	*ln(l_it)*	β_{kim}	*ln(im_it)*	β_{kt}	*t*	Estimated *e*
			0.5457	*-0.0492*	*8.38178*	*0.1279*	*7.80206*	*-0.1074*	*9.264882*	*-0.0154*	*4.97619*	0.059519
	Labour	$e_l = \partial lny/\partial lnl_{it}$	β_l	β_{ll}	*ln(l_it)*	β_{kl}	*ln(k_it)*	β_{lim}	*ln(im_it)*	β_{lt}	*t*	
			0.3247	*-0.1029*	*7.802062*	*0.1279*	*8.38178*	*-0.0485*	*9.264882*	*0.0082*	*4.97619*	0.185355
	Intermediate	$e_{im} = \partial lny/\partial lnim_{it}$	β_{im}	β_{imim}	*ln(im_it)*	β_{iml}	*ln(l_it)*	β_{kim}	*ln(k_it)*	β_{imt}	*t*	
			0.691	*0.1423*	*9.264882*	*-0.0485*	*7.80206*	*-0.1074*	*8.38178*	*0.0054*	*4.97619*	0.757661
	Returns to	$e = e_k + e_l + e_{im}$										1.002535
	Tech.	$\partial lny/\partial t$	β_t	β_{tt}	*t*	β_{lt}	*ln(l_it)*	β_{kt}	*ln(k_it)*	β_{imt}	*ln(im_it)*	
			0.0286	*-0.0023*	*4.97619*	*0.0082*	*7.80206*	*-0.0154*	*8.38178*	*0.0054*	*9.26488*	0.002083

Source: Author's estimates

Table 6.8: The calculations of returns to scale and technical change of Thai listed manufacturing sector and sub-manufacturing sectors

Sectors		**Output Elasticity**	Estimated parameters and mean value of inputs								
	Capital	$e_k = \partial lny/\partial \ln k_{it}$	β_k	β_{kk}	$\ln(k_{it})$	β_{kl}	$\ln(l_{it})$	β_{kim}	$\ln(im_{it})$	β_{kt}	t	Estimated e
			1.0018	*-0.1546*	*8.64896*	*0.1627*	*7.21283*	*-0.1234*	*9.110764*	*0.0032*	*5.32494*	-0.269030
Industrials	Labour	$e_l = \partial lny/\partial lnl_{it}$	β_l	β_{ll}	$\ln(l_{it})$	β_{kl}	$\ln(k_{it})$	β_{lim}	$\ln(im_{it})$	β_{lt}	t	
			-0.2765	*0.2178*	*7.212825*	*0.1627*	*8.64896*	*-0.2495*	*9.110764*	*-0.0219*	*5.32494*	0.311887
	Intermediate	$e_{im} = \partial lny/\partial lnim_{it}$	β_{im}	β_{imim}	$\ln(im_{it})$	β_{iml}	$\ln(l_{it})$	β_{kim}	$\ln(k_{it})$	β_{imt}	t	
			-3.5993	*0.7253*	*9.110764*	*-0.2495*	*7.21283*	*-0.1234*	*8.648955*	*0.0457*	*5.32494*	0.385206
	Returns to	$e = e_k + e_l + e_{im}$										0.428062
	Tech. Change	$\partial lny/\partial t$	β_t	β_{tt}	t	β_{lt}	$\ln(l_{it})$	β_{kt}	$\ln(k_{it})$	β_{imt}	$\ln(im_{it})$	
			-0.2646	*0.0008*	*5.324937*	*-0.0219*	*7.21283*	*0.0032*	*8.64896*	*0.0457*	*9.11076*	0.025738
	Capital	$e_k = \partial lny/\partial \ln k_{it}$	β_k	β_{kk}	$\ln(k_{it})$	β_{kl}	$\ln(l_{it})$	β_{kim}	$\ln(im_{it})$	β_{kt}	t	Estimated e
			0.1298	*-0.0493*	*9.313047*	*0.0563*	*7.7973*	*-0.0041*	*9.674245*	*-0.0017*	*5.22849*	0.061102
Other Sectors	Labour	$e_l = \partial lny/\partial lnl_{it}$	β_l	β_{ll}	$\ln(l_{it})$	β_{kl}	$\ln(k_{it})$	β_{lim}	$\ln(im_{it})$	β_{lt}	t	
			0.5256	*0.0948*	*7.797295*	*0.0563*	*9.31305*	*-0.1725*	*9.674245*	*0.0105*	*5.22849*	0.175200
	Intermediate	$e_{im} = \partial lny/\partial lnim_{it}$	β_{im}	β_{imim}	$\ln(im_{it})$	β_{iml}	$\ln(l_{it})$	β_{kim}	$\ln(k_{it})$	β_{imt}	t	
			0.3823	*0.1868*	*9.674245*	*-0.1725*	*7.7973*	*-0.0041*	*9.313047*	*-0.0073*	*5.22849*	0.768064
	Returns to	$e = e_k + e_l + e_{im}$										1.004366
	Tech. Change	$\partial lny/\partial t$	β_t	β_{tt}	t	β_{lt}	$\ln(l_{it})$	β_{kt}	$\ln(k_{it})$	β_{imt}	$\ln(im_{it})$	
			0.0596	*-0.0091*	*5.228487*	*0.0105*	*7.7973*	*-0.0017*	*9.313047*	*-0.0073*	*9.67425*	0.007438

Source: Author's estimates

Note: The estimated parameters in Table 6.8 refer to Table 6.7 and the mean values of all inputs refer to Tables 6.1 to 6.5.

$$Note: Ln(y_{it}) = \beta_0 + \beta_1 \ln(L_{it}) + \beta_2 \ln(K_{it}) + \beta_3 \ln(IM_{it}) + \beta_4 (t) + \frac{1}{2}\beta_5 \ln(L_{it}^2) + \frac{1}{2}\beta_6 \ln(K_{it}^2) + \frac{1}{2}\beta_7 \ln(IM_{it}^2) + \frac{1}{2}\beta_8 (t^2) + \beta_9 \ln(L_{it}) * \ln(K_{it})$$

$$+\beta_{10} \ln(L_{it}) * \ln(IM_{it}) + \beta_{11} \ln(L_{it}) * \ln(t) + \beta_{12} \ln(K_{it}) * \ln(IM_{it}) + B_{13}(K_{it}) * (t) + B_{14}(IM_{it}) * (t) + V_{it} - U_{it}$$

From Table 6.9 intermediate inputs have a high production elasticity, followed by the labour input and capital input, respectively, for the SET's manufacturing sector as well as all sub manufacturing sectors. In other words the empirical results reveal that the production of Thai listed manufacturing enterprises is mainly contributed by intermediate inputs and labour input, but capital is found to be the least important input. A measure of returns to scale, given by the sum of the elasticities of output with respect to each input, provides more economic meaning, indicating whether firms in the manufacturing sector are operating under increasing, decreasing, or constant returns to scale. The returns to scale, given by 0.9187, indicates the existence of decreasing returns to scale[82] for Thai listed manufacturing enterprises (see Table 6.9). For manufacturing subsectors there is evidence of constant returns to scale for the Agro and Food Industry (1.0038) and Consumer Products (1.0025) and Other Sectors (1.0044), but evidence of moderate decreasing returns to scale is found in the Industrials sector (0.4281) (see Table 6.9).

Table 6.9: Estimated production elasticities, returns to scale, and technical change rate

	All Manufacturing	Agro & Food Industry	Consumer Products	Industrials	Other Sectors
Production Elasticity					
Capital	0.0168	0.0552	0.0595	-0.2690	0.0611
Labour	0.2716	0.1549	0.1854	0.3119	0.1752
Intermediate Inputs	0.6303	0.7937	0.7576	0.38521	0.7681
Returns to Scale	0.9187	1.0038	1.0025	0.4281	1.0044
Tech. Change Rate	0.0205	-	0.0021	0.0257	0.0074

Source: Author's estimates

Under the Translog specification for technology, Equation (6.2), the rate of technical change is given by $\frac{\partial lny}{\partial t} = \beta_4 + \beta_8 * t + \beta_{11} * \ln(l_{it}) + \beta_{13} * \ln(k_{it}) + \beta_{14} * \ln(im_{it})$ (Kim, 1992). From Table 6.9 the rate of technical change is found to be 0.0205 for the SET's manufacturing sector, indicating that the rate of technical change

[82] Constant returns to scale refers to an m-fold change in all inputs resulting in an m-fold change in output; increasing returns to scale refers to a change in output by more than an m-fold change in all inputs; decreasing returns to scale refers to a change in output less than an m- fold change in all inputs (OECD, 2001, p125).

increases at 2.05 percent per year. The positive rates of technical change, given by 0.0021, 0.0257, 0.0074, indicate that the rate of technical change increase at 0.21 percent, 2.57 percent, and 0.74 percent for the Consumer Products, Industrials, and Other Sectors, respectively. In addition, the estimates of β_{11} and β_{13} are also significantly negative and positive, respectively, for the SET's manufacturing sector (see Equation (6.2), Table 6.7). This evidence implies that there is the existence of labour-using and capital-saving technical progress for Thai listed manufacturing enterprises over the period 2000 to 2008. For sub-manufacturing sectors the evidence for labour-using technical progress is also found for Industrials, as indicated by a negative coefficient sign, but it is not statistically significant.

On the other hand evidence for labour-saving technical progress is found for Other Sectors due to a significant and positive estimated coefficient. Such labour-saving technical progress is also found for Consumer Products due to a positive coefficient sign for β_{11}, but it is not statistically significant. Focusing on the capital input used for technical progress, the existence of capital-using technical progress is found for Consumer Products due to a significant and negative coefficient sign for β_{13}. The existence of capital-using and capital-saving technical progress is also found for Other Sectors and Industrials, respectively, but their estimated coefficients are not statistically significant.

Table 6.10: Technical efficiency scores (2000 - 2008) predicted by FRONTIER 4.1

Sector(s)	No. of Firms	Minimum	Maximum	Mean	Std. Deviation
All manufacturing sector	1309	0.003	0.955	0.812	0.123
Sub-manufacturing sector:					
1. Agro and Food Industry	323	0.476	0.993	0.948	0.060
2. Consumer Products	252	0.012	0.988	0.875	0.173
3. Industrials[83]	397	0.016	1.000	0.519	0.327
4. Other Sectors	337	0.225	0.980	0.887	0.102

Source: Author's estimates

[83] Average technical efficiency is the lowest compared with mean technical efficiencies of other sub - manufacturing sectors, but this result is consistent with the evidence that Industrials is the only sector that experiences moderate returns to scale (see Table 6.9).

With respect to the Battese and Coelli (1995) model, technical efficiency scores can be predicted through estimates of the Translog frontier production function using FRONTIER 4.1 which are summarized in Table 6.10. Average technical efficiency scores are given by 0.812 (81.2%) for all Thai listed manufacturing enterprises over the period 2000 to 2008. Comparing among the sub-manufacturing sectors listed[84] the Agro and Food Industry perform the best, followed by those listed manufacturing firms in the Other Sectors, and Consumer Products, and Industrials (see Table 6.10).

(ii) Results from estimates of an inefficiency effects model (using SFA)

Following the Battese and Coelli (1995) model the empirical results shown in Table 6.11 are obtained from an inefficiency effects model using FRONTIER 4.1. In other words, the effects of business environment and firm-specific variables upon a firm's technical inefficiency are examined in this part.

However, the signs of the estimated coefficients as shown in Table 6.11 must be interpreted conversely in order to be consistent with the hypotheses discussed in Chapter 5, which focus on the effects of business environment and firm-specific variables on technical efficiency and not technical inefficiency.

For the inefficiency effects model the estimate of the variance parameter (γ) which is close to one indicates that the residual variation is highly related to the inefficiency component (Battese and Coelli, 1995, p330). From Table 6.11 it can be seen that the estimated γ (0.870) is high and significant for overall Thai listed manufacturing enterprises, indicating that much of the variation in the composite error term is due to inefficiency effects ($U_{it}s$). Similarly, the estimated γs are also high for the Agro and Food Industry, Consumer Products, and Other Sectors, which are given by 0.697, 0.995, and 0.807 respectively. The exception to this is the Industrials sector where γ is equal to 0.233[85] and this is statistically significant at the 5 percent level of significance.

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[84] The Translog frontier production function is estimated separately for each sub manufacturing sector.
[85] This result is also consistent with other empirical findings (e.g., moderate decreasing returns to scale and low mean technical efficiency compared with other sub manufacturing sectors) (see footnote 83).

Table 6.11: Maximum-likelihood estimates for parameters of the inefficiency models from the Stochastic Frontier Analysis (SFA) approach

Inefficiency Variables	All Manufacturing	Agro & Food Industry	Consumer Products	Industrials	Other Sectors[a]
Constant	12.8522*	1.6140*	10.3713*	13.2751*	1.8095*
	(1.7039)	(0.5875)	(1.4807)	(1.0327)	(0.5490)
Leverage (LEV)	-0.0357*	0.1670*	-1.3650*	0.0195	0.4244*
	(0.0175)	(0.0306)	(0.3315)	(0.0131)	(0.0897)
Liquidity (LIQ)	0.2208*	-0.0464*	0.1165*	0.1288*	0.0135**
	(0.0146)	(0.0190)	(0.0147)	(0.0147)	(0.0077)
Internal financing (INF)	0.6401*	0.1015*	0.9345*	0.1275	0.2167*
	(0.1194)	(0.0342)	(0.1176)	(0.0879)	(0.0891)
External financing (EXF)	0.00007*	0.000002	0.00004	0.00007*	-0.00001**
	(0.00001)	(0.000003)	(0.00008)	(0.00001)	(0.00001)
Executive remuneration (EXC)	-0.4883*	-0.2485	-5.0034*	-0.1132**	-0.2790
	(0.2564)	(0.1718)	(0.6406)	(0.0681)	(0.4275)
Controlling ownership (TOP5)	-0.0345*	-0.0005	-0.0088	-0.0142*	-0.0053*
	(0.0033)	(0.0012)	(0.0084)	(0.0024)	(0.0017)
Managerial ownership (MGR)	-0.0211*	-0.0010	-0.0087	-0.0043*	0.0153*
	(0.0031)	(0.0008)	(0.0060)	(0.0018)	(0.0037)
Exports (EXP)	-0.0124*	0.0015*	0.0070*	-0.0051*	-0.0023**
	(0.0022)	(0.0005)	(0.0032)	(0.0014)	(0.0012)
Research and Development (R&D)	0.8098*	-0.0286	0.8405*	0.0711	-0.2449*
	(0.1511)	(0.0640)	(0.3273)	(0.0829)	(0.0737)
Government assistance (GOVT)	-0.6720*	0.0327	-0.4809*	0.0905	-0.1830*
	(0.1732)	(0.0466)	(0.1901)	(0.0788)	(0.0792)
Foreign cooperation (FCO)	0.3051*	0.2085*	0.8618*	-0.3426*	-0.6338*
	(0.1002)	(0.0546)	(0.1577)	(0.1024)	(0.0946)
Firm Size (SIZE)	-0.7578*	-0.1355*	-0.7978*	-0.8221*	-0.1634*
	(0.1076)	(0.0295)	(0.0781)	(0.0635)	(0.0361)
Firm Age (AGE)	-0.0389*	0.0019	0.0267*	0.0085*	0.0073*
	(0.0066)	(0.0031)	(0.0092)	(0.0036)	(0.0028)
Family -owned firm (FAM)	-3.6974*	0.2022	-3.3580*	0.0358	-0.2756*
	(0.2669)	(0.3720)	(0.3167)	(0.2385)	(0.1014)
Foreign -owned firm (FGR)	-3.8385*	0.0611	-3.3701*	0.2698	1.1706*
	(0.5746)	(0.3770)	(0.3578)	(0.2310)	(0.2140)
Domestic- owned firm (DOM)	-1.3651*	0.4357	-0.1193	0.4520**	0.3781*
	(0.2002)	(0.3797)	(0.5458)	(0.2415)	(0.1742)
Hybrid -owned firm (HYD)	-2.6310*	0.0598	-3.6325*	-0.0449	0.2178
	(0.2141)	(0.3986)	(0.4534)	(0.2486)	(0.1588)
Variance parameters					
sigma-square	1.0536*	0.0093*	0.4190*	0.1866*	0.0850*
	(0.0669)	(0.0016)	(0.0366)	(0.0139)	(0.0229)
gamma(γ)	0.8698*	0.6965*	0.9947*	0.2328*	0.8068*
	(0.0113)	(0.0645)	(0.0020)	(0.0443)	(0.0718)
Log-likelihood function	-744.76	428.05	187.99	-212.97	132.94

Source: Author's estimates

Note: Standard Errors (S.E.) are in parentheses; * and ** indicate that the coefficients are statistically significant at the 5% and 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Computer components); The empirical results refer to Equations 6.4.

For the overall significance of the estimated model there is strong evidence that inefficiency effects are a linear function of all the explanatory variables, since all the LR test statistics are greater than the critical value at the 5 percent level of significance for the SET's manufacturing sector. This includes all sub - manufacturing sectors (see Section 6.4 (vi)). The empirical results shown in Table 6.11 reveal the effects of firm-specific and business environment variables on technical efficiency by applying the inefficiency effects model of the Battese and Coelli (1995) model using FRONTIER 4.1.

Leverage has a significant and positive effect on a firm's technical efficiency for the SET's manufacturing sector, including Consumer Products, as suggested by Sena (2006) and Mok et al. (2007). This result implies that financially constrained firms are likely to utilize their financial resources and control input costs effectively, resulting in an enhancement of their technical efficiency. The positive result is different from the findings of Goldar et al. (2003) which concluded that financially constrained firms may have difficulty in operating their businesses effectively due to the inability to meet their financial liabilities, resulting in lower levels of their efficiency. A significant and negative relationship, however, is found for the Agro and Food Industry and Other Sectors. Leverage does not exert a significant effect on the efficiency of the Industrials sector. To confirm this conclusion there is strong evidence that liquidity has a significant and negative relationship with a firm's technical efficiency for the SET's manufacturing sector in aggregate, including sub-manufacturing sectors such as Consumer Products, Industrials, and Other Sectors, but a significant and positive relationship is found for the Agro and Food Industry. This negative result implies that financially healthy firms may use their financial resources and control input costs ineffectively due to their abundant financial resources.

In addition, internal financing is also found to have a significant and negative effect on a firm's technical efficiency for the SET's manufacturing sector in aggregate, including the Agro & Industry, Consumer Products, and Other Sectors. This implies that the agency problem exists for the use of internal funds, since managers do not appear to maximise shareholders' interests or have strong incentives to abuse internal funds, as suggested by Jensen (1986). A positive result is also found for the Industrials sector, but it is not statistically significant.

External financing is also found to have a significant and negative effect on a firm's technical efficiency for the SET's manufacturing sector in aggregate and for Industrials, contradicting results obtained by Kim (2003). This negative result implies that financial institutions may impose restrictive conditions on their loan agreements which may negatively affect the operation of firms. A significant and positive association is found for Other Sectors. This positive finding may indicate that firms which obtain external funds (loans) from financial institutions are likely to be technically efficient, since financial institutions are likely to provide funds for firms which can pay back their loans. It is insignificant in the Agro and Food Industry and Consumer products sectors. However, the effect of external financing on a firm's technical efficiency is very small for the SET's manufacturing sector including all sub-manufacturing sectors due to a very small size of the estimated coefficients.

Executive remuneration is also significant and positively related with a firm's technical efficiency for the SET's manufacturing sector including Consumer Products and industrials, as suggested by Baek and Pagán (2002), but is insignificant for the other manufacturing sub - sectors. This positive result implies that listed manufacturing firms with higher levels of executive remuneration tend to be more technically efficient. In practice, the amount of bonuses or increased salaries which executives (i.e., board of directors and managers) will receive depends upon the firm's annual net profits. In some Thai listed manufacturing firms the amount of executive remuneration (i.e., bonuses) that executives receive is based on the percentage of the firm's annual net profits. Therefore, a firm which provides high executive remuneration tends to achieve an increase in its technical efficiency.

For ownership structure, controlling ownership is found to have a significant and positive effect on a firm's technical efficiency for the SET's manufacturing sector including Industrials, and Other Sectors but is not significant for the Agro and Food Industry and Consumer Products sectors. This positive result is similar to the findings of Wiwattanakantang (2001) and Yammeesri and Lodh (2003), who revealed that controlling ownership is positively related to a firm's performance as evaluated by accounting or financial measures (e.g., ROA, sales-assets ratio, stock returns and profitability). This finding also supports the agency theory that controlling shareholders tend to perform better than dispersed shareholders, since a high level of ownership concentration can reduce agency costs.

Furthermore, managerial ownership is found to have a significant and positive effect on a firm's technical efficiency for the SET's manufacturing sector including Industrials, but a significant and negative effect is found for the Other Sectors. This positive finding is consistent with results obtained by Liao et al. (2010). This indicates that the agency problem is reduced, since managerial ownership can help align the potentially conflicting interests of shareholders and managers, as suggested by Jensen and Meckling (1976). In addition, the empirical results are found to be positive, but not significant for the Agro and Food Industry and Consumer Products sectors.

Exporting has a significant and positive relationship with a firm's technical efficiency for the SET's manufacturing sector in aggregate, including Industrials and Other Sectors, but such a significant and negative effect is found in the Agro and Food Industry and for Consumer Products. In other words, evidence of the learning-by-exporting hypothesis is only found in the SET's manufacturing sector in aggregate, and for the Industrials and Other Sectors. This positive result indicates that exporting firms are also likely to improve their technical efficiency due to their learning-by-exporting experience (i.e., new product designs and production methods).

Research and Development (R&D) is found to have a significant and negative impact on a firm's technical efficiency for the SET's manufacturing sector in aggregate, including Consumer Products, but a significant and positive relationship is found for Other Sectors. The significant and negative result for the R&D dummy variable found in the SET's manufacturing sector including Consumer Products can be interpreted that listed manufacturing enterprises which have research and development (R&D) are likely to have lower technical efficiency compared with their counterparts which have no research and development (R&D). Such a negative finding also implies that most listed manufacturing firms misreported their R&D activities, since they did not intend to implement them as they reported to investors. It is not significant for the technical efficiency of firms in the Agro and Food Industry and Industrials sectors.

Government assistance is significant and negatively related with a firm's technical efficiency for the SET's manufacturing sector in aggregate, including Consumer Products and Other Sectors. This negative result implies that government assistance does not promote the firm's technical efficiency, since it only focuses on financial privileges (e.g., exemption or reduction from corporate income tax on net income from the promoted projects) provided by the Board of Investment (BOI) and lacks assistance in improving firm innovation.

Foreign cooperation is found to have a significantly negative effect on a firm's technical efficiency for the SET's manufacturing sector in aggregate and including the Agro and Food Industry and Consumer Products, but a significant and positive effect is found for Industrials and Other Sectors. This negative result implies that Thai listed manufacturing firms which required foreign cooperation (e.g., technical assistance) faced operational problems within their firms. According to their financial reports, most were required to pay for such foreign technical assistance. The significant and negative result of a dummy variable for foreign cooperation found in the SET's manufacturing sector, including the Agro and Food Industry and Consumer Products indicates that listed manufacturing enterprises with foreign cooperation tend to have lower technical efficiency compared with their counterparts with no foreign cooperation.

There is strong evidence that firm size has a significant and positive relationship with technical efficiency for the SET's manufacturing sector in aggregate as well as all sub-manufacturing sectors. This positive result is also consistent with the findings of Charoenrat and Harvie (2011), which found a positive relationship between firm size and technical efficiency for 13,176 Thai SMEs in three northern-eastern provinces. This finding also implies that large firms are likely to obtain higher levels of technical efficiency due to economies of scale. Firm age has a significant and positive effect on a firm's technical efficiency for the SET's manufacturing sector[86] in

[86] It is observed that all the sub-manufacturing sectors produce a negative relationship, but a positive association is found for the SET's manufacturing sector in aggregate. This is due to the difference in production technology in each sub-manufacturing sector. More specifically, the Agro and Food Industry sector has no technical progress. Moreover, the empirical results estimated by the SFA approach will be compared with the empirical evidence obtained from the DEA approach for robustness. Therefore, the DEA approach is useful for this situation, since it does not require any functional form.

aggregate, but a significant and negative relationship is found for the Consumer Products, Industrials, and Other Sectors. A positive result is also found for the Agro and Food Industry sector, but is not statistically significant. This positive result implies that firm technical efficiency is enhanced through a learning-by-doing experience.

Focusing on the types of owned firms, family-owned firms have a significant and positive effect on technical efficiency for the SET's manufacturing sector in aggregate, including the Consumer Products and Other Sectors. This positive result is similar to the empirical studies of Wiwattanakantang (2001) and Yammeesri and Lodh (2003), except that their studies focused on firm performance as measured by profitability and financial ratios. This also implies that family ownership has the advantage of enhancing communications between related members in the firm, as suggested by Fama and Jensen (1983). In other words the separation of management and control, which causes agency problems, is alleviated due the close relationship among family members within their firm. It is insignificant for the other sub - sectors.

Foreign - owned firms are found to have a significant and positive effect on technical efficiency for the SET's manufacturing sector including Consumer Products. The significant positive relationship between foreign ownership and technical efficiency is also consistent with empirical results obtained from a number of other studies (Fukuyama et al. 1999; Goldar et al. 2003; Bottasso & Sembenelli 2004). This implies that foreign-owned firms have superior technology, managerial expertise, good corporate governance, and a strong - market network (Kimura and Kiyota, 2007). Such significant and negative evidence[87], however, is found for Other Sectors. Moreover, it is insignificant for other sub-manufacturing sectors.

Domestic - owned firms are found to have a significant and positive effect on technical efficiency for the SET's manufacturing sector in aggregate, but a significant and negative effect is found for the Industrials and Other Sectors. A positive effect for the technical efficiency of firms is also found for the Consumer Products sector, but it is not statistically significant. The result is not statistically significant for the Agro and

[87] This negative result contradicts results obtained from other empirical studies which were reviewed in Section 3.5.2, Chapter 3. However, this SFA finding will be cross checked with the DEA result for the "Other Sectors" sub-sector.

Food Industry sector. Hybrid-owned firms are found to have a significant and positive effect on technical efficiency for the SET's manufacturing sector in aggregate, and for the Consumer Products sector, but it is insignificant for other sub - sectors. Comparing among types of owned firms the empirical results, as indicated by the size of the significantly estimated coefficients, reveal that foreign - owned firms perform the best for the SET's manufacturing sector, followed by family - owned firms, hybrid - owned firms, and domestic - owned firms, given joint - owned firms as the base category[88].

6.5.2 Results from the Data Envelopment Analysis (DEA) approach

This section presents empirical results obtained from the two-stage Data Envelopment Analysis (DEA) approach for the SET's manufacturing sector, including all sub-manufacturing sectors, which can be divided into two stages of the estimation: (i) estimates of the DEA technical efficiency scores[89] predicted by DEAP 2.1 and (ii) estimates of the maximum - likelihood Tobit model.

(i) Results from estimates of the DEA technical efficiency scores

Section 6.5.2 (i) provides results from estimates of DEA technical efficiency scores for the first step of the two-stage DEA approach. For this part the output orientated model is used assuming fixed input amounts and maximized output production[90]. One output and three inputs, as previously used for the Stochastic Frontier Analysis (SFA), are also used to predict DEA technical efficiency scores. Technical efficiency scores are predicted by VRS linear programming as analysed by DEAP 2.1 (see Equation 6.4). In addition, the multiple - stage DEA option provided in DEAP 2.1 is applied to predict technical efficiency scores (see Section 6.2.2). The efficiency scores predicted by DEAP 2.1 are summarized in Table 6.12.

DEAP 2.1[91] provides three different types of estimated efficiency scores: (i) constant returns to scale (CRS) technical efficiency, (ii) variable returns to scale (VRS) technical efficiency, (iii) and scale efficiency (see Section 6.2.2). Only the VRS

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[88] This is to avoid the problem of the dummy variable trap.

[89] DEA technical efficiency scores will be converted to technical inefficiency scores by subtracting them from "unity".

[90] Coelli et al. (2005, p180) pointed out that the selection of orientation (e.g., input or output orientated model) has only a very small impact on predicted efficiency scores.

[91] By selecting the variable returns to scale option in DEAP 2.1. In addition, only CRS technical efficiency scores are obtained if constant returns to scale is selected.

technical efficiency scores, however, will be used for estimates of the maximum-likelihood Tobit model, since VRS technical efficiency scores predicted by DEAP 2.1 for the DEA approach is equivalent to pure technical efficiency scores predicted by FRONTIER 4.1 for the SFA approach.

Table 6.12: Efficiency scores (2000 - 2008) predicted by DEAP 2.1

Sector	Technical	No. of Obs.	Minimum	Maximum	Mean	Std. Deviation
All manufacturing sector	CRS	1309	0.474	1.00	0.814	0.068
(1+2+3+4)	VRS	1309	0.503	1.00	0.887	0.065
	SCALE	1309	0.714	1.00	0.918	0.058
Sub-manufacturing sectors						
1. Agro & Food Industries	CRS	323	0.707	1.00	0.809	0.055
	VRS	323	0.708	1.00	0.889	0.052
	SCALE	323	0.726	1.00	0.911	0.056
2.Consumer Products	CRS	252	0.583	1.00	0.784	0.062
	VRS	252	0.653	1.00	0.854	0.058
	SCALE	252	0.777	1.00	0.918	0.051
3.Industrials	CRS	397	0.474	1.00	0.848	0.075
	VRS	397	0.503	1.00	0.911	0.070
	SCALE	397	0.738	1.00	0.931	0.052
4.Other Sectors	CRS	337	0.691	1.00	0.801	0.057
	VRS	337	0.691	1.00	0.883	0.062
	SCALE	337	0.714	1.00	0.909	0.066

Source: Author's estimates

Note: CRS = Constant Returns to Scale Technical Efficiency; VRS = Variable Returns to Scale Technical Efficiency; SCALE = Scale Efficiency. Predicted technical efficiency scores are classified with respect to manufacturing firms in aggregate and for manufacturing sub-sectors.

From Table 6.12 the average VRS technical efficiency score is given by 0.887 for Thai listed manufacturing enterprises over the period 2000 to 2008.

(ii) Results from estimates of the maximum-likelihood Tobit model

This section provides empirical results obtained from the second stage of the two-stage DEA approach. The maximum-likelihood Tobit Model is used to conduct the empirical analysis in this part (see Section 6.5.2). Technical inefficiency scores are used as the dependent variable, which are simply calculated by subtracting VRS efficiency scores predicted by DEAP 2.1 from "unity". The business environment and firm-specific variables, as previously used in the SFA approach, are also applied as the independent variables for this part. The heteroskedasticity-robust standard errors are used for this model, which are shown in parentheses in Table 6.13. In addition, the overall significance of the estimated model is tested by conducting the likelihood-ratio test statistic (LR statistic) as discussed in Section 6.4 (vi).

Table 6.13: Maximum-likelihood Tobit estimates for parameters of the two-stage DEA approach

Firm Specific Variables	All Manufacturing	Agro & Food Industry	Consumer Products	Industrials	Other Sectors[a]
Left censoring (value) at zero	93	13	1	52	27
Right censoring (value) at one	0	0	0	0	0
Uncensored observations	1216	310	251	345	310
Total observations	1309	323	252	397	337
Dependent variable: Technical inefficiency (VRS)					
Constant	0.5833*	0.6566*	0.7427*	0.3209*	0.4815*
	(0.0447)	(0.0561)	(0.0837)	(0.0792)	(0.0507)
Leverage (LEV)	-0.0048*	0.0128**	-0.0355*	-0.0035	0.0288*
	(0.0022)	(0.0068)	(0.0122)	(0.0023)	(0.0127)
Liquidity (LIQ)	0.0023*	0.0012	0.0024*	0.0071*	-0.0014
	(0.0011)	(0.0019)	(0.0010)	(0.0030)	(0.0020)
Internal financing (INF)	0.0052	0.0029	0.0119**	-0.0056	-0.0116*
	(0.0035)	(0.0048)	(0.0067)	(0.0080)	(0.0055)
External financing (EXF)	0.0000006	-0.0000004	0.0000001	0.000006*	-0.0000015*
	(0.0000007)	(0.0000003)	(0.0000053)	(0.000001)	(0.0000006)
Executive remuneration (EXC)	-0.1026*	-0.0964**	-0.1862*	-0.0955*	0.0343
	(0.0263)	(0.0514)	(0.0649)	(0.0357)	(0.0434)
Controlling ownership (TOP5)	-0.0002	0.0003*	-0.0002	-0.0001	-0.0005*
	(0.0002)	(0.0002)	(0.0003)	(0.0003)	(0.0002)
Managerial ownership (MGR)	-0.0004*	-0.0002*	0.0004**	-0.0007*	-0.0001
	(0.0001)	(0.0001)	(0.0002)	(0.0002)	(0.0002)
Exports (EXP)	-0.0001*	-0.0002*	0.0001	-0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
Research and Development (R&D)	0.0142*	0.0243*	0.0260*	-0.0078	0.0275*
	(0.0051)	(0.0071)	(0.0120)	(0.0114)	(0.0100)
Government assistance (GOVT)	0.0075**	0.0163*	0.0128**	0.0238*	0.0094
	(0.0041)	(0.0062)	(0.0068)	(0.0088)	(0.0062)
Foreign cooperation (FCO)	0.0042	0.0006	0.0077	0.0164*	0.0011
	(0.0035)	(0.0068)	(0.0076)	(0.0077)	(0.0071)
Firm Size (SIZE)	-0.0295*	-0.0369*	-0.0428*	-0.0186*	-0.0238*
	(0.0025)	(0.0028)	(0.0052)	(0.0051)	(0.0032)
Firm Age (AGE)	-0.00004	0.0013*	0.0010*	0.0005	-0.0004
	(0.0002)	(0.0002)	(0.0004)	(0.0003)	(0.0003)
Family -owned firm (FAM)	-0.0263*	-0.0717*	-0.0340*	0.0492*	-0.0067
	(0.0065)	(0.0151)	(0.0108)	(0.0161)	(0.0090)
Foreign -owned firm (FGR)	-0.0424*	-0.0757*	-0.0332*	0.0040	-0.0212*
	(0.0073)	(0.0141)	(0.0131)	(0.0153)	(0.0099)
Domestic- owned firm (DOM)	-0.0059	-0.0461*	0.0097	0.0482*	0.0306*
	(0.0090)	(0.0185)	(0.0176)	(0.0181)	(0.0111)
Hybrid -owned firm (HYD)	-0.0217*	-0.0634*	-0.0225**	0.0212	0.0322*
	(0.0089)	(0.0169)	(0.0126)	(0.0242)	(0.0120)
Error Distribution	*0.0593**	*0.0346**	*0.0443**	*0.0646**	*0.0498**
	(0.0024)	*(0.0016)*	*(0.0025)*	*(0.0029)*	*(0.0028)*
Log likelihood (unrestricted)	*1596.95*	*589.18*	*424.53*	*401.75*	*464.18*
Log likelihood (restricted)[b]	*1405.30*	*444.52*	*357.39*	*330.60*	*362.22*
LR test	*383.29**	*289.33**	*134.29**	*142.29**	*203.93**
Critical value	*27.59*	*27.59*	*27.59*	*27.59*	*27.59*

Source: Author's estimates

Note: Huber/White robust standard errors (S.E.) are in parentheses; * and ** indicate that the coefficients are statistically significant at the 5% level and 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology; [b] Inefficiency scores are regressed by a constant.

The LR test statistics are all greater than the critical value at the 5 percent level of significance, indicating that joint explanatory variables significantly explain all estimated models (see Table 6.13). From Table 6.13 the empirical results reveal the effects of business environment and firm-specific variables on technical inefficiency. However, the signs of the estimated coefficients are interpreted in the opposite direction in order to be consistent with the hypotheses discussed in Chapter 5, which focus on the effects of these inefficiency variables on firm technical efficiency.

From Table 6.13 leverage has a significant and positive association with a firm's technical efficiency for the SET's manufacturing sector including Consumer Products, but a significant and negative relationship is found for the Agro and Food Industry and Other Sectors. This positive finding implies that financially constrained firms have efficient control over their financial resource input costs, resulting in an improvement of their efficiency. No significant relationship is found for the Industrials sector. To confirm this conclusion there is evidence to suggest that liquidity has a significant and negative relationship with a firm's technical efficiency for the SET's manufacturing sector, including Consumer Products and Industrials. No significant relationship is found for the Agro and Food and Other Sectors.

Moreover, internal financing is also found to have a significant and negative effect on a firm's technical efficiency for Consumer Products, but a significant and positive effect is found for the Other Sectors. This negative finding implies that the use of internal funds causes an agency problem, since managers tend not to maximise shareholders' interests or have strong incentives to abuse internal funds. No significant relationship is found for the manufacturing sector in aggregate and for the Agro and Food Industry and Industrials sub sectors. External financing is also found to have a significant and negative effect on a firm's technical efficiency for the Industrials sector, but a significant and positive association is also found for the Other Sectors. However, the effect of external financing on a firm's technical efficiency is very weak due to very small size of the estimated coefficients (close to zero) for the Industrials and Other Sectors. No significant relationship is found for the manufacturing sector in aggregate and for the Agro and Food Industry and Consumer Products sub-sectors.

The effect of executive remuneration on a firm's technical efficiency is found to be significant and positive for the SET's manufacturing sector including Agro and Food Industry, Consumer Products, and Industrials, but is not significant for the Other Sectors. This positive finding indicates that listed manufacturing firms with higher levels of executive remuneration are likely to be more technically efficient, since managers have strong incentives to control the firms' input costs effectively or maximise the firms' profit which in turn will increase executive remuneration.

For ownership structure, controlling ownership is significant and positively related with a firm's technical efficiency for Other Sectors, but is significant and negatively related in the Agro and Food Industry. A positive relationship is found for the SET's manufacturing sector in aggregate and for Consumer Products and Industrials sectors, but is not statistically significant. This positive finding also supports the agency theory that controlling shareholders are likely to perform better than dispersed shareholders, since they have strong incentives to protect the interests of their firms. In other words, a high level of controlling ownership can reduce agency costs.

Furthermore, managerial ownership is found to have a significant and positive effect on a firm's technical efficiency for the SET's manufacturing sector in aggregate and for the Agro and Food Industry and Industrials sectors. A positive relationship is also found for Other Sectors, but it is not statistically significant. The positive result implies that managerial ownership can help align the conflict of interests between shareholders and managers, or reduce the agency problem (Jensen and Meckling, 1976). A significant and negative relationship is found for Consumer Products. This negative finding shows that managerial shareholders exert more controlling power over the firm's operation, which results in a deterioration of a firm's performance. Exporting is also significant and positively related with a firm's technical efficiency for the SET's manufacturing sector in aggregate and for the Agro and Food Industry. In other words, the learning-by-exporting hypothesis exists for the SET's manufacturing sector and the Agro and Food Industry. No significant relationship, however, is found for Consumer Products, Industrials, and Other Sectors.

Research and Development (R&D) is found to have a significant and negative impact on a firm's technical efficiency for the SET's manufacturing sector in aggregate and all other sub-manufacturing sectors, except Industrials. The significantly negative dummy variable for research and development (R&D) indicates that listed manufacturing enterprises are likely to have lower technical efficiency compared with their counterparts with no research and development (R&D). This negative result implies that all Thai listed manufacturing firms, except those firms in the Industrials sub-sector, did not intend to implement their R&D seriously as stated in their annual reports.

Government assistance is significant and negatively related with a firm's technical efficiency for the SET's manufacturing sector in aggregate and for the Agro and Food Industry, Consumer Products, and Industrials. The significant and negative dummy variable for government assistance implies that listed manufacturing enterprises with government assistance tend to have lower technical efficiency than their counterparts with no government assistance. The relationship with Other Sectors is also negative but is not significant. This negative finding also implies that government assistance in the form of financial privileges provided by the Board of Investment (BOI) is not effective in promoting the technical efficiency of firms.

Foreign cooperation is only found to have a significant and negative affect on a firm's technical efficiency for Industrials. The significant and negative dummy variable for foreign cooperation implies that listed manufacturing enterprises with foreign cooperation have lower technical efficiency compared with their counterparts with no foreign cooperation. This negative result also implies that firms faced operational problems within them before they required foreign assistance. More importantly, most firms had to pay for such technical assistance. No significant relationship, however, is found for the SET's manufacturing sector, including other sub-manufacturing sectors. There is strong evidence that firm size has a significant and positive relationship with technical efficiency for the SET's manufacturing sector in aggregate and for all sub-manufacturing sectors. This positive finding also implies that large firms tend to have higher levels of technical efficiency due to economies of scale. Firm age has a significant and negative effect on the technical efficiency for the Agro and Food Industry and Consumer Products, but is insignificant for the manufacturing sector in aggregate and for all other sub-sectors. This positive result implies that the technical efficiency of firms is enhanced through accumulated experience.

Focusing on the various types of firm ownership, family-owned firms have a significant and positive relationship with the technical efficiency of the SET's manufacturing sector in aggregate, including that of the Agro and Food Industry and Consumer Products. This also implies that the separation of management and control, which causes agency problems, is reduced due to the close relationship among family members within their firms. However, a significant and negative relationship is found for the Industrials sector, indicating that family-owned firms can cause an agency problem due to lack of monitoring of the interests of minority shareholders. In other words they are likely to implement policies which benefit themselves, but deteriorate the overall performance of their firms. There is no significant relationship for the Other Sectors. Foreign-owned firms also have a significant and positive effect on the technical efficiency of the SET's manufacturing sector in aggregate as well as the Agro and Food Industry, Consumer Products, and Other Sectors. This implies that foreign-owned firms bring new technology, managerial expertise, good corporate governance, and a strong market network for domestic listed firms. No significant relationship is found for the Industrials sector.

Domestic-owned firms are found to have a significant and positive relationship with technical efficiency for the Agro and Food Industry, but a significant and negative relationship is found for the Industrials and Other Sectors. No significant relationship is found for the manufacturing sector in aggregate and for the Consumer Products sector. Hybrid-owned firms are found to have a significant and positive association with technical efficiency for the SET's manufacturing sector in aggregate and including the Agro and Food Industry and Consumer Product sectors, but a significant and negative effect is found for Other Sectors. No significant relationship was found in the Industrials sector. Comparing among the different types of owned firms, the size of the estimated dummy coefficients, given joint-owned firms as the base firm, indicate that foreign-owned firms perform the best, followed by family-owned firms, hybrid-owned firms, and domestic-owned firms for Thai listed manufacturing enterprises.

Table 6.14: Average technical efficiency scores classified by estimating approaches and the SET's manufacturing sectors

	All Manufacturing			Agro and Food Industry			Consumer Products			Industrials			Other Sectors		
	CRSTE	VRSTE	SCALE	CRSTE	VRSTE	SCALE	CRSTE	VRSTE	SCALE	CRSTE	VRSTE	SCALE	CRSTE	VRSTE	SCALE
2000															
SFA	-	0.808	-	-	0.947	-	-	0.864	-	-	0.443	-	-	0.876	-
DEA	0.814	0.871	0.936	0.825	0.885	0.935	0.799	0.851	0.940	0.830	0.885	0.940	0.795	0.858	0.930
2001															
SFA	-	0.821	-	-	0.943	-	-	0.862	-	-	0.453	-	-	0.866	-
DEA	0.838	0.895	0.938	0.838	0.900	0.933	0.827	0.881	0.940	0.860	0.908	0.947	0.825	0.888	0.932
2002															
SFA	-	0.786	-	-	0.944	-	-	0.854	-	-	0.454	-	-	0.874	-
DEA	0.832	0.896	0.930	0.828	0.898	0.923	0.816	0.875	0.933	0.855	0.908	0.942	0.823	0.895	0.922
2003															
SFA	-	0.819	-	-	0.946	-	-	0.864	-	-	0.463	-	-	0.896	-
DEA	0.890	0.927	0.960	0.892	0.927	0.963	0.851	0.899	0.947	0.915	0.944	0.970	0.888	0.928	0.957
2004															
SFA	-	0.820	-	-	0.948	-	-	0.891	-	-	0.563	-	-	0.889	-
DEA	0.826	0.901	0.918	0.817	0.898	0.912	0.804	0.876	0.919	0.855	0.923	0.927	0.813	0.896	0.910
2005															
SFA	-	0.813	-	-	0.951	-	-	0.900	-	-	0.566	-	-	0.900	-
DEA	0.779	0.878	0.889	0.757	0.868	0.875	0.740	0.839	0.883	0.828	0.911	0.910	0.765	0.873	0.880
2006															
SFA	-	0.815	-	-	0.955	-	-	0.884	-	-	0.577	-	-	0.895	-
DEA	0.789	0.878	0.900	0.778	0.875	0.890	0.743	0.833	0.894	0.836	0.910	0.920	0.773	0.874	0.887
2007															
SFA	-	0.813	-	-	0.961	-	-	0.870	-	-	0.551	-	-	0.891	-
DEA	0.784	0.876	0.897	0.770	0.877	0.880	0.736	0.821	0.898	0.832	0.909	0.917	0.772	0.874	0.887
2008															
SFA	-	0.813	-	-	0.965	-	-	0.888	-	-	0.741	-	-	0.891	-
DEA	0.787	0.870	0.906	0.774	0.873	0.889	0.738	0.815	0.906	0.835	0.904	0.925	0.773	0.865	0.896
2000 - 2008															
SFA	-	0.812	-	-	0.948	-	-	0.875	-	-	0.519	-	-	0.887	-
DEA	0.814	0.887	0.918	0.809	0.889	0.912	0.784	0.854	0.918	0.848	0.911	0.931	0.801	0.883	0.909

Source: Author's estimates

Note: Following the Battese and Coelli (1995) model technical efficiency scores are obtained from the estimates of FRONTIER 4.1 by estimating the Translog frontier production function. Predicted technical efficiency scores are classified with respect to each sub-manufacturing sector.

Table 6.15: Number of listed manufacturing firms classified by types of returns to scales and the SET's manufacturing sectors

	All Manufacturing						Agro & Food Industry						Consumer Products						Industrials						Other Sectors					
	DRS	%	IRS	%	CRS	%	DRS	%	IRS	%	CRS	%	DRS	%	IRS	%	CRS	%	DRS	%	IRS	%	CRS	%	DRS	%	IRS	%	CRS	%
2000	100	73%	33	24%	4	3%	30	81%	7	19%	0	0%	23	77%	6	20%	1	3%	22	59%	13	35%	2	5%	25	76%	7	21%	1	3%
2001	109	81%	23	17%	3	2%	35	95%	2	5%	0	0%	24	86%	4	14%	0	0%	23	64%	11	31%	2	6%	27	79%	6	18%	1	3%
2002	115	85%	18	13%	3	2%	36	97%	0	0%	1	3%	25	89%	3	11%	0	0%	27	71%	9	24%	2	5%	27	82%	6	18%	0	0%
2003	114	83%	18	13%	5	4%	32	97%	0	0%	1	3%	25	93%	1	4%	1	4%	29	73%	9	23%	2	5%	28	80%	6	17%	1	3%
2004	139	95%	5	3%	2	1%	35	100%	0	0%	0	0%	27	100%	0	0%	0	0%	41	89%	3	7%	2	4%	36	95%	2	5%	0	0%
2005	138	91%	12	8%	2	1%	35	97%	1	3%	0	0%	27	100%	0	0%	0	0%	40	82%	7	14%	2	4%	36	90%	4	10%	0	0%
2006	140	89%	15	10%	2	1%	35	97%	1	3%	0	0%	28	97%	1	3%	0	0%	40	78%	9	18%	2	4%	37	90%	4	10%	0	0%
2007	141	91%	12	8%	2	1%	35	100%	0	0%	0	0%	27	96%	1	4%	0	0%	41	82%	8	16%	1	2%	38	90%	3	7%	1	2%
2008	135	88%	14	9%	5	3%	35	100%	0	0%	0	0%	26	93%	2	7%	0	0%	37	74%	9	18%	4	8%	37	90%	3	7%	1	2%

Source: Author's estimates

Note: DRS is Decreasing Returns to Scale; IRS is Increasing Returns to Scale; CRS is Constant Returns to Scale. Technical efficiency scores are predicted by VRS linear programming using by DEAP 2.1. Predicted technical efficiency scores are classified with respect to each sub-manufacturing sector.

Table 6.16: Nonparametric correlation (Spearman rank-order correlation)

All Thai listed manufacturing firms			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.562**
		Sig. (2-tailed)	.	0.000
		N	1309	1309
	DEA VRS	Correlation Coefficient	0.562**	1.000
		Sig. (2-tailed)	0.000	.
		N	1309	1309
(1) Agro & food industry sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.224**
		Sig. (2-tailed)	.	.
		N	323	323
	DEA VRS	Correlation Coefficient	0.224*	1.000
		Sig. (2-tailed)	0.000	.
		N	323	323
(2) Consumer products sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.351**
		Sig. (2-tailed)	.	0.000
		N	252	252
	DEA VRS	Correlation Coefficient	0.351**	1.000
		Sig. (2-tailed)	0.000	.
		N	252	252
(3) Industrials sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.303**
		Sig. (2-tailed)	.	0.000
		N	397	397
	DEA VRS	Correlation Coefficient	0.303**	1.000
		Sig. (2-tailed)	0.000	.
		N	397	397
(4) Other sectors sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.363**
		Sig. (2-tailed)	.	0
		N	337	337
	DEA VRS	Correlation Coefficient	0.363**	1.000
		Sig. (2-tailed)	0.000	.
		N	337	337

Source: Author's estimates

Note: ** The correlation is significant at the 0.01 level (2-tailed); The estimated Spearman rank-order correlation coefficients in this table refer to the technical efficiency scores predicted by the SFA and DEA approaches as summarized in Table 6.14.

6.5.3 Consistency of the results from Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA)

This section aims to compare the empirical results obtained from the SFA and DEA approaches in Sections 6.5.1 and 6.5.2, and these are summarized in Table 6.17.

Table 6.17: Comparison of the results of maximum-likelihood estimates for parameters between the SFA and the two-stage DEA approaches

Dependent variable: Technical inefficiency	**All Manufacturing**		**Agro & Food Industry**		**Consumer Products**		**Industrials**		**Other Sectors[a]**	
(Pure or VRS)	**SFA**	**DEA**	**SFA**	**DEA**	**SFA**	**DEA**	**SFA**	**DEA**	**SFA**	**DEA**
Independent variables :										
Constant	+*	+*	+*	+*	+*	+*	+*	+*	+*	+*
Leverage	-*	-*	+*	+**	-*	-*	+	-	+*	+*
Liquidity	+*	+*	-*	+	+*	+*	+*	+*	+**	-
Internal financing	+*	+	+*	+	+*	+**	+	-	+*	-*
External financing	+*	+	+	-	+	+	+*	+*	-**	-*
Executive remuneration	-*	-*	-	-**	-*	-*	-**	-*	-	+
Controlling ownership	-*	-	-	+*	-	-	-*	-	-*	-*
Managerial ownership	-*	-*	-	-*	-	+**	-*	-*	+*	-
Exports	-*	-*	+*	-*	+*	+	-*	-	-**	-
R&D	+*	+*	-	+*	+*	+*	+	-	-*	+*
Government assistance	-*	+**	+	+*	-*	+**	+	+*	-*	+
Foreign cooperation	+*	+	+*	+	+*	+	-*	+*	-*	+
Firm size	-*	-*	-*	-*	-*	-*	-*	-*	-*	-*
Firm age	-*	-	+	+*	+*	+*	+*	+	+*	-
Family owned firm	-*	-*	+	-*	-*	-*	+	+*	-*	-
Foreign owned firm	-*	-*	+	-*	-*	-*	+	+	+*	-*
Domestic owned firm	-*	-	+	-*	-	+	+**	+*	+*	+*
Hybrid owned firm	-*	-*	+	-*	-*	-**	-	+	+	+*

Source: Author's estimates

Note: * and ** indicate that the coefficients are statistically significant at the 5% and 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Electronic components).

The empirical results obtained from the SFA and two-stage DEA approaches are quite consistent for overall Thai listed manufacturing enterprises. Average technical efficiency scores predicted by the SFA and DEA approaches are compared and summarized in Table 6.14. The average technical efficiency scores for Thai listed manufacturing enterprises predicted by the SFA and the DEA approaches are very close, and are given by 0.812 and 0.887, respectively (see Table 6.14)[92]. Due to differences in the SFA and VRS DEA technical efficiency scores in the Industrials sub-sector, a Spearman rank-order correlation, which is a non-parametric correlation test, was conducted to examine the ranking consistency for Thai listed manufacturing firms, including all manufacturing sub-sectors as shown in Table 6.16. The values of the estimated Spearman rank correlation coefficients[93] are 0.562, 0.224, 0.351, 0.303, and 0.363 for the Thai listed manufacturing sector, the Agro and Food Industry sub-sector, the Consumer Products sub-sector, the Industrials sub-sector, and the Other Sectors sub-sector, respectively. Moreover, all estimated correlation coefficients are found to be statistically significant at the 1 percent level of significance, and therefore the results of both the SFA and DEA techniques are consistent in terms of ranking (see Sirasoontorn, 2004[94]).

The technical efficiency scores obtained from DEA should normally be lower than that obtained from SFA, since the technical efficiency scores predicted by DEA does not separate the non-negative technical inefficiency components (U_{its}) from the systematic errors (V_{it}). However, if the estimated γ is close to 1 this implies that the error variation is mainly due to inefficiency effects. For overall Thai listed manufacturing enterprises γ is given by 0.870, which indicates that the overall error variations ($U_{it}\ s$ and $V_{it}s$) are mostly due to inefficiency components ($U_{it}s$), and insignificantly caused by random error terms ($V_{it}s$). Therefore, technical efficiency

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[92] Average technical efficiency scores for the manufacturing sub-sectors predicted by the SFA and DEA approaches are very close, except for the Industrials sub-sector where TE scores predicted by both approaches differ, as given by 0.519 and 0.911, respectively (see Table 6.14). This is because the estimated gamma (γ) of the Industrials sub - sector is 0.233 which is close to 0, indicating that the inefficiency effects model does not perform well. This result is consistent with the SFA evidence that the Industrials sub-sector is the only sub-sector that experiences moderate returns to scale (see Table 6.9). Unlike the SFA approach the DEA approach does not require a functional form in predicting efficiency scores.

[93] Appendix 2 also shows the estimated Spearman rank-order correlation coefficients. Unlike the results of Table 6.16 the results of Appendix 2 are based on the SFA technical efficiency scores which are estimated from the Translog Production function of all Thai listed manufacturing firms (1,309 observations). The SFA TE scores are then classified according to each sub - manufacturing sector. All estimated correlation coefficients are statistically significant at the 1 percent level of significance, but the values of the estimated correlation coefficients in Appendix 2 are higher than the ones shown in Table 6.16.

[94] For Sirasoontorn (2004) the estimated Spearman rank-order correlation coefficient between both approaches is 0.55 for Thai and Australian power plants.

scores obtained from SFA can also be smaller than those scores obtained from DEA due to the effect of inefficiency components (Sirasoontorn, 2004).

The empirical results from both estimation approaches also reveal that Thai listed manufacturing enterprises operated under decreasing returns to scale over the period 2000 to 2008. The production returns to scale, given by 0.9187, indicates the existence of moderate decreasing returns to scale for Thai listed manufacturing enterprises (see Table 6.9). Similarly, the DEA approach indicates that approximately 86% of Thai listed manufacturing firms, on average, operated under decreasing returns to scale (DRS) during the period 2000 to 2008, given the specification of the output-orientated model (see Table 6.15). The empirical results from both the SFA and the two-stage DEA approaches are found to be quite consistent (see Table 6.17).

The empirical results from both approaches reveal that leverage (financial constraints) has a significant and positive effect on a firm's technical efficiency for the SET's manufacturing sector in aggregate and for Consumer Products, but a significant and negative result is found for the Agro and Food Industry and Other Sectors. A significant and positive result implies that financially constrained firms tend to utilize their financial resources and control input costs effectively, leading to an enhancement in their technical efficiency. Moreover, this positive result also implies that Thai listed manufacturing firms have become more risk averse, resulting in more effective control of their input costs. No significant relationship is found for the Industrials sector.

To confirm this conclusion, both estimation approaches reveal that a firm's liquidity is found to be significant and negatively related with technical efficiency for the SET's manufacturing sector in aggregate and for the Consumer Products and Industrials sub sectors. This finding also implies that financially unconstrained firms are not likely to control their input costs effectively due to sufficient financial resources. Inconclusive results are found for the Agro and Food Industry and Other Sectors due to the differences in estimated coefficient signs and significance results.

The empirical evidence from both approaches also confirms that internal financing has a significant and negative relationship with a firm's technical efficiency for Consumer Products, but inconclusive results are found for the Other Sectors. The negative result implies that an agency problem exists from the use of internal funds, since managers do not appear to maximize shareholders' interests or have a strong incentive to abuse internal funds. This is especially the case in underdeveloped countries where firms' managerial rights are not fully developed and their information is not fully publicized, and therefore managers attempt to maximize their benefits rather than the firm's value (Kim, 2003, p134).

Both estimation approaches also reveal a positive relationship for the SET's manufacturing sector in aggregate and for the Agro and Food Industry sector, but only the empirical results estimated by the SFA approach is statistically significant. This positive finding also implies that there exists a strong incentive for listed firms in the Agro and Food Industry sub-sector to monitor the allocation of their internal funds when these have been lent by either the owner manager or by major shareholders. No significant relationship is found for the Industrials sector.

Both approaches also confirm that external financing has a significant and negative association with a firm's technical efficiency for Industrials, but a significant and positive relationship is found for the Other Sectors. Both estimation approaches also reveal a negative relationship for the SET's manufacturing sector in aggregate, but only the empirical results estimated by the SFA approach is statistically significant. No significant relationship is found for the Agro and Food Industry and Consumer Products sub sectors. The relationship between external finance and firm technical efficiency is very weak, since the estimated "external financing" coefficients are very small (close to zero) for the SET's manufacturing sector in aggregate and including all sub-manufacturing sectors.

The empirical results from both estimation approaches reveal that "executive remuneration" is also found to be significant and positively related with a firm's technical efficiency for the SET's listed manufacturing sector in aggregate and including Consumer Products and Industrials sectors, indicating that listed manufacturing firms with higher levels of executive remuneration tend to have more technical efficiency. For the Agro and Food Industry both estimation approaches show a positive relationship between executive remuneration and firm technical efficiency, but only the empirical result from the DEA approach is statistically significant. No significant relationship is found for the Other Sectors. As previously discussed, executive remuneration also depends upon the firm's annual net profits. In some listed firms the amount of executive remuneration (i.e., bonuses) that executives receive is based on the percentage of the firm's annual net profits. This reward system which provides high executive remuneration, therefore, tends to achieve an increase in technical efficiency.

The empirical results from both approaches confirm that managerial ownership has a significant and positive relationship with the technical efficiency of SET manufacturing sector firms, including Industrials. This indicates that the agency problem is reduced, since managerial ownership can help resolve the conflict of interests between shareholders and managers. A positive effect is also observed in the Agro and Food Industry, but only the empirical result from the DEA approach is statistically significant. An inconclusive relationship is also found for the Consumer Products and Other Sectors due to differences in significance results and estimated coefficient signs.

The empirical evidence from both estimation approaches reveal that controlling ownership has a significant and positive effect on a firm's technical efficiency for Other Sectors. A positive effect is also found for the SET's manufacturing sector in aggregate and for the Industrials sector, but significant results are only found from the SFA approach. A positive result is also found for Consumer Products, but is not statistically significant. The empirical result found in the Agro and Food Industry is inconclusive due to differences in the estimated coefficient signs and significance results. A positive result supports the agency theory that controlling shareholders are likely to perform better than dispersed shareholders, since a high level of ownership concentration can reduce agency costs.

Learning-by-exporting evidence is also found for Thai listed manufacturing enterprises, since the two estimation approaches confirm that the coefficient for "exports" has a significant and positive association with a firm's technical efficiency. A positive relationship is also found for the Industrials and Other Sectors, but only the empirical result from the SFA approach is statistically significant. This positive result implies that export market experience (i.e., new product designs and production methods), gained from communication between foreign partners and exporting firms, tends to improve the technical efficiency of exporting firms. A negative association is also found for Consumer Products, but only the SFA approach produces a significant result. The empirical result found in the Agro and Food Industry sub-sector is ambiguous due to differences in the estimated coefficient signs and significance results.

Research and development (R&D) is found to be significant and negatively associated with firm technical efficiency for the SET's manufacturing sector including Consumer Products, indicating that listed manufacturing firms with R&D are not likely to have higher technical efficiency compared with listed manufacturing firms with no R&D. This result is different from that of many other empirical results, where a positive effect on a firm's technical efficiency is found (see Section 3.6, Chapter 3). Such a negative finding also implies that the R&D activities of listed manufacturing firms were misreported in their annual reports, and in fact they did not intend to implement them seriously. The empirical results found in the Agro and Food Industry and Other Sectors are inconclusive due to differences in estimated coefficient signs and significance results. No significant result was found for the Industrials sub-sector.

Focusing on the classification of different ownership types among listed manufacturing enterprises, the results from both approaches indicate that family-ownership of firms has a significant and positive effect on their technical efficiency for the SET's manufacturing sector including Consumer Products. A positive result is also found for Other Sectors, but only the empirical result from the SFA approach is statistically significant. This positive result indicates that agency problems are reduced due to the close relationship among family members. In other words, family ownership has advantages in communicating with other related members, and hence the separation of management and control, which causes agency problems, is reduced due to the close relationship among family members within the firm (Fama and Jensen, 1983). A negative relationship is also found in the Industrials sector, but only the empirical result from the DEA approach is statistically significant. This negative result, however, indicates that agency problems exist from family ownership, since it has the power to expropriate or marginalise the interests of minority shareholders. An inconclusive result is found for the Agro and Food Industry due to the differences in the estimated coefficient signs and significance results.

The empirical results from both estimation approaches reveal that foreign-ownership of firms has a significant and positive relationship with firm technical efficiency for the SET's manufacturing sector including Consumer Products. This positive result indicates that foreign ownership has increasingly become important for the improvement of firm technical efficiency, since it brings superior technology, managerial expertise, good corporate governance, and a strong foreign - market network (Kimura and Kiyota, 2007). A negative result is also found for Industrials, but the empirical results from both estimation approaches are statistically insignificant. Inconclusive results, however, are found for the Agro and Food Industry and Other Sectors due to the differences in estimated coefficient signs and significance results.

For domestic-owned firms a positive association is also found from both estimation approaches for the SET's manufacturing sector, but only the SFA approach produces a significant result. The empirical results from both estimation approaches reveal a significant and negative relationship between domestic-owned firms and their technical efficiency for the Industrials and Other Sectors. An inconclusive result is found for Agro and Food Industry due to differences in the estimated coefficient signs and significance results. No significant result is found for Consumer Products.

Hybrid-ownership of firms is found to have a significant and positive effect on their technical efficiency for the SET's manufacturing sector including Consumer

Products. An inconclusive result is found for the Agro and Food Industry Sector due to differences in the estimated coefficient signs and significance results. However, a negative result is also found for the Other Sectors, but only the DEA approach produces a significant result. No significant result is also found for Industrials. Joint-ownership of firms, as indicated by a constant term, is found to have a significant and negative relationship with firm technical efficiency for the SET's manufacturing sector including all sub-manufacturing sectors, indicating that joint-ownership of firms has the least technical efficiency compared with other ownership types. For Thai listed manufacturing enterprises, as indicated by significant dummy ownership coefficients, foreign-owned firms perform the best among other types of owned firms, followed by family-owned firms, hybrid-owned firms and domestic-owned firms, given joint-owned firms as the base category.

Moreover, there is strong evidence from both estimation approaches that a firm's size tends to have a statistically positive effect on its technical efficiency for the SET's manufacturing sector including all sub-manufacturing sectors. This indicates that firms are likely to perform better when their size is large due to economies of scale, more business opportunities, improved efficiency in asset usage, capital, technology management, and other operational synergies.

Both estimation approaches reveal that the effect of a firm's age on its technical efficiency is found to have a positive effect on firm technical efficiency for the SET's manufacturing sector, but the result from only the SFA approach is statistically significant. A positive result indicates that learning-by-doing, as captured by the number of operating years, is found to be positively related to technical efficiency for Thai listed manufacturing enterprises. Both estimation approaches, however, find a significant and negative relationship between a firm's age and its technical efficiency for Consumer Products. Such a negative result is also found for the Agro and Food Industry and the Industrials sub-sectors. The empirical result from the DEA approach is statistically significant for the Agro and Food Industry, but a significant result from the SFA approach is only found for the Industrials sector. This negative finding also implies that old firms may lack the ability to improve their physical capital, but young firms may apply more modern technology. Moreover, they may be more proactive, flexible, and aggressive than older firms (Aggrey et al., 2010).

In addition, the relationship between government assistance and a firm's technical efficiency is found to be inconclusive for the SET's manufacturing sector including Consumer Products, due to the same significant results but differences in the signs of the estimated coefficients. A negative relationship is also found for the Agro and Food Industry and for Industrials, but only the DEA approach produces results that are significant. As previously discussed, this negative result implies that government assistance which only focuses on financial privileges provided by the BOI is not likely to improve firm technical efficiency. An inconclusive result is found for Other Sectors due to differences in estimated coefficient signs and significance results. Lastly, foreign cooperation has a negative impact on a firm's technical efficiency for the SET's manufacturing sector including the Agro and Food Industry and Consumer Products sub-sectors, but only the SFA approach produces a significant result. As previously discussed, listed firms may have faced operational problems before requiring foreign cooperation. In addition, they must pay for such technical assistance. Inconclusive results are found for the Industrials and Other Sectors due to differences in the signs of estimated coefficients and for the significance results.

6.6 The self-selection hypothesis

This section aims to analyse the self-selection hypothesis for Thai listed manufacturing enterprises as part of hypothesis 8 in Chapter 5. In other words, the effect of a firm's technical efficiency on its export participation is examined in this section. More specifically, inefficiency scores obtained from the Stochastic Frontier (SFA) and the Data Envelopment Analysis (DEA) approaches[95] are used separately as the independent variable to examine this hypothesis. For the self-selection hypothesis a dummy dependent variable for firm export participation is introduced, and hence the binary response model is applicable to investigate this hypothesis.

[95] Inefficiency scores are calculated by taking predicted efficiency scores subtracted from "unity".

For the binary response model, Wooldridge (2006, p256, 582) also mentioned that the Probit and Logit models can overcome certain drawbacks from the limited probability model (LPM), since the LPM model violates the homoskedasticity assumption which is important for justifying the t and F statistics. The assumption of linear parameters between the dependent and independent variables is also generally required for the LPM model under the OLS estimation. The Probit model is also more popularly compared with the Logit model, since economists are likely to favour the normality assumption of the Probit model (Wooldridge, 2006, p385). In addition, the method of maximum likelihood estimation of the Probit model automatically accounts for the heteroskedasticity problem. As a result, the maximum likelihood estimation (MLE) of the Probit model is applied in this section. For the Probit model the G function is assumed to be an increasing function which lies between zero and one (i.e., 0<G(z)< 1). The Probit model can be written as follows (Wooldridge, 2006):

$$G(z) = \phi(z) = \int_{-\infty}^{z} \emptyset(v)dv \tag{6.11}$$

Where

G (z) is the standard normal cumulative distribution function (cdf)

ϕ (z) is the standard normal density which is given by $(2\pi)^{-1/2}$exp (-z^2/ 2)

Firm export participation regressed by the lagged independent variables[96] are investigated for the self-selection hypothesis since it is believed that export participation may be dependent on previous firm-specific variables (Bernard and Wagner, 2001; Greenaway et al., 2007; Bellone et al., 2010). The equation can be written as follows[97]:

[96] All independent variables are lagged one year so as to reduce possible simultaneity problems (see Bernard and Jensen, 1999, p12).

[97]The equation of firm export participation without lagged independent variables (Z_{it}= β_0+$\beta_1 Size_{it}$+$\beta_2 Age_{it} Inef_{it}$ + $\beta_4 Lev_{it}$+$\beta_5 Finvst_{it}$+v_{it}) has also been examined, which provides quite consistent results compared with Equation 6.12 (See Appendix 4). For the self-selection hypothesis Equation 6.12, however, produces more consistent results, since the empirical results, obtained by using either SFA or DEA technical inefficiency scores, consistently reveal a significant and positive association between a firm's technical efficiency and its export participation for the SET's manufacturing sector including almost all sub - manufacturing sectors (see Table 6.20).

$$Z_{it} = \beta_0 + \beta_1 Size_{i,t-1} + \beta_2 Age_{i,t-1} + \beta_3 Inef_{i,t-1}$$
$$+\beta_4 Lev_{i,t-1} + \beta_5 Finvst_{i,t-1} + v_{it} \quad (6.12)$$

Where

Z_{it} = Dummy variable for export participation

$$Z_{it} = \begin{cases} 1 \text{ if firm } i \text{ at time } t \text{ engages in export} \\ 0, \text{otherwise} \end{cases}$$

$Size_{i,t-1}$ = Size of firm *i* at time *t-1*, represented by the logarithm of total assets

$Age_{i,t-1}$ = Age of firm *i* at time *t-1,* represented by the logarithm of number of operating years

$Inef_{i,t-1}$ = Inefficiency scores of firm *i* at time *t-1,* obtained from the Stochastic Frontier Analysis (SFA) or the Data Envelopment Analysis (DEA)

$Lev_{i,t-1}$ = Leverage of firm *i* at time *t-1*, represented by the ratio of total debt to total assets (the D/A Ratio)

$Finvst_{i,t-1}$= The percentage of equity held by foreign investors of firm *i* at time *t-1*.

v_{it} = Random error ($V_{it} \sim N(0, \sigma_W^2)$)

From Equation 6.9, besides an investigation of the self-selection hypothesis there are important factors that significantly affect firm export participation such as firm size, firm age, firm leverage, and foreign investment (foreign ownership). Firm size is one of the important factors that can determine firm export participation, since large firms can cover sunk costs necessary to enter into export markets (Greenaway et al., 2007). In other words, large firms can earn sufficient profits to cover their sunk costs incurred during exporting (Jongwanich and Kohpaiboon, 2008). Firm age, indicated by a learning-by-doing experience, can also significantly affect firm export decisions, since old firms can compete with foreign companies due to their cumulative experience, business network, and reputation. However, Aggrey et al. (2010) pointed out that young firms are more proactive, flexible, and aggressive than old firms. As a result, they are willing to adopt modern technology, but old firms are stuck with outdated physical capital. Few empirical studies have investigated the effect of leverage on firm export participation (Greenaway et al., 2007; Bellone et al., 2010). Leverage can obstruct the possibility of a firm to export, since more liquid and less leveraged firms are likely to export due to their ability to cover exporting sunk costs. Foreign investment (foreign ownership) is also one of the significant factors that influences a firm's decision to export, since foreign investment (foreign ownership) brings advanced production technology, managerial expertise, foreign networks and distribution (Jongwanich and Kohpaiboon, 2008).

The empirical results obtained from Equation (6.12) produces consistent results for the self-selection hypothesis. Table 6.18 and 6.19 show the empirical results for the self-selection hypothesis. The difference between Table 6.18 and 6.19 is that technical inefficiency scores are predicted by the Stochastic Frontier Analysis (SFA) and the Data Envelopment Analysis (DEA), respectively. The signs of the estimated coefficients for technical inefficiency scores, however, are interpreted in the opposite direction to be consistent with hypothesis 8 discussed in Chapter 5.

Table 6.18: Maximum-likelihood Probit estimates for export participation of listed manufacturing firms (using SFA technical inefficiency scores)

Dependent variable: Export Participation	**All Manufacturing**	**Agro & Food Industry**	**Consumer Products**	**Industrials**	**Other Sectors[a]**
Obs. with Dependent variable = 0	247	40	1	85	121
Obs. with Dependent variable = 1	884	243	218	253	170
Total observations	1131	283	219	338	291
Independent variables:					
Constant	-1.278**	-0.734	-54.910**	-1.938	-2.878*
	(0.729)	(1.897)	(29.029)	(1.435)	(0.938)
Firm Size$_{t-1}$	0.199*	0.163**	4.397**	0.268*	0.373*
	(0.041)	(0.095)	(2.401)	(0.079)	(0.062)
Firm Age$_{t-1}$	-0.248*	-0.120	2.009	-0.394*	-0.686*
	(0.097)	(0.331)	(1.808)	(0.167)	(0.155)
Technical Inefficiency (SFA)$_{t-1}$	***-1.131****	***-0.950***	***-22.608****	***-2.449****	***-1.568*****
	(0.363)	***(1.761)***	***(10.692)***	***(0.686)***	***(0.919)***
Leverage$_{t-1}$	0.054*	-0.140	-2.336	0.565*	-0.414**
	(0.021)	(0.239)	(1.906)	(0.252)	(0.236)
Foreign Investment$_{t-1}$	0.009*	0.001	0.461*	0.002	0.014*
	(0.002)	(0.007)	(0.227)	(0.005)	(0.003)
McFadden R-squared	0.076	0.020	0.560	0.175	0.250
LR statistic	89.946	4.586	7.150	66.754	98.922
Probability (LR statistic)	0.000	0.468	0.210	0.000	0.000

Source: Author's estimates

Note: Huber/White Robust Standard Errors (S.E.) are in parentheses; * and ** indicate that the coefficients are statistically significant at the 5% and 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Electronic components).

From Table 6.18 the empirical results reveal that the P-values for the LR test statistics are less than 0.05, indicating that the joint significance of all explanatory variables are statistically significant at the 5 percent level of significance for the SET's manufacturing sector, including all sub-manufacturing sectors, except for the Agro and Food Industry and Consumer Products sub-sector. For the self selection hypothesis a firm's technical efficiency has a significant and positive relationship with its export participation for the SET's manufacturing sector, including Consumer Products, Industrials, and Other Sectors. A positive result is also found for the Agro and Food Industry sector, but is not statistically significant at the 5 percent level of significance (see Table 6.18).

Table 6.19: Maximum-likelihood Probit estimates for export participation of listed manufacturing firms (using DEA technical inefficiency scores)

Dependent variable: Export Participation	**All Manufacturing**	**Agro & Food Industry**	**Consumer Products**	**Industrials**	**Other Sectors[a]**
Obs. with Dependent variable = 0	247	40	1	85	121
Obs. with Dependent variable = 1	884	243	218	253	170
Total observations	1131	283	219	338	291
Constant	-1.848*	2.044	2.757	-3.597*	-4.801*
	(0.777)	(1.823)	(8.937)	(1.319)	(1.191)
Firm $Size_{t-1}$	0.224*	-0.015	0.290	0.334*	0.474*
	(0.045)	(0.114)	(0.642)	(0.078)	(0.073)
Firm Age_{t-1}	-0.249*	-0.040	-0.334	-0.199	-0.759*
	(0.100)	(0.337)	(0.598)	(0.162)	(0.156)
Technical Inefficiency(DEA)$_{t-1}$	***-0.136***	***-5.353****	***-13.141****	***-3.276****	***2.549***
	(0.845)	**(2.345)**	**(5.458)**	**(1.283)**	**(1.843)**
$Leverage_{t-1}$	0.035**	-0.073	-2.426*	0.535**	-0.423**
	(0.020)	(0.233)	(0.787)	(0.276)	(0.247)
Foreign $Investment_{t-1}$	0.009*	0.002	0.583*	0.001	0.014*
	(0.002)	(0.007)	(0.245)	(0.005)	(0.003)
McFadden R-squared	0.066	0.037	0.427	0.145	0.249
LR statistic	78.694	8.602	5.449	55.225	98.303
Prob (LR statistic)	0.000	0.126	0.364	0.000	0.000

Source: Author's estimates

Note: Huber/White Robust Standard Errors (S.E.) are in parentheses; * and ** indicate that the coefficients are statistically significant at the 5% and 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Electronic components).

With respect to DEA technical inefficiency scores used for the empirical analysis the empirical results are shown in Table 6.19. These show that the P-values for the LR test statistics are less than 0.05, indicating that the joint significance of all explanatory variables are statistically significant at the 5 percent level of significance for the SET's manufacturing sector including all sub-manufacturing sectors, except for the Agro and Food Industry and Consumer Products sub sectors. From Table 6.19 a firm's technical efficiency has a significant and positive effect on its export participation for the Agro and Food Industry, Consumer Products, and Industrials sub sectors. A positive result is also found in the SET's manufacturing sector, but is not statistically significant.

Table 6.20: Comparison of the results of maximum-likelihood estimates for parameters between SFA technical inefficiency scores and DEA technical inefficiency scores

Dependent variable: Export Participation	All Manufacturing		Agro & Food Industry		Consumer Products		Industrials		Other Sectors[a]	
	SFA	DEA	SFA	DEA	SFA	DEA	SFA	DEA	SFA	DEA
Independent variables :										
Constant	-**	-*	-	+	-**	+	-	-*	-*	-*
Firm Size$_{t-1}$	+*	+*	+**	-	+**	+	+*	+*	+*	+*
Firm Age$_{t-1}$	-*	-*	-	-	+	-	-*	-	-*	-*
Technical Inefficiency$_{t-1}$	-*	-	-	-*	-*	-*	-*	-*	-**	+
Leverage$_{t-1}$	+*	+**	-	-	-	-*	+*	+**	-**	-**
Foreign Investment$_{t-1}$	+*	+*	+	+	+*	+*	+	+	+*	+*

Source: Author's estimates
Note: * and ** indicate that the coefficients are statistically significant at the 5% and the 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Electronic components).

From Table 6.20 the empirical results, obtained by using either SFA or DEA technical inefficiency scores, consistently reveal a significant and positive relationship between a firm's technical efficiency and its export participation for the Consumer products and Industrials sub sectors. A positive result is also found for the SET's manufacturing sector, but only the empirical result using SFA technical inefficiency scores is statistically significant. A positive result between a firm's technical efficiency and its export participation is observed for the Agro and Food Industry, but the empirical evidence using only the DEA technical inefficiency scores is statistically significant. A significant and positive result applying SFA technical inefficiency scores is found for the Other Sectors, but the empirical evidence using DEA technical inefficiency scores is statistically insignificant at the 5 percent level of significance. As a result, the significant and positive evidence is consistent with other empirical studies, implying that only more efficient firms participate in the export market since they can compete with foreign enterprises (see Section 3.8.2, Chapter 3). In other words, the self-selection hypothesis exists for the case of Thai listed manufacturing enterprises.

Besides the empirical evidence for the self-selection hypothesis, foreign investment (foreign ownership) has a significant and positive effect on a firm's export participation for the SET's manufacturing sector, including the Consumer Products and Other Sectors. A positive result is also found in all other sub sectors, but is not statistically significant. This result is also consistent with other empirical studies (Greenaway et al., 2007; Jongwanich and Kohpaiboon, 2008; Aggrey et al., 2010). For example, Greenaway et al. (2007) found that foreign ownership has a significant and positive effect on firm export participation for 9,292 UK manufacturing firms over the period 1993 to 2003. For Thailand Jongwanich and Kohpaiboon (2008) used the 1997 Thai manufacturing census and found that foreign ownership has a significant and positive impact on firm export participation for Thai manufacturing enterprises. This positive result implies that an increase in foreign participation also encourages firms to participate in the export market, since foreign partners bring new foreign markets and distribution, new products, managerial know how, and advanced production technology (Jongwanich and Kohpaiboon, 2008). Jongwanich and Kohpaiboon (2008, p21) also pointed out that foreign owned firms can cover sunk costs and enter into foreign markets more easily than domestically owned firms.

Leverage is also found to have a significant and positive impact upon a firm's export participation for the SET's manufacturing sector, including Industrials, but a significant and negative association is found for the Other Sectors. A negative result is also found for the Agro and Food industry and Consumer Products. However, the empirical result using DEA inefficiency scores is found to be statistically significant for only Consumer Products. This positive result is different from other empirical studies that exporters are financially healthier than non-exporters (Greenaway et al., 2007; Bellone et al., 2010). However, this result is plausible for young exporters.

Their leverage can be increased, since they must pay sunk costs in entering into export markets (Greenaway et al., 2007, p382). Moreover, the empirical evidence indicates that there is a significant and positive association between a firm's size and its export participation for the SET's manufacturing sector including Industrials and Other Sectors, indicating that large firms are likely to engage in the export market due to their ability to compete internationally with foreign enterprises. In other words, the high fixed costs of exporting (sunk costs) cause difficulty for small firms to engage in export markets. A significant and positive effect is also found for Consumer Products, but only the result using SFA technical inefficiency scores is statistically significant. An inconclusive result is found for the Agro and Food Industry sector due to differences in the estimated coefficient signs and significance results. Finally, the effect of a firm's age and its export participation is found to be significantly negative for the SET's manufacturing sector including Other Sectors. A negative effect is also found in the Industrials sector, but only the result using SFA technical inefficiency scores is statistically significant. No significant evidence, however, is found for the Agro and Food Industry and Consumer Products sub sectors. This negative result also implies that old firms may be stuck with outdated physical capital, but young firms may apply more modern technology and they may be more proactive, flexible, and aggressive than old firms (Aggrey et al., 2010).

6.7 Conclusions

This chapter has aimed to measure the technical efficiency performance of Thai listed manufacturing enterprises, and answer eight hypotheses highlighted in Chapter 5, by employing two estimation approaches to test for the robustness of the results: (i) the Stochastic Frontier Analysis (SFA) approach and (ii) the two - stage Data Envelopment Analysis (DEA) approach. For the SFA approach the Battese and Coelli (1995) model was applied, which is applicable for unbalanced panel data for Thai listed manufacturing enterprises.

For the Battese and Coelli (1995) model the Translog frontier production function and the inefficiency effects model are estimated simultaneously by FRONTIER 4.1. Technical inefficiency effects, used as the dependent variable, are estimated using the Translog frontier production function, and are then regressed on business environment and firm-specific variables (the independent variables) simultaneously. For the two-stage DEA approach the first-stage is to predict technical efficiency scores using variable returns to scale (VRS) linear programming by DEAP 2.1. Technical efficiency scores predicted by DEAP 2.1 are converted into technical inefficiency scores by subtracting predicted technical efficiency scores from “unity”.

Moreover, business environment and firm-specific variables, previously used for the SFA approach, are also applied as the independent variables. The maximum-likelihood Tobit model is applied to study the effects of business environment and firm-specific variables on firm technical inefficiency scores for the second stage of the two - stage DEA approach. The empirical results from the SFA and DEA are summarized in Table 6.17. In addition, the maximum-likelihood Probit model is conducted to answer the last part of hypothesis 8 discussed in Chapter 5. Eight hypotheses discussed in Chapter 5 are answered, which focus on the empirical evidence for Thai listed manufacturing enterprises as follows:

Hypothesis 1: There is strong evidence from both estimation approaches that financial constraints (leverage) have a significant and positive relationship with technical efficiency for Thai listed manufacturing enterprises, implying that financially constrained firms tend to improve their technical efficiency through the effective control of input costs and financial resources. Vice versa, the empirical evidence from both estimation approaches also indicate that liquidity has a negative effect on the technical efficiency of Thai listed manufacturing enterprises, indicating that financially healthy firms are likely to neglect enhancing their technical efficiency due to an excess of financial liquidity.

Hypothesis 2: The empirical evidence from the SFA approach reveals that external financing has a significant and negative relationship with technical efficiency for Thai listed manufacturing enterprises, which is opposite to the statement of this hypothesis. A negative result is also found from the DEA approach, but it is not statistically significant. This negative finding does not suggest a significant impact on a firm’s technical efficiency due to the very small size (close to zero) of the estimated "external financing" coefficient. On the other hand, there is evidence from the SFA approach that internal financing has a significant and negative effect on technical efficiency for Thai listed manufacturing enterprises, indicating that managers tend to utilize internal funds ineffectively due to a lack of external monitoring. Kim (2003, p134) also emphasized that this normally exists in several underdeveloped countries where firms' managerial skills are not fully strengthened and firm operation information is not fully disclosed to investors, and therefore there is an opportunity for managers to maximize their benefits rather than the firm's value. A negative result is also found from the DEA approach, but it is not statistically significant.

Hypothesis 3: The empirical evidence from both estimation approaches reveal that research and development (R&D) expenditure has a significant and negative relationship with technical efficiency for Thai listed manufacturing enterprises. This result is different from the expected positive result for this hypothesis. Such a negative finding, however, suggests that most listed manufacturing firms misleadingly reported their R&D activities in their annual report, and in fact did not intend to implement these activities seriously.

Hypothesis 4: The empirical results from the SFA approach reveal that controlling ownership has a significant and positive effect on technical efficiency for Thai listed manufacturing enterprises. This supports the agency theory that controlling shareholders are likely to perform better than dispersed shareholders, since a high level of ownership concentration can reduce agency costs. A positive result is also found from the DEA approach, but it is not statistically significant.

Hypothesis 5: There is strong evidence from both estimation approaches that managerial ownership has a significant and positive effect on technical efficiency for Thai listed manufacturing enterprises. This indicates that the agency problem is reduced, since managerial ownership can help align the conflict of interests between shareholders and managers. In other words this result implies that a group of people, who receive direct benefits from the firm through dividends relative to the level of their cash flow or voting rights, tend to monitor the firm carefully and effectively. On the contrary, managers who do not hold any ownership over a firm's cash flow or voting stocks lack the incentive to monitor the firm effectively, since they do not participate in profit sharing in the form of dividends.

Hypothesis 6: There is strong evidence from both estimation approaches that executive remuneration has a significant and positive effect on technical efficiency for Thai listed manufacturing enterprises, indicating that listed manufacturing firms with higher levels of executive remuneration tend to have more technical efficiency. The reason is that the amount of bonuses or increased salaries that executives (i.e., board of directors and managers), will receive, in practice, depends upon the firm's annual net profits. In some listed firms, the amount of executive remuneration (i.e., bonuses) is based on the percentage of the firm's annual net profits. Hence, there is a strong incentive for executives to control input costs and maximize the firm's net profit.

Hypothesis 7: There is strong evidence from both estimation approaches that foreign and family ownership exerts a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises. With respect to the size of the estimated coefficients for each type of owned-firm, there is strong evidence from both estimation approaches that foreign-owned firms perform the best for Thai listed manufacturing enterprises, followed by family-owned firms, hybrid-owned firms and domestic-owned firms, given joint-owned firms as the base category.

Hypothesis 8: There is strong evidence from both estimation approaches that exporting has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises. This result reveals the existence of a learning by exporting hypothesis, indicating that exporting firms are also likely to improve their technical efficiency due to their learning-by-exporting experience (i.e., new product designs and production methods). Vice versa, there is evidence that a firm's technical efficiency predicted by the SFA approach has a significant and positive effect on its export participation for Thai listed manufacturing enterprises. In other words the self-selection hypothesis exists for Thai listed manufacturing enterprises, implying that only more efficient firms participate in the export market since they can compete with foreign enterprises. The positive effect of a firm's technical efficiency predicted by the DEA approach on its export participation is also found for Thai listed manufacturing enterprises, but it is not statistically significant.

Besides the empirical evidence for the hypotheses mentioned above, this chapter has also shown empirical evidence with respect to the effects of (i) firm age, (ii) firm size, (iii) government assistance, and (iv) foreign cooperation on firm technical efficiency. There is strong evidence that a firm's size has a statistically positive effect on its technical efficiency for Thai listed manufacturing enterprises. Furthermore, the empirical results from both estimation approaches reveal that a firm's age is positively related with its technical efficiency for Thai listed manufacturing enterprises, but only the empirical evidence from the SFA reveals a significant result. This positive result implies that a firm's technical efficiency is improved through accumulated experience.

The relationship between government assistance and a firm's technical efficiency, however, is found to be inconclusive. While both approaches indicate that this is significant the coefficients have different signs (positive and negative). Lastly, empirical results from both estimation approaches indicate that foreign cooperation has a negative impact on the technical efficiency of Thai listed manufacturing enterprises, but only the empirical result obtained from the SFA approach is statistically significant. For sub-listed manufacturing sectors the results from both approaches empirically find quite consistent results in coefficient signs, but significance results from both estimation approaches may be different (see Table 6.17).

In comparing the two estimation approaches, the advantage of the stochastic frontier analysis (SFA) approach, under the specification of Battese and Coelli (1995), is that it allows investigation of technical progress through an estimated production function. For the DEA approach the investigation of technological progress can be referred to, for example, using a Malmquist TFP index, which can be decomposed into "*technical efficiency change*" and "*technological change*" (see Chapter 4). A Malmquist TFP index analysed by DEA, however, can only be applied for the case of balanced panel data. The SFA approach can investigate types of returns to scale for the industry-level context through an aggregate of estimated input elasticities (Coelli et al., 2005, p304**),** but the DEA approach can examine types of returns to scale for the firm-level context. For the SFA approach the coefficients of time interacted with labour (β_{11}) and capita; (β_{13}) for Thai listed manufacturing enterprises are significantly negative and positive, respectively, indicating that technical change has been labour-using but capital-saving (see Table 6.7). This result implies that technological progress for Thai listed manufacturing firms still relies on basic production resources, such as labour input.

Similarly, the production of Thai listed manufacturing firms is also mainly contributed by intermediate inputs and labour input, but capital is found to be the least important input (see Table 6.9). The rate of technical change is found to be 0.0205 for the SET's manufacturing sector, indicating that the rate of technical change increases at 2.05 percent per year (see Table 6.9). Furthermore, both estimation approaches reveal that Thai listed manufacturing enterprises have been operating under decreasing returns to scale over the period 2000 to 2008, since the calculated returns to scale is given by 0.919 for the SFA approach (see Table 6.9). This finding is also consistent with the empirical evidence from the DEA approach that approximately 86 percent of the listed manufacturing enterprises were operating under decreasing returns to scale (DRS) on average over the period 2000 to 2008.

The drawback of FRONTIER 4.1 used for the SFA approach has also been found by the author. The empirical results are volatile subject to the decimal digits used in each variable[98]. This problem has not been raised in any literature. To deal with this problem it is necessary to apply the same decimal digits for all variables[99] across all sub manufacturing sectors. This can help in producing accurate and reliable empirical results for this thesis.

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[98] Except a dummy variable, since it only has "1" or "0".
[99] Eight decimal digits are applied for all variables.

A two stage DEA approach[100] can be useful for a robust checking of the empirical results, since it applies different software and techniques. One prominent advantage of this approach is that it does not require any functional form of the production function. For the SFA approach the differences in production technologies (e.g., Cobb-Douglas and Translog Production functions) and the significance of estimated coefficient inputs, however, can alter the empirical results of a particular study. A number of studies in the efficiency literature also suggest that it seems prudent to analyse the firm's technical efficiency using both estimation techniques to "cross-check" the results (Bauer et al., 1998; Stone, 2002; Jacobs et al., 2006; Miranda et al., 2010). Finally, the empirical results obtained for all hypotheses, including other related questions, will be used to conduct the policy implications in Chapter 7.

[100] DEAP Version 2.1 is used to produce technical efficiency scores for the first stage, and other econometric softwares (e.g., EVIEWS and STATA) can be used for the second stage to link business environment and firm specific variables with technical inefficiency scores (converted from technical efficiency scores).

CHAPTER 7

Policy Implications and Recommendations

7.1 Introduction

The purpose of this chapter is to provide valuable policy implications and recommendations based on the empirical evidence for the technical efficiency performance of Thai listed manufacturing enterprises, and hypotheses 1 to 8 in Chapter 6. These policies and recommendations aim to improve the technical efficiency of Thai listed manufacturing enterprises. The structure of this chapter is as follows:

Section 7.2 lays emphasis upon policy implications and recommendations based on the empirical evidence for the technical efficiency performance of Thai listed manufacturing enterprises. Section 7.3 focuses on policy implications and recommendations based on the empirical evidence for hypotheses 1 and 2. The first part of this section provides policies and recommendations focusing on the empirical evidence of hypothesis 1 which is related to the effects of leverage and liquidity on the technical efficiency of Thai listed manufacturing firms. The second part of this section also suggests policy implications and recommendations based on the empirical result for hypothesis 2, which investigates the effects of internal and external financing on the technical efficiency of Thai listed manufacturing enterprises. Section 7.4 provides policies and recommendations based on the empirical result for hypothesis 3, which examines the effect of research and development (R&D) on the technical efficiency of Thai listed manufacturing enterprises. Section 7.5 also suggests policy implications and recommendations with respect to the empirical results for hypotheses 4 and 5. The first part of this section focuses on policies and recommendations based on the empirical evidence of hypothesis 4 which examines the effect of controlling ownership on the technical efficiency of Thai listed manufacturing firms. In addition, the second part of this section lays emphasis upon policies and recommendations based on the empirical evidence for hypothesis 5, which is related to the effect of managerial ownership on the technical efficiency of Thai listed manufacturing enterprises. Section 7.6 also provides policy implications and recommendations based on the empirical results for hypothesis 6, which investigates the effect of executive remuneration on the technical efficiency of Thai listed manufacturing enterprises. Section 7.7 also suggests policy implications and recommendations focusing on the empirical evidence for hypothesis 7, which is related to the effects of foreign and family ownership on the technical efficiency of Thai listed manufacturing enterprises. Section 7.8 introduces policy implications and recommendations based on the empirical findings for the last hypothesis, which examines the existence of the learning-by-exporting and self-selection hypotheses for Thai listed manufacturing enterprises. Section 7.9 also provides policy implications and recommendations based on the empirical evidence of the effect of firm-specific factors (e.g., firm size and firm age) on the technical efficiency of Thai listed manufacturing enterprises. Finally, conclusions are provided in Section 7.10.

7.2 The technical efficiency performance of Thai listed manufacturing enterprises

The SFA and DEA approaches reveal predicted mean technical efficiency scores of Thai listed manufacturing enterprises of 0.812 and 0.887, respectively, indicating that Thai listed manufacturing enterprises operated at a high level of technical efficiency. Even though the technical efficiency performance of Thai listed manufacturing firms is high, they have operated under decreasing returns to scale[101], and have relied on labour-intensive or low value added production activities (see Chapter 6). To operate on a higher production frontier, or to enhance the future technical efficiency performance of Thai listed manufacturing enterprises, they should focus on upgrading their production technology, or participating in higher value-adding production activities. The government, via the Board of Investment (BOI), can help promote the enhancement of their production technology, and higher value-adding production activity participation through BOI financial and non-

[101] The estimated returns to scale is calculated by the sum of the elasticity of output with respect to capital (e_k), the elasticity of output with respect to labour (e_l), and the elasticity of output with respect to intermediate inputs (e_{im}) (see Section 6.5.1). From Tables 6.8 and 6.9 in Chapter 6 the estimated returns to scale for Thai listed manufacturing firms is 0.9187, which is lower than one. This result indicates that their production operated under "decreasing returns to scale" during the period 2000 to 2008.

financial privileges. According to investment promotion policies prescribed by the BOI, promoting the competitiveness of Thai quality and production standards in the world market is one of the BOI's key investment promotion policies. In practice the BOI has introduced measures to encourage investors to improve their production along with an increase in their revenues and the maintenance of their employment since 4th March 2009 (The Board of Investment, 2010a). The BOI investment promotion measures aim to provide financial incentives such as (i) import duty exemption on new machinery and (ii) a three-year corporate income tax exemption on revenues which are obtained from the production of new products for investors who upgrade their existing production line for new manufactured goods (The Board of Investment, 2010a). The SET and SEC can promote and facilitate fundraising which will be used for productive investments of Thai listed manufacturing firms, such as upgrading their production technology and improving their value-adding production.

7.3 Finance (Hypotheses 1 and 2)

7.3.1 Leverage and liquidity (Hypothesis 1)

Focusing on the empirical evidence for hypothesis 1, there is strong evidence from both estimation approaches that financial constraints (leverage) have a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises. Vice versa, the empirical results from both estimation approaches also indicate that more liquidity is associated with less technical efficiency for Thai listed manufacturing enterprises.

Listed manufacturing firms which have high leverage are likely to improve their technical efficiency through the effective control of input costs and financial resources. In addition, it is possible that Thai listed manufacturing enterprises, which are found to have high leverage, might be investing in capital intensive projects, since they aim to improve their future production process or extend the capacity of their production (e.g., building new plant, acquiring new machinery and equipment). These capital intensive projects, however, require large funding (e.g., long-term loans received from financial institutions, or issuance of debentures). As a result they might be technically efficient, but their leverage might be high due to new technology investment used for enhancing the efficiency and effectiveness of their future production. However, Thai listed manufacturing enterprises, which have high liquidity, might appear to be less technically efficient, since they might be stuck with old machinery and equipment, and prefer not to invest in new technology. The SET and SEC, therefore, should promote only productive investments by Thai listed manufacturing firms. More specifically, the SET and SEC[102] can support and facilitate them in raising enough funds (e.g., issuing shares to (i) existing shareholders (rights offering), (ii) a specific group of strategic investors (private placement), and (iii) public investors (public offering)) to finance their technology investments (see hypothesis 2 in Section 7.3.1). In other words, the SET can help attract foreign and local investors to invest in Thai listed manufacturing enterprises which have productive investments. As discussed earlier in Section 7.2, the BOI can promote BOI privileged participation of Thai listed manufacturing firms which are interested in launching new products and upgrading their production technology.

7.3.2 Internal and external financing (Hypothesis 2)

From the empirical evidence for hypothesis 2 both internal and external financing are found to have a significant and negative association with the technical efficiency of Thai listed manufacturing enterprises, but external financing has a very small estimated coefficient (close to zero). A significant and negative effect of internal financing on the technical efficiency of Thai listed manufacturing enterprises indicates that managers tend to utilize internal funds ineffectively due to a lack of external monitoring (see Chapter 6). However, it is unavoidable for Thai listed manufacturing enterprises to use either external or internal financing. Focusing on the use of internal financing it is possible that firms' managerial skills are not fully strengthened and firm operation information is not fully disclosed to investors, and, therefore, there is an opportunity for managers to maximize their benefits rather than the firm's value (Kim, 2003, p134). As a result, internal financing transactions should be fully disclosed to avoid an agency problem. Managers (or connected persons to listed manufacturing companies) may use internal funds for their own interests, or they lack the desire to maximize shareholders' interests due to the lack

[102] The SEC, which is an independent state agency, has responsibilities for supervising and developing the Thai capital market. A listed manufacturing firm must obtain approval from the SEC when raising funds by a public offering.

of external monitoring from banks or financial institutions as argued by Jensen (1986). In other to reduce these influences the SET monitors any connected transaction between listed companies including subsidiaries and persons who control the companies' decision-making. There are a number of connected transactions of listed companies which have been monitored by the SET, such as (i) an ordinary and normal business transaction, (ii) a supporting ordinary and normal business transaction, (iii) a short-term property rental or lease, (iv) an asset or service transaction, and (v) a financial assistance transaction.

According to the SET's connected transaction regulations, financial assistance transactions can be classified into two categories. First, where any listed company, including its subsidiary, receives or grants financial assistance to another company. Moreover, a connected person is someone who holds shares in another company "*less than or equal*" to his share holdings in a listed company including its subsidiaries. In this case the listed company is required to compare the connected transaction value with its net tangible assets (NTA)[103], and follow the criteria and procedures as summarized in Table 7.1.

Second, where any listed company, including its subsidiary, grants financial assistance to a person or a company. In addition, a connected person is someone who holds shares in that company "*more than*" the shares that he actually holds in the listed company including its subsidiaries. The listed firm, therefore, must compare the connected transaction value with its net tangible assets (NTA), and follow the criteria and procedures as summarized in Table 7.2.

As a result the SET has imposed the criteria and procedures for its members to follow if they have connected transactions involving financial assistance.

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[103] NTA = total assets – (total liabilities + intangible assets + minority equity) (The Stock Exchange of Thailand, 2009, p55).

Table 7.1: The criteria and procedures for financial assistance transactions (Case 1)

Levels of connected transaction	Criteria	Procedures
Non-significance	Less than or equal to THB 1 million or 0.03 % of NTA (whichever is higher)	• Summarize and disclose in the annual report.
Moderate significance	Greater than THB 1 million or 0.03% of NTA (whichever is higher) but less than THB 20 million or 3% of NTA (whichever is higher)	• Obtain approval from the board of directors, and report to the SET. • Summarize and disclose in the annual report.
Substantial significance	More than or equal to THB 20 million or 3 % of NTA (whichever is higher)	• Obtain approval from the board of directors, and report to the SET. • Obtain approval from shareholders. • Summarize and disclose in the annual report.

Source: Author (the information is obtained from the Listed Companies Handbook (2009)); Where, NTA is net tangible assets (see footnote 103).

Table 7.2: The criteria and procedures for financial assistance transactions (Case 2)

Levels of connected transaction	Criteria	Procedures
Moderate significance	Less than THB 100 million or 3 % of NTA (whichever is lower)	• Obtain approval from the board of directors, and report to the SET. • Summarize and disclose in the annual report.
Substantial significance	More than or equal to THB 100 million or 3 % of NTA (whichever is lower)	• Obtain approval from the board of directors, and report to the SET. • Appoint an independent financial analyst. • Obtain approval from shareholders. • Summarize and disclose in the annual report.

Source: Author (the information is obtained from the Listed Companies Handbook (2009)); Where, NTA is net tangible assets (see footnote 103).

This is to prevent a conflict of interest caused by connected persons and to protect the benefits of shareholders. In the case of substantial significance, as indicated in Tables 7.1 and 7.2, shareholders, especially minority shareholders, play an important role in monitoring these connected transactions, since they need to approve these connected transactions. Therefore, information with respect to minority shareholders' roles and rights should be promoted, since this can help them in realizing the importance of their voting rights for the meeting of shareholders and also encourage them to participate in shareholders' meetings. In addition, the SET should monitor listed manufacturing firms to ensure their internal financing transactions are fully disclosed to minority shareholders.

Focusing on the effect of external financing on the technical efficiency of Thai listed manufacturing firms, the negative result[104] for hypothesis 2 implies that listed manufacturing firms, which obtain external financing, are obligated to pay different interest payments subject to the amount of their loans and current economic conditions (e.g., financial institutions normally prefer to provide a floating interest rate which can be altered according to (i) interest rates announced by the Bank of Thailand and (ii) financial costs of each financial institution). More importantly, listed manufacturing firms are obligated to pay principle and interest to creditors on time as stated in their loan agreements. They, however, might not be able to pay their loans and interest regularly due to unexpected circumstances (e.g., Thai political unrest, global financial crisis, unexpected interest rate hike, and Thai currency appreciation). Therefore, interest payments known as the cost of external financing can decrease the competitiveness and efficiency of Thai listed manufacturing enterprises[105]. It is possible that Thai listed manufacturing firms might misuse the loans granted by financial institutions and put these to other purposes (e.g., buying listed firms' shares in the stock market), resulting in a deterioration of their efficiency performance.

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[104] However, the effect of external financing on the technical efficiency of Thai listed manufacturing firms is very small (its estimated coefficient is close to zero).

[105] The fluctuation of interest rates charged by financial institutions directly impacts the cost of production of firms (or the input cost in firm production) and, therefore, may adversely affect the competitiveness and efficiency of Thai listed manufacturing firms.

As a result, equity instruments (e.g., issuing shares to investors) are also alternative funding sources for Thai listed manufacturing firms, besides issuing debt instruments (e.g., debentures) and borrowing funds from financial institutions (e.g., short-term and long-term loans). A dividend payment is the cost of equity instruments, but it provides more flexibility than a loan repayment (The Stock Exchange of Thailand, 2009b). The reason is that the amount of the dividend payment is subject to the performance of Thai listed manufacturing firms, which will be paid only in the case where profits are made. Issuing equity instruments, however, may cause dilution of control for existing shareholders (or the dilution effect). In practice, the listed manufacturing firms' equity can be issued to different investors such as (i) existing shareholders (rights offering), (ii) a specific group of strategic investors (private placement), and (iii) public investors (public offering). Thai listed manufacturing firms can, firstly, consider a rights offering[106] to existing shareholders. In other words, they should provide the opportunity for existing shareholders to buy new shares subject to the proportion of their existing shares. It is possible that some of the existing shareholders prefer not to buy new shares or maintain their controlling rights, and therefore they may initiate a public offering[107] (e.g., offering new shares to the public) or a private placement[108] (e.g., involving a particular group of strategic investors). These equity instruments can increase the liquidity and stock prices of firms.

In addition, the SET and the government, via the SEC, may support equity financing that will be used to conduct only productive investments (e.g., upgrading new technology), and avoid equity financing support which aims to roll over the existing debts of Thai listed manufacturing firms. All information regarding the

[106] For a rights offering listed firms must receive approval from the board of directors and from a meeting of shareholders. In addition, they must write notices of the allocation of new shares to existing shareholders and the Stock Exchange of Thailand (SET) at least five business days beforehand (The Stock Exchange of Thailand, 2009b).

[107] After obtaining approval from the board of directors and the meeting of shareholders as well as informing the Stock Exchange of Thailand (SET), listed firms must submit their applications and reports (a filing) to the Office of Securities Commission (SEC) for final approval (The Stock Exchange of Thailand, 2009b).

[108] For a private placement (PP) listed firms must obtain approval from the board of directors and the meeting of shareholders as well as informing the Stock Exchange of Thailand (SET). However, there is no requirement for them to submit their applications and reports to the Office of Securities Commission (SEC) for final approval, but they need to disclose the information (e.g., the subscription form, the payment methods, the name of investors) to the SET (The Stock Exchange of Thailand, 2009b).

purpose of the use of equity financing should be fully disclosed to investors, especially for the case of public offerings. This is because incorrect or hidden information about listed manufacturing firms' securities provided to investors can harm investors' benefits, and, therefore, reduce the reliability of the Thai equity market. Finally, in practice, it is very difficult to determine an adequate level of internal and external financing to be used for each Thai listed manufacturing firm[109], due to differences in their financial status and size. In practice, listed manufacturing firms are normally required to appoint an independent financial analyst to provide a third party comment on their financial activities which directly affect shareholders' benefits (e.g., issuing debentures or shares). These financial analysts must be certified by the SEC so that they can legally comment on those listed manufacturing firms' financial activities. Therefore, the government, via the SEC, can play an important role in promoting the reliability of these financial analysts. For example, providing regular training courses related to updated regulations of the SEC for certified financial analysts are also important to prevent any harmful action to shareholders or investors. Strong and prompt penalties on those financial analysts, including listed manufacturing firms, who are fraudulent should be strengthened to ensure compatibility with international standards.

7.4 Research and Development (R&D) (Hypothesis 3)

The empirical evidence for hypothesis 3 in Chapter 6 reveals that for both approaches research and development (R&D) has a significant and negative impact on the technical efficiency of Thai listed manufacturing enterprises. This result is the opposite of what might be expected. Such a negative finding, however, suggests that most listed manufacturing firms might misleadingly reported R&D activities in their annual report, and in fact did not intend to implement these activities seriously. In other words, they used R&D funds very ineffectively or in areas that did not enhance their technical efficiency. In addition, some deductible expenses such as total R&D expenditure, job training expenses, and expenditure on the provision of equipment for the disabled are allowed to increase at a 200 percent rate of actual expenses for the purpose of corporate income tax (CIT) reduction (The Board of Investment,

[109] From the finance literature this refers to the optimal capital structure where a firm uses a mix of concentrated debt and equity to maximise its value (Beal, 2008, p241).

2010b). Thai listed manufacturing enterprises also report their R&D activities including employee training activities in their annual reports (56-1 form). As a result they are likely to include these expenses in order to reduce their corporate income tax and provide a good image to the public and possible investors without enhancing their efficiency, since they have lacked serious intention to develop, for example, their existing products and production processes as well as enhancing their employee capabilities.

The government, including the SET, should, therefore, monitor Thai listed manufacturing firms' R&D and employee training activities very closely, since these R&D activities, including all R&D transactions, have not required disclosure in their annual reports since 2008**.** For example, R&D evaluation reports should be required and submitted to the government (e.g., the Revenue Department of Thailand) instead of providing only R&D billing expenses to claim the reduction in corporate income tax (CIT). The government, via the BOI, can play an important role in promoting the technical efficiency of Thai listed manufacturing firms by providing financial and non-financial privileges for those firms which lay emphasis on R&D activities. More importantly, the government should focus on promoting the SET manufacturing sector's innovation readiness, including all manufacturing sub-sectors besides providing financial privileges[110]. Providing only financial privileges for Thai listed manufacturing firms may help them generate more profits during the BOI's financial privilege period, but they lack a long-term efficiency improvement.

The BOI should review these activities regularly, after BOI privileges have been granted, to increase the effectiveness of this policy implementation, and, therefore, enhance the performance of Thai listed manufacturing firms. Similarly, R&D evaluation reports must be submitted to the SET besides providing brief explanations of R&D activities as listed in manufacturing firms' annual reports. It is also recommended that the SET conduct its annual R&D report which aims to provide the ranking of Thai listed manufacturing firms' R&D development and give explicit recognition to those firms which have successfully achieved their R&D

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[110] See "government assistance" in Section 7.9 for similar comments.

improvement. This is to encourage serious R&D activity participation by Thai listed manufacturing firms.

7.5 Ownership structure (Hypotheses 4 and 5)

7.5.1 Controlling ownership (Hypothesis 4)

For hypothesis 4 the empirical results from the SFA approach reveal that controlling ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises. A positive result is also found from the DEA approach, but it is not statistically significant. Controlling shareholders are, therefore, likely to improve the performance of Thai listed manufacturing enterprises, since they are likely to monitor their listed firms very closely, which is different from dispersed shareholders who lack the incentive and ability to monitor their firms.

Without close monitoring of listed manufacturing firms which have a high level of controlling ownership, controlling shareholders may deteriorate the performance of Thai listed manufacturing firms since the interest of controlling shareholders may not align with those of non-controlling shareholders (Shleifer and Vishny, 1997; Bebchuk et al., 1999). In other words, they might conduct corrupt activities (e.g., conducting connected transactions which only benefit their group but which adversely affects the profitability of listed firms). As a result, providing information with respect to minority shareholders' roles and voting rights over their listed manufacturing companies is very important, and, therefore, should be promoted as a checks and balances mechanism. For example, most minority shareholders focus upon annual dividends paid by their listed manufacturing firms. They lack a willingness to monitor the operation of their listed manufacturing firms. In other words, they prefer not to attend "annual general meetings (AGM)" including "extraordinary general meetings (EGM)", since they believe that they cannot influence any proposed agenda in the meeting. This might reduce the benefits that they receive in the future, since current actions by the management of listed manufacturing firms may adversely affect the overall firms' performance or only benefit a specific group (e.g., executives, directors, or any persons related to executives and directors).

According to the Public Limited Company Act (2535) there are a number of special cases (e.g., (i) increasing or decreasing registered capital, (ii) selling or transferring a company's business to other persons, (iii) buying other companies' businesses, (iv) signing, changing, and exterminating a business lease of the company with other companies as well as assigning other persons to manage the company's business and merging the company's business with other persons for the purpose of sharing profit and losses, (v) issuing the company's debentures) where listed companies[111] must have shareholders controlling at least 75 percent of total shares attending the meeting and eligible to vote (see Public Limited Company Act (2535)). Minority shareholders, therefore, can play an important role in monitoring listed manufacturing firms' actions as mentioned previously. As a result, it is very important to promote a checks and balances mechanism by educating the importance of their roles and controlling rights over their listed manufacturing companies. The reasons for this are now discussed:

With respect to the Public Limited Company Act (2535), Section 108 of this Act also provides the right for shareholders to request the court[112] to order cancellation or suspended resolution of that shareholders' meeting if they found that the company did not follow the rules and conduct as stated in its articles of association[113], or in this Act's provisions. However, they must submit their appeal within one month. More specifically, "*at least five shareholders*" or "*shareholders gathering at least 10 percent of the total number of sold shares*" are eligible to request the court to consider and cancel the resolution of a particular meeting which are contradictory with the company's articles of association or the Public Law Limited Company Act (2535). In addition, Section 129 of this Act also provides "*shareholders who gather at least 10 percent of the total number of sold shares*" or "*one-third of the total number of shareholders*" can request the registrar to appoint

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[111] In order to become a listed company it must be registered as a "public limited company" or corporation established under a special law, and approved by the Stock Exchange of Thailand (SET) subject to the SET's listing criteria (The Stock Exchange of Thailand, 2009a).

[112]In Bangkok the court is referred to as the Civil and Provincial Court. For the rest of Thailand each province has its own Provincial and Municipal Court. They, therefore, can request the court in the province where a listed manufacturing enterprise has been established.

[113]The articles are required in establishing a company. For a listed company the articles of association consists of a number of chapters, such as (i) general provisions, (ii) directors, (iii) shares and shareholders, (iv) shareholder meetings , (v) balance sheet, and (vi) dividend and reserve fund.

an inspector(s) to investigate the company's operations and financial status (see Public Limited Company Act (2535)). As a result, if minority shareholders fail to closely monitor the transparency of listed manufacturing companies' operations, their benefits might not be maximized due to agency costs from mismanaged or corrupt activities. The Stock Exchange of Thailand (SET), the government, via the Office of Securities and Exchange Commission (SEC), and the Thai Investors Association (TIA) can continuously provide training courses, or necessary updated information, regarding investors (or shareholders)' roles and rights, since the SET's rules and regulations have been continuously improved.

The SET has also considered the importance of maintaining sufficient minority shareholders, and, therefore, every listed company[114] must have at least 150 shareholders whose shares must amount to not less than 15 percent of the listed company's paid-up capital. A listed company which cannot meet this requirement (or the free-float requirement) for two consecutive years or more will result in a public announcement by the SET, and penalty fees based on the level of their free float shortfall and the number of years where they have started to experience a free float shortfall. This is a good monitoring policy in maintaining sufficient minority shareholders. Therefore, it is very important that the SET keeps monitoring Thai listed manufacturing enterprises to meet the free float requirement. In addition, the SET should disclose the names of those listed companies which cannot meet free float requirements promptly. This is because it would help new investors to decide whether they should invest in those listed manufacturing firms or not. This also helps encourage listed manufacturing companies to rectify this problem in order to maintain their good public image. The government, via the SEC, can help protect minority shareholders by strengthening its regulations to be in line with international corporate governance standards to protect minority shareholders' benefits, since any action of listed manufacturing firms, which directly affects shareholder's benefits or decisions (e.g., issuing securities and disclosing company information to investors), must be approved by the SEC.

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[114] Companies which are rehabilitating under the Central Bankruptcy Court and are not required to organize their annual general meeting (AGM) are exempted from the free-float requirement.

7.5.2 Managerial ownership (Hypothesis 5)

The empirical results for hypothesis 5 indicate strong evidence from both estimation approaches that managerial ownership has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises. This indicates that managerial ownership can reduce the agency problem by helping to align the interests of both shareholders and managers (see Chapter 6). From Appendices 1.1 and 1.2 the 10 best listed manufacturing enterprises in 2008 have managerial ownership averaging 23.38 percent which is higher than managerial ownership of the 10 least listed manufacturing enterprises, averaging 16.81 percent.

Managerial ownership, therefore, can be promoted for Thai listed manufacturing enterprises, since it can enhance their technical efficiency. In practice, "stock options" provided for executives, including employees, can be used to increase managerial ownership of Thai listed manufacturing enterprises. Stock options are the right that employees receive to purchase their companies' shares for a specific price and also at a specified period of time (Delves, 2004). In the case of Thailand, stock options are also known as the "Employee Stock Option Program (ESOP)". The ESOP allows employees, including executives, to engage in the listed firms' performance through the appreciation of their companies' share values and the receipt of dividends. As part of the ESOP either "warrant" or "convertible debentures (CD)" can be provided for executives and employees. These securities can be converted to the shares of the listed manufacturing firm at a specific price within a certain period.

The ESOP, however, may cause some problems, as follows: (i) The ESOP may dilute the share prices of listed companies (price dilution) and the control of existing shareholders (control dilution); (ii) listed companies may engage in misconduct in relation to the ESOP For example, they may specify a very low exercise price for their securities given to executives and employees (e.g., warrant and convertible debenture (CD)) compared with the current market price of their listed companies' securities. Executives and employees, therefore, can earn profits in converting, for example, their warrants to their listed manufacturing companies' shares. Therefore, this will harm the long-term performance of Thai listed manufacturing companies, since they may lack the incentive to work harder. Furthermore, listed manufacturing companies may issue and offer their securities (e.g., warrant and convertible debentures) only to a specific group of executives and employees. One of the concerns is how to specify an appropriate vesting period for ESOPs, since they may allow their executives and employees to exercise their securities very promptly. This might not be useful in enhancing the long-term performance of listed companies. Delves (2002, p xiii) also pointed out good and bad characteristics of stock options as shown in Table 7.3.

Table 7.3: Stock options - different characteristics

Stock Options Characteristics	
Good	Options for start-ups and other cash-strapped companies; options that are based on performance; options with exercise prices that vary with the market.
OK	Fixed-price options as part of a mix of performance-based incentives and/or required stock ownership
Bad	Fixed-price options for large, established public companies.
Ugly	Mega grants of fixed price options to executives of large, established public companies.
Very Ugly	Mega grants of options to executives of poorly performing companies whose stock price has dropped suddenly.

Source: Delves (2002, p xiii)

As a result the ESOP may cause problems in relation to control and price dilution for existing investors (or shareholders). The SEC has realized these problems, and therefore its notification regarding “Offer for Sale of Securities to Companies’ Directors or Employees” has been implemented for Thai listed companies since 2008. According to the notification of the SEC, Thor-Chor 32/2551 (2008)[115], if any listed company specifies the exercise price of its securities (e.g., warrant and convertible debenture) lower than ten percent of its share’s current market price, or it issues securities to executives and employees that are more than five percent of total voting shares, they must obtain the approval from at least two-thirds of current shareholders who attend the meeting and have a voting right. More importantly, not more than 5 percent of shareholders who attend the meeting and

[115] The title in Thai is, “Offer for Sale of Securities to Companies’ Directors or Employees” .

have a voting right can veto the ESOP initiated by any listed company. Therefore, information regarding minority shareholders' roles and controlling rights over their listed manufacturing firms should by promoted for a checks and balances mechanism, as previously discussed. In addition, the SET and SEC should monitor the ESOP very closely by checking that they fully disclose all information (e.g., exercise price and time of securities, groups of persons who receive securities from the ESOP) necessary for shareholders to make the correct approval.

7.6 Executive remuneration (Hypothesis 6)

The empirical evidence for hypothesis 6 suggests that there is strong evidence from both estimation approaches that executive remuneration has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises (see Chapter 6). More specifically, the top 10 best listed manufacturing firms obtain higher levels of executive remuneration relative to total labour expenditure, averaging 23.38 percent in 2008, compared with that of the top 10 least listed manufacturing firms, averaging 16.81 percent in 2008 (see Appendices 1.1 and 1.2).

As a result, performance based incentives for executives should be promoted since they can enhance the technical efficiency of Thai listed manufacturing enterprises. Ellig (2002, p5) also pointed out that there are four basic compensation elements such as (i) salary, (ii) employee benefits and perquisites[116] (e.g., time off with pay, health care, survivor protection, employee stock option schemes (ESOP), and retirement coverage), (iii) short-term incentives which are based on individual rather than group achievement (e.g., bonus, or salary increases awarded for a yearly achievement), and (iv) long-term incentives which are based on group rather than individual achievement (e.g., stock options, or salary increases awarded for the accomplishment of multi-year targets). Ellig (2002, p460) also suggested that a salary or a short-term pay incentive is not sufficient for executives to promote a firm's performance, and, therefore, long-term incentives should be promoted in order to increase the firm's long-term performance. The reason is that long-term incentives encourage executives to engage in the firm's long-term goals if their payouts are attractive enough (Ellig, 2002, p7).

[116] Perquisites are also known as executive benefits (Ellig, 2002, p6).

According to the SET's 15 principles of good corporate governance for listed companies (2006), the SET's 10th principle similarly recommended that the level and composition of remuneration should be appropriate and high enough to keep qualified directors but for them not to be overpaid[117]. In addition, executives and directors should be compensated (e.g., an increase in salaries, bonuses, or stock options) based on each listed manufacturing enterprise's performance and also individual executive's performance. Executives and directors should be remunerated based on listed manufacturing companies' compensation policy proposed by the compensation committee or the board of directors.

Unreasonable executive compensation may be proposed, since some directors and executives, who are also members of the board of directors, may propose executive pays and rewards which purposely benefit themselves. For example, the CEO is normally the chairman of the board of directors, and, therefore, conflicts of interest between the board of directors and the CEO with respect to executive remuneration can also arise (Alston, 2006). Ellig (2002, p521) also provided a comparison between reasonable and non-reasonable executive pay as summarized in Table 7.4. Similarly, the Thai Institute of Directors Association (2007) also suggested that the compensation committee should consider available director compensation surveys[118] or hiring a consulting firm before proposing an appropriate remuneration package to the company. The director compensation survey of the companies listed in the SET has been published every two years since 2001, which provides a benchmark of the composition and compensation amounts provided to listed companies' executives in different firm sizes and businesses (Thai Institute of Directors Association, 2010).

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[117] Reasonable executive remuneration can be referred to as (i) the average executive remuneration for all companies listed in the SET, based on the Director Compensation Survey, or (ii) that advocated by a compensation consultant.

[118] For Thai listed enterprises

Table 7.4: Unreasonable and reasonable executive compensation characteristics

	May be unreasonable	May be reasonable
Executive Pay	• Little experience • Light work schedule • Either significant increase in pay or no change for years • Pay significantly higher than for other companies or data not available • Pay set near end of year (when profits can be more exactly measured) • Pay of shareholder-owners higher than comparable non-shareholder employees • Has significant holdings of company stock	• Extensive experience • Work long hours • Increase in pay consistent with growth of company, increase in responsibility, or back pay for lean years. • Pay is basically consistent with comparable sized companies in comparable industries • Basis for pay clearly set at beginning of year • Pay of shareholder - owners equal to or lower than others in firm with responsibilities • Non-stockholder or one with percentage of ownership

Source: Ellig (2002, p521)

Buchholtz et al. (1998), however, pointed out that compensation committee members may propose a generous pay package for executives and directors, since they are also obligated to the board of directors (e.g., the CEO) for appointing them. Therefore, the compensation committee members should not be connected with any member of the board of directors (Alston, 2006).

For Thailand the Thai Institute of Directors Association (2007) also suggested that at least two-thirds of the compensation committee members should be independent directors, and the remainder should be non-executive directors. The chairman of the compensation committee should be an independent director. More importantly, appropriate executive pays and rewards recommended by the compensation committee should be proposed to the listed companies' annual general meeting (AGM) for the approval of shareholders. Listed manufacturing companies should also fully disclose their compensation committee's objectives and policies, and also executive compensation figures and benefits that are in their annual company reports (Form 56-1) (see Thai Institute of Directors Association, 2007). Training courses[119] regarding the roles of compensation committee members should

[119] The training programme for compensation committee members is normally provided by the Thai Institute of Directors Association each year.

be promoted, since this can help them to propose transparent and appropriate policies for executive compensation based on their firms' performance. Finally, providing knowledge for minority shareholders regarding their roles and voting rights over Thai listed manufacturing firms should be emphasised, since executive remuneration must be finally approved by Thai listed manufacturing firms' shareholders, and, therefore, minority shareholders can examine this proposed agenda in the shareholders' meeting.

7.7 Types of firm ownership (foreign and family) (Hypothesis 7)

The empirical evidence for hypothesis 7 suggests that there is strong evidence from both estimation approaches to indicate that foreign and family ownership exert a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises (see Chapter 6). Based on the magnitude of the estimated coefficients for each type of owned-firms, there is strong evidence from both estimation approaches to indicate that foreign-owned firms perform the best, followed by family-owned firms. As a result, foreign and family ownership can be promoted for Thai listed manufacturing enterprises.

7.7.1 Foreign ownership

There is no problem with a foreign shareholding limit for Thai listed manufacturing firms, since their foreign shareholding limit can be relaxed up to 100 percent if their manufacturing projects are approved by the Board of Investment (BOI). Their businesses, however, must not be classified into three lists of prohibited businesses such as (i) businesses that foreigners are not permitted for special reasons (e.g., newspaper, radio, and television station undertaking, fishing, farming, raising animals, extraction of Thai medical herbs, and forestry), (ii) businesses which are concerned with (1) national security or safety (e.g., war equipment or their components, aircraft, and components of fire-arms and explosives), (2) art and culture, customs, and native manufacturing and handicrafts (e.g., production of Thai musical instruments, Thai silk textiles, and goldware, silverware, nielloware, bronzeware, or lacquerware), and (3) natural resources and the environment. (e.g., sugar from sugarcane and timber conversions to make furniture and articles of wood), and (iii) businesses which Thais are not ready to compete with foreigners (e.g., legal, architectural, and engineering services, brokerage, retail and wholesale trades) (Department of Business Development, 1999; The Board of Investment, 2010a).

However, the major concern is how to increase the confidence of foreign investors to invest in Thai listed manufacturing firms or establish their businesses in Thailand. Good corporate governance[120] should be continually promoted, and should be closely monitored by the SET and SEC. For example, reliable and transparent disclosure of Thai listed manufacturing enterprises' information should be continuously promoted. The corporate governance of Thai listed manufacturing companies should be developed to be in line with international corporate governance standards. The institutional framework for best accounting and auditing practices should be continuously strengthened to enhance the quality and reliability of Thai listed manufacturing firms' financial and non-financial information. Rules and responsibilities of board of directors should also be continuously strengthened. Prompt and strong punishment for illegal activities caused by Thai listed manufacturing firms should also be strengthened in order to promote the confidence of foreign investors. Currently, a corporate governance report of Thai listed companies[121], which ranks Thai listed enterprises' corporate governance, has been published for investors (National CG Committee, 2009). This report should also be continuously supported, since this can increase the confidence of foreign investors as well as domestic investors. Moreover, this can motivate Thai listed manufacturing firms, which are not qualified or ranked in the lower level, to improve their corporate governance standard.

A number of Thai listed manufacturing enterprises prefer to limit foreign shareholding due to the policies of their companies, even though they are allowed to have up to 100 percent foreign shareholding according to the BOI's approval. The

[120] As previously discussed in Chapter 2, major development of Thai corporate governance began after the 1997 financial crisis.
[121] This report has been issued by the National Corporate Governance Committee in cooperation with the Stock Exchange of Thailand (SET), the Office of Securities and Exchange Commission (SEC), and the Thai Institute of Directors (IOD). There are six score ranges such as (i) not pass (score range: <50), (ii) pass (score range: 50-59), (iii) satisfactory (score range: 60-69), (iv) good (score range: 70-79), (v) very good (score range: 80-89), and (vi) excellent (score range: 90-100) (National CG Committee, 2009).

SET has also initiated Non-Voting Depository Receipts (NVDRs)[122] to avoid foreign shareholding limits in case listed firms cannot issue shares to foreign investors due to their foreign shareholding limit. NVDR holders can obtain similar financial benefits to that of stock holders (i.e. dividends, rights, and warrants), except NVDR holders are not eligible to vote (Thai NVDR, 2010). Moreover, government agencies such as the BOI and Ministry of Commerce (especially the Department of Business Development (DBD)) can play an important role in promoting foreign participation in Thai listed manufacturing enterprises. For instance, tax-based and non-tax incentives which are approved by the BOI for promoted projects, can also attract foreign investment.

The BOI, therefore, can promote foreign investors through benefits that they would receive if their promoted projects are successfully approved. In addition, the Department of Business Development (DBD) can promote foreign investment, since all foreign business operations in Thailand must be approved by the DBD. Therefore, effective procedures for obtaining foreign business operations as well as providing accurate and prompt information for foreign investors can be promoted to boost the confidence of foreign investors. These can help increase the number of listed enterprises owned by foreign investors for Thai listed manufacturing firms in the future.

7.7.2 Family ownership

To promote family ownership of Thai listed manufacturing enterprises, potential manufacturing firms owned by family members can be promoted for listing on the SET. More specifically, 99 percent of business establishments in Thailand are small and medium sized enterprises (Ministry of Industry, 2009). They might be considered as a potentially targeted group, since they are also mostly operated by family members. The SET can provide all information with respect to benefits that they would receive when their securities are listed in the SET (e.g., long-term source of capital, positive public image, attracting foreign investment, tax privileges on dividends, and shareholder protection), since many Thai SMEs may perceive that

[122] NVDRs are newly listed securities issued by Thai NVDR Company Limited (Thai NVDR), which is wholly owned by the SET.

their control will disappear if they become listed companies. In addition, Thai SMEs might not be interested in being listed in the SET or the Market for Alternative Investment (MAI), due to criteria and procedures for listing (e.g., management criteria, financial criteria, distribution of minority shareholders) as well as the rules and regulations that they must follow after becoming listed firms. In other words, they may lack transparency in their financial dealings.

Providing all information regarding how they can benefit from being listed in the SET and what procedures and criteria they should follow are very important. As previously discussed in Chapter 2, family ownership, however, can cause agency problems since this has the potential to expropriate the interests of minority shareholders. In other words, policies may be implemented which benefit the family owners but which may adversely affect the overall performance of the firm (Porta et al., 1999). Therefore, training courses with respect to the SET's rules and regulations[123] should be provided to educate newly listed manufacturing firms owned by family members, as this can protect minority shareholders and enhance the corporate governance of listed manufacturing firms. Moreover, the promotion of family-owned firms, especially for Thai listed enterprises, may lead to crony capitalism, and therefore may not promote competition in the market as referred to by Doner and Ramsay (2000) and Rock (2002). Good corporate governance practices in Thailand must be continuously enhanced to be in line with international standards as suggested by the World Bank (2005) (see Section 2.6, Chapter 2). Enhancing strong enforcement of violation of laws is also important to promote Thailand's good corporate governance practices[124].

[123] The SET's rules and regulations are as follows: (i) disclosure due to significant events, (ii) increasing capital, (iii) connected transactions, (iv) acquisition or disposition of assets, (v) maintaining the status of a listed company, (vi) roles and responsibilities of board of directors and audit committees, (vii) distribution of minority shareholders, and (viii) preparing financial statements and reports (The Stock Exchange of Thailand, 2009).

[124] Good corporate governance practices refer to (i) enhancing rights of shareholders, (ii) improving disclosure and transparency, and (iii) increasing the accountability of directors and management (see Section 2.6, Chapter 2).

7.8 Exporting (Hypothesis 8)

7.8.1 Learning-by-exporting hypothesis

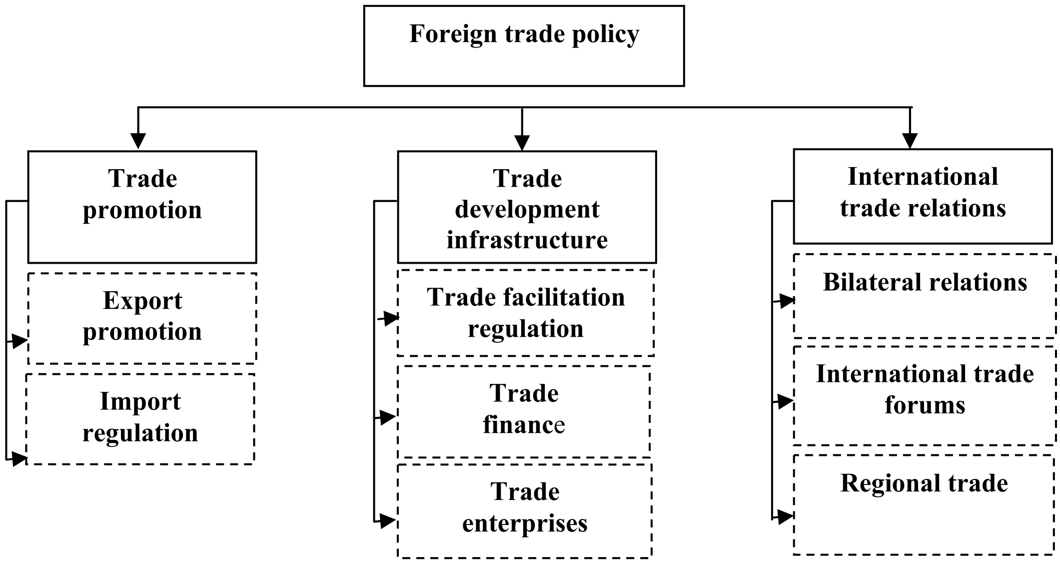
The empirical evidence for the first part of hypothesis 8 indicates strong evidence from both estimation approaches that exporting has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises (see Chapter 6). This result shows that the learning by exporting hypothesis exists for the case of Thai listed manufacturing enterprises, implying that exporting by firms is likely to enhance their technical efficiency due to a learning-by-exporting experience.

As a result, listed manufacturing enterprises can be encouraged to participate more in foreign markets since this can help enhance their technical efficiency. This is because they can gain benefits from their learning-by-exporting experience and by developing new product designs and upgrading production technology. In practice, the government can play an important role in promoting exporting for Thai listed manufacturing firms, as well as other non-listed manufacturing firms. ESCAP (2001) suggested that government policies (e.g., foreign trade policy, national development plans, monetary policy, fiscal policy, production and price controls, private investment regimes, and foreign exchange policy) are one of the key factors for a country's national export promotion to be successful.

There are two main policies which can impact a country's foreign trade, such as (i) foreign trade policies which refer to policies and practices directly affecting and regulating import and export operations (e.g., trade promotion policy[125], trade development infrastructure policy, and international trade relations policy), and (ii) other policies which regulate other economic activities which has an impact on foreign trade performance (e.g., national development plans, monetary policy, fiscal policy, production and price controls, private investment regimes, and foreign exchange policy). Moreover, foreign trade policy can be sub divided into three trade channels (see Figure 7.1).

[125] A "trade promotion policy" consists of programmes and measures that help promote and develop trade with other countries (ESCAP, 2001, p15).

Figure 7.1: Aspects of foreign trade policy



Source: Economic and Social Commission for Asia and the Pacific (ESCAP) (2001, p17)

According to export promotion, as indicated in Figure 7.1, a trade promotion organization (TPO) plays an important role in carrying out export promotion activities to help facilitate a country's products, and increase the volume of its export sales (ESCAP, 2001). There are a number of export promotion measures that can be implemented in order to promote exporting for Thai listed manufacturing enterprises, such as (i) searching and providing new foreign markets, (ii) promoting the trade logistics system, and (iii) promoting product competitiveness (e.g., quality and design improvement). In the case of Thailand the Department of Export Promotion (DEP) also acts as the TPO.

In 2010 the DEP, including government agencies and the private sector, promoted exporting for Thai enterprises, such as (i) promoting Thailand's trade logistics system through a number of activities (e.g., organizing the Thailand International Logistic Fair, providing training programs on how to reduce logistic costs for Thai exporters, developing distribution channels for Thai exports (e.g., establishing worldwide distribution centres), and (ii) expanding new export markets by initiating a number of exhibition projects (e.g., the International Production Exhibition, Thailand Exhibition and Outlet, and the New Markets for Exporters (NME)) (Department of Export Promotion, 2010).

One export promotion policy benefit is to provide tax and non-tax privileges[126] for Thai exporting manufacturers, since this can increase their exporting motivation in competing with foreign competitors due to the reduction in their production costs. Therefore, the BOI can help provide tax and non-tax privileges. One of the BOI investment policies is to enhance the competitiveness of domestic products in the world market. As a result the BOI provides high priority to export-oriented investment products (Akrasanee et al., 1989). Every promoted project must receive the International Standard for Organization (ISO) 9000 certification or similar international certification (The Board of Investment, 2010a).

Under trade promotion policy, strict import regulations, such as imposing tariffs and non-tariffs barriers on foreign importers, also play an important role in protecting a country's local industries, especially infant industries. The term, technical barriers to trade[127], which is one of the non-tariff barriers to trade, has become an important trade instrument in protecting a country's local industries. The government, therefore, should provide necessary information for Thai listed manufacturing firms as well as Thai non-listed manufacturing firms to be able to meet exporting countries' technical rules. This will help promote the competitiveness of Thai listed manufacturing enterprises' exports as well as that of other non-listed manufacturing firms. Focusing on Thai listed manufacturing firms, newly listed companies in the SET and MAI can apply to receive corporate income tax exemption if their projects are eligible for investment promotion announced by the BOI. In addition, their existing projects, which have been approved by the BOI before being listed in the SET and MAI, can obtain additional rights and benefits (see The Board of Investment, 2009c).

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[126] Tax incentives include corporate income tax exemptions, or exemptions or reductions of import duties on machinery and raw materials. Non-tax privileges include permission to employ foreign workers, own land, and take or remit foreign currency abroad (The Board of Investment, 2010b).

[127] Technical barriers to trade can be divided into two terms: (i) product standards and (ii) regulations (Thilmany and Barrett, 1997). This normally refers to when countries impose their technical rules such as packaging, product definitions, labelling on foreign importers to protect their local producers. However, technical barriers violate the provisions of WTO which require countries to have fair treatment between imported and local products. This conflicting issue can be solved by bilateral and multinational trade negotiations (Sumner, 2011).

From Figure 7.1 the development of trade infrastructure is also one of the important factors used to promote exporting for Thai listed manufacturing enterprises, which can be classified into (i) trade facilitation regulation, (ii) trade finance, and (iii) trade enterprises. Trade facilitation regulation should be transparent and be backed by a strong legal framework. In other words, the process and application procedures for imports and exports should be transparent and follow international practices. It may be difficult for new exporters to acquire sufficient loans from financial institutions. Therefore, financial assistance is also an important factor in facilitating and promoting Thai listed manufacturing exporters. To promote exporting for Thai listed manufacturing firms the government should promote the importance of specialized financial institutions, such as the Export and Import Bank of Thailand (EXIM Bank)[128] and export insurance agencies[129]. Finally, international trade relations are also one of the important factors that can promote the export performance of Thai listed manufacturing enterprises through bilateral trade relations, international trade forums, and regional trade.

7.8.2 Self-selection hypothesis

The empirical evidence for the second part of hypothesis 8 indicates that a firm's technical efficiency, as predicted by the SFA approach, has a significant and positive effect on its export participation for Thai listed manufacturing enterprises. The positive effect of a firm's technical efficiency predicted by the DEA approach on its export participation is also found for Thai listed manufacturing enterprises, but it is not statistically significant.

As a result the self-selection hypothesis appears to exist for Thai listed manufacturing enterprises, indicating that only efficient firms are able to participate

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[128] The EXIM Bank provides a number of specialized financial facilitation services for importers and exporters in domestic and foreign markets, such as (i) working capital loans, (ii) term loans (e.g., a term loan for business expansion and long-term credit for export of capital goods), (iii) financing for overseas projects, (iv) export credit insurance, (v) buyer and bank risk assessment reports (BRA), buyer's credit, and (vi) export financing services with free export credit insurance service, especially for exports destined for ASEAN+6 (ASEAN, China, Japan, South Korea, India, Australia, and New Zealand markets) (Export-Import Bank of Thailand, 2010).

[129] Trading enterprises can assist local manufacturers to sell their products to foreign markets at minimum transaction costs and risks, since trading enterprises have (i) strong foreign networks, (ii) expertise in dealing with future international market opportunities and developments, (iii) strong knowledge regarding necessary export and import procedures (e.g., shipping, warehousing, insurance, and trade financing) (ESCAP, 2001).

in the export market since they can compete with foreign enterprises. The government, therefore, can promote Thai listed manufacturing firms to become more technically efficient. A number of firm-specific and business environment factors, which have been found to have a significant and positive impact on the technical efficiency of Thai listed manufacturing firms, can be promoted, such as (i) increase firm size, (ii) more concentrated (controlling) and managerial ownership, (iii) more foreign and family ownership participation, (iv) attractive executive remuneration, and (v) exporting. For example, the SET and the government, via the SEC, can promote an increase in the consolidated size of Thai listed manufacturing firms, which can be promoted by fundraising which will be used for productive investment (e.g., upgrading production technology).

Other policy implications and recommendations related to other firm-specific and business environment factors should also be focused upon for Thai listed manufacturing enterprises, such as (i) strengthening good corporate governance among Thai listed manufacturing enterprises, (ii) providing information for minority shareholders with respect to their roles and voting rights, and (iii) improving production technology.

7.9 Other factors

Firm size

There is strong evidence that a firm's size has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises. In addition, large firms can also participate in foreign markets, since they can cover sunk costs necessary to enter into export markets (Greenaway et al., 2007). In other words, they can earn sufficient revenue to cover their sunk costs incurred during exporting (Jongwanich and Kohpaiboon, 2008) (see Chapter 6). The SET and SEC, therefore, might promote an increase in the consolidated size of Thai listed manufacturing firms including all manufacturing sub-sectors, since large Thai listed manufacturing firms tend to have higher technical efficiency, and they are also likely to participate in foreign markets. For Thai listed enterprises an increase in firm size can be promoted through fundraising (or increasing capital), and, therefore, the SET and SEC may promote and facilitate their fundraising which will be used for productive investment (e.g., upgrading production technology), which can generate their future and sustainable revenues. Financial institutions can also promote an increase in the size of Thai listed manufacturing firms by providing funds (loans) for commercially viable projects. Moreover, potential manufacturing firms which are listed in the MAI can be promoted to be listed in the SET[130]. This policy can help increase the size of Thai listed manufacturing firms, and therefore improve the technical efficiency of Thai listed manufacturing firms.

Firm age

The empirical results from both estimation approaches reveal that firm age is positively related with technical efficiency for Thai listed manufacturing enterprises, but only the empirical evidence from the SFA reveals a significant result. Furthermore, firm age has a significant and positive effect on its export decision since old firms can compete with foreign companies due to their accumulative experience, business networks and reputation (see Chapter 6).

Therefore, the SET and SEC can help facilitate the listing of long established manufacturing firms in the SET. More importantly, long established small and medium sized enterprises (SMEs), which have been operated by family entrepreneurs and foreigners, might be targeted as newly potential listed manufacturing firms if they meet the SET's listing criteria. From the empirical evidence, older Thai listed manufacturing firms are likely to have a higher level of technical efficiency compared with younger ones. Therefore, policies which focus on how to help young listed manufacturing firms to increase their technical efficiency and participate in foreign markets are also necessary (e.g., promoting cross-learning between young firms and old firms, promoting networking, providing business training and tax holiday to young established firms, and attracting foreign direct investment). The reasons are that young listed manufacturing firms may lack (i) sufficient experience in operating their businesses, (ii) financial resources in upgrading new production

[130] Firms which are willing to be listed in the SET must have paid-up capital valued at 200 million baht (after initial public offering), and have been in operation for at least three years with the same company management for at least 1 year. In addition, they must obtain at least 50 million baht combined minimum net profits from operations over the past two or three years, and at least 30 million baht net profits from operations for the latest full year (The Stock Exchange of Thailand, 2009).

technology and enhancing human capital, (iii) domestic and international business networks, and (iv) reputation (brand name).

Government Assistance

Inconclusive results are obtained for the effect of government assistance on a firm's technical efficiency for Thai manufacturing firms, including Consumer Products and Other Sectors sub-sectors. A negative finding is found for the Agro and Food Industry and Industrials sub-sectors. According to the Ministry of Industry (2009), Thai manufacturing firms' productivity has been low due to the lack of their innovation readiness. In other words, they lack the creation of high value-added products, new technology, skilled labour, and know-how in developing the quality of their products (Ministry of Industry, 2009). This implies that government assistance should focus on how to improve the innovation of SET manufacturing enterprises, including those firms in the Consumer Products and Other Sectors sub-sectors besides providing financial support. Innovation can be classified into two dimensions, which are product innovation through the novelty of new products or product improvement, and process innovation through the novelty of technology and technological improvement.

All of the policy implications and recommendations previously identified are summarized and provided in Table 7.5.

Table 7.5: Summary of policy implications and recommendations

Hypothesis	Policy implications and recommendations
	• To improve the technical efficiency performance of Thai listed manufacturing enterprises, they should concentrate on upgrading their production technology and participating in higher value - added production activities. - The government, via the BOI, can promote the enhancement of their production technology, and higher value-adding production participation through BOI financial and non-financial privileges. - The SET and SEC can promote and facilitate fundraising which will be used for their productive investments, such as upgrading their production technology and improving their value-adding production.

Table 7.5: Summary of policy implications and recommendations

Hypothesis	Policy implications and recommendations
H 1 (Leverage and liquidity)	• Promote the effective control of input costs and financial resources. • Promote only productive investment. - The SET can help attract foreign and local investors to invest in the securities of Thai listed manufacturing firms which focus on productive investment. - The government, via the BOI, can promote the BOI privileged participation of Thai listed manufacturing firms which are interested in launching new products, and upgrading their production technology.
H 2 (Internal and external financing)	• Internal financing transactions should be fully disclosed to avoid an agency problem. • Information regarding minority shareholders' roles and rights should be promoted, since they have a voting right to monitor connected transactions (e.g., providing loans for related firms). • External financing equity instruments (e.g., share issuance to investors) are also alternative funding sources besides debt instruments (e.g., debentures, loans from financial institutions). - A dividend payment is the cost of equity instruments, but provides more flexibility than a loan repayment. - The SET and the government, via the SEC, may support targeted equity financing which will be used for productive investments (e.g., upgrading new technology or producing new products), and avoid equity financing support which aims to roll over the existing debts of Thai listed manufacturing firms. - All information regarding the purpose of the use of equity financing should be fully disclosed to investors. • Financial analysts should play an import role in providing adequate comments on financial activities (e.g., the use of external and internal financing) of Thai listed manufacturing firms. - Training courses for certified financial analysts related to updated regulations of the SET and SEC can be promoted. - Strong and prompt penalties to those financial analysts, including Thai listed manufacturing firms, which are fraudulent should be strengthened.
H 3 (R&D)	• The government, including the SET, should monitor Thai listed manufacturing firms' R&D and employee training activities very closely. - R&D evaluation reports should be required and submitted to the government (e.g., the Revenue Department of Thailand) instead of providing R&D billing expenses to claim the reduction in corporate income tax (CIT). - R&D evaluation reports should also be submitted to the SET. The SET may conduct an annual R&D report of Thai listed manufacturing firms, which provides the ranking of their R&D development and the recognition for those which have successfully achieved their R&D activities. • The government, via the BOI, can play an important role in promoting R&D activities of Thai listed manufacturing firms through the BOI privileges for those which focus on serious R&D activities (e.g., developing new production technology and new products, and engaging in employee training and development).

Table 7.5: Summary of policy implications and recommendations (continued)

Hypothesis	Policy implications and recommendations
H 4 (Controlling ownership)	• Providing information with respect to minority shareholders' roles and voting rights should be promoted for a checks and balances mechanism. - For example, Section 108 of the Public Limited Company Act (2535) provides the right for shareholders to request the court to order cancellation or suspended resolution of that shareholder's meeting if they find that the company did not follow the rules and regulations as stated in its articles of association (see Section 7.4 of this chapter). - Section 129 of the Public Limited Company Act (2535) provides the right for shareholders to request the registrar to appoint an inspector(s) to investigate the company's operations and financial status (see Section 7.4 of this chapter). • The SET, SEC, and Thai Investors Association (TIA) should continuously provide training or necessary updated information regarding investor's roles and rights. • The SET should keep monitoring Thai listed manufacturing enterprises to meet sufficient minority shareholders (the free float requirement). - The name of those listed manufacturing firms which cannot meet a free float requirement should be disclosed very promptly. • The government, via the SEC, can help protect minority shareholders by strengthening its rules and regulations to be in line with international corporate governance standards.
H 5 (Managerial ownership)	• The "Employee Stock Option Program (ESOP)" can be used to promote managerial ownership - The SET and the government, via the SEC, should monitor the ESOP very closely so that Thai listed manufacturing firms fully disclose their information (e.g., exercise price and time of securities, groups of persons who receive securities from the ESOP) necessary for shareholders to make the correct approval. • Knowledge regarding minority shareholders' roles and controlling rights over Thai listed manufacturing firms should be promoted. - For example, according to the notification of the SEC, Thor-Chor 32/255, if any listed company specifies the exercise price of its securities lower than ten percent of its share's current market price, or it issues securities to executives and employees that are more than five percent of total voting shares, they must obtain the approval from at least two-thirds of current shareholders who attend the meeting and have a voting right. - Not more than 5 percent of shareholders who attend the meeting and have a voting right can veto the ESOP initiated by any listed company.
H 6 (Executive remuneration)	• Performance based incentives can be promoted for Thai listed manufacturing firms. - The compensation committee should be promoted, and compensation committee members should be independent or non-executive directors. - Available director compensation surveys or hiring a consulting firm are also necessary for the compensation committee in proposing an appropriate remuneration package to the company. - Training courses regarding the roles of compensation committee members should be promoted, since this can help them to propose transparent and appropriate compensation policies for executives based on their firms' performance. • Providing knowledge for minority shareholders regarding their roles and voting rights over Thai listed manufacturing firms should be emphasised, since executive remuneration must be finally approved by shareholders, and, therefore, minority shareholders can examine this proposed agenda in the shareholders' meeting.

Table 7.5: Summary of policy implications and recommendations (continued)

Hypothesis	Policy implications and recommendations
H 7 (Types of owned firms: foreign and family ownership)	• Good corporate governance should be continually promoted to be in line with international standard, and closely monitored by the SET and SEC. The following are part of corporate governance which should be continuously promoted for Thai listed manufacturing firms: - Reliable and transparent disclosure of Thai listed manufacturing enterprises' information - The institutional framework for best accounting and auditing practices - Adequate rules and responsibilities of board of directors - Prompt and strong punishment for illegal activities caused by Thai listed manufacturing firms - Reliable corporate governance reporting of Thai listed companies • The government, via the BOI, can promote foreign direct investment through BOI privileges, as foreign shareholding can be allowed up to 100 percent for unrestricted businesses. In addition, the government, via the DBD, can promote foreign investment by strengthening procedures for obtaining foreign business operations as well as providing accurate and prompt information for foreign investors. • Non-Voting Depository Receipts (NVDRs) are also useful to avoid the foreign shareholding limit in cases where listed manufacturing firms are not eligible to obtain BOI privileges • To promote family ownership, Thai SMEs can be a potentially targeted group, since they are mostly operated by family members. The following measures should also be promoted: - Providing all information regarding the listing benefits for Thai SMEs - Providing training courses with respect to the SET's rules and regulations for newly listed manufacturing firms owned by family members
H 8 (Exporting: Learning-by -exporting and self-selection hypotheses)	• For the learning-by-exporting hypothesis the government can play an important role in promoting exporting for Thai listed manufacturing firms. - Besides other policies, foreign trade policy can promote exporting of Thai listed manufacturing firms, which can be sub divided into three trade channels ,such as (i) trade promotion, (ii) trade development infrastructure, and (iii) international trade relations. These trade areas can be promoted as follows: - Focusing on trade promotion the government, via the DEP, can help promote exporting of Thai listed manufacturing firms, such as (i) promoting the trade logistics system and (ii) expanding new export markets, (iii) promoting product competitiveness (e.g., quality and design improvement). In addition, the government, via the BOI, can help promote their exporting by providing BOI privileges for those which focus on export-oriented investment. - Focusing on trade development infrastructure, trade facility regulation should be transparent and backed by a strong legal framework. Trade finance can help facilitate and promote Thai manufacturing exporters, and, therefore, specialized financial institutions for exporting should be promoted, such as the EXIM bank and export insurance agencies. - International trade relations (e.g., bilateral trade relations, international trade forums, and regional trade) can also help promote exporting by Thai listed manufacturing firms. • For the self-selection hypothesis the government can promote Thai listed manufacturing enterprises to become more technically efficient. A number of firm-specific and business environment variables have been found to have a significant and positive impact on technical efficiency and which should be promoted, such as (i) increase firm size, (ii) more concentrated (controlling) and managerial ownership, (iii) more foreign and family ownership participation, and (iv) attractive executive remuneration. Moreover, strengthening good corporate governance, knowledge for minority shareholders, and improving production technology should be focused upon for Thai listed manufacturing enterprises.

Table 7.5: Summary of policy implications and recommendations (continued)

Other factors	Policy implications and recommendations
Firm size	• The SET and the government, via the SEC, can promote an increase in the consolidated size of Thai listed manufacturing firms, which can be promoted by fundraising (increasing capital). - The SET and SEC may promote and facilitate their fundraising which will be used for productive investment (e.g., upgrading production technology). - Financial institutions can be a key driver to promote an increase in the size of Thai listed manufacturing firms, by supporting funds (loans) for commercially sustainable projects. - Potential manufacturing firms which are listed in the MAI can be promoted to be listed in the SET if they meet the SET's listing criteria.
Firm age	• The SET and the government, via the SEC, can facilitate the listing of long established manufacturing firms in the SET. - Long established SMEs, which have been operated by family entrepreneurs and foreigners, can be targeted as newly potential listed manufacturing firms. • Policies which focus on how to help young listed manufacturing firms to increase their technical efficiency and participate in foreign markets can be promoted, such as (i) promoting cross-learning between young firms and old firms, (ii) promoting networking and FDI, (iii) providing business training to young listed manufacturing firms, and (iv) providing tax holiday for young firms.
Government assistance	• The government should provide the assistance to improve the innovation for the SET's manufacturing enterprises. - Product innovation which is the novelty of new products or product improvement should be promoted for Thai listed manufacturing enterprises. - Process innovation which is the novelty of technology and technical improvement should be promoted for Thai listed manufacturing enterprises.

Source: Author

7.10 Conclusions

This chapter has provided policy implications and recommendations based on empirical evidence obtained for hypotheses 1 to 8, as well as other selected firm specific factors (e.g., firm size and firm age) that significantly affect the technical efficiency of Thai listed manufacturing enterprises.

From earlier discussions the SET and the government, via a number of government agencies (e.g., the Office of Securities and Exchange Commission (SEC), the Board of Investment of Thailand (BOI), the Department of Export Promotion (DEP), the Revenue Department (RD), the Department of Business Development (DBD), and the Export and Import Bank of Thailand (EXIM bank)), can play an important role in promoting the technical efficiency of Thai listed manufacturing firms through a number of policy implementations and recommendations (see Table 7.5). Focusing on the roles of the SET and SEC, good corporate governance among Thai listed manufacturing enterprises should be continuously promoted so as to be in line with international corporate governance standards, through (i) reliable and transparent disclosure of Thai listed manufacturing enterprises' information, (ii) adoption of the institutional framework for best accounting and auditing practices, (iii) adequate rules and responsibilities of board of directors, and (iv) prompt and strong punishment for illegal activities caused by Thai listed manufacturing firms including other related parties (e.g., financial analysts).

In addition, the SET and SEC should (i) monitor Thai listed manufacturing enterprises' transactions very closely so as to ensure compliance with their rules and regulations as well as international corporate governance standards, (ii) provide training courses related to updated rules and regulations for newly and existing listed manufacturing enterprises, including related parties, and (iii) facilitate fundraising for Thai listed manufacturing enterprises to be used for productive investment (e.g., upgrading production technology and developing new products). These policy implications and recommendations, therefore, are crucial in enhancing the performance of Thai listed manufacturing firms, as suggested for almost all the hypotheses (see Table 7.5).

More importantly, providing knowledge for minority shareholders regarding their roles and voting rights is very important for a checks and balances mechanism, to avoid an agency problem, since transactions of Thai listed manufacturing enterprises, which directly affect companies and shareholders' benefits, must be approved by shareholders. Thus, minority shareholders can play an important role in monitoring any proposed agenda, and appointing an inspector(s) to investigate the company's operations and financial status. This is also used for the recommendation of hypothesis 4 (controlling ownership), hypothesis 5 (managerial ownership), and hypothesis 6 (executive remuneration). Other government agencies, especially the BOI, also play an important role in promoting (i) the performance of Thai listed manufacturing enterprises, (ii) foreign investment participation, (iii) exporting of Thai listed manufacturing enterprises, and (iv) serious R&D participation of Thai listed manufacturing enterprises.

The government can encourage those Thai listed manufacturing enterprises as well as foreign companies to participate in their production and product improvement as well as productive investment, for example, by providing BOI financial and non-financial privileges. Other useful policy implications and recommendations which are not mentioned in this part are also summarized and provided in Table 7.5. In the next chapter (Chapter 8) the major conclusions from this thesis, limitations of this thesis and areas for further research will be discussed.

CHAPTER 8

CONCLUSIONS

8.1 Introduction

The main research objectives of this thesis have been to: (i) measure the technical efficiency of Thai listed manufacturing enterprises; (ii) identify and measure firm-specific and business environment factors which significantly affect the inefficiency performance of Thai listed manufacturing firms; and (iii) provide evidence based policy implications and recommendations to enhance the efficiency and competitiveness of listed manufacturing enterprises. The following main research questions have been addressed according to the above objectives, (i) How do Thai listed manufacturing enterprises perform in terms of technical efficiency?; (ii) What are the important factors which significantly contribute to the technical efficiency performance of Thai listed manufacturing enterprise?; and (iii) How can the overall technical efficiency performance of Thai listed manufacturing enterprises be enhanced? (see Chapter 1).

To address these research objectives and questions, this thesis has conducted a comprehensive literature review focusing on different measurements of a firm's performance, as well as the literature regarding the effects of firm-specific and business environment variables on a firm's performance, including technical efficiency, such as (i) financial factors (e.g., financial constraints (leverage) and sources of finance), (ii) ownership structure (e.g., types of ownership, controlling ownership, and managerial ownership), (iii) research and development (R&D), and (iv) executive remuneration. Other firm-specific and business environment factors that affect a firm's performance have also been discussed. The two-way relationship (the self-selection and learning-by-exporting hypotheses) between a firm's performance and its export participation has also been reviewed in Chapter 3.

To measure the technical efficiency performance and factors affecting the technical inefficiency of 178 Thai listed manufacturing enterprises over the period

2000 to 2008, this thesis has applied both the Stochastic Frontier Analysis (SFA) based on the Battese and Coelli (1995) model and the two-stage Data Envelopment Analysis (DEA) approach in Chapter 4. The main reason for doing so is to increase the degree of confidence when conducting the empirical analysis in Chapter 6, since it cannot be concluded which estimation approach is more preferable due to their advantages and disadvantages as discussed in Section 4.5 of Chapter 4. Before conducting the empirical analysis in Chapter 6 eight unique hypotheses were developed in Chapter 5 from a review of the literature in Chapter 3 (see Chapter 5).

This thesis has made a significant contribution to the existing finance and economics literature in terms of (i) measuring the technical efficiency performance of Thai listed manufacturing enterprises, and (ii) identifying and examining eight unique hypotheses which have not been empirically examined before for the case of Thai listed manufacturing enterprises. More importantly, most hypotheses[131] have also made a significant contribution to the study of listed manufacturing enterprises in other countries.

This is also the first study to apply both parametric (Stochastic Frontier Analysis (SFA) and non-parametric (two-stage Data Envelopment Analysis (DEA)) approaches in the context of Thai listed manufacturing enterprises, aimed at increasing the confidence of the empirical analysis and for robustness checking. A firm-level dataset, used for the empirical analysis of Thai listed manufacturing enterprises, has been compiled by the author due to the unavailability of existing firm level survey data. The raw data (electronic reports) were obtained from the SET covering the period 2000 to 2008, utilising (i) consolidated financial reports, (ii) annual reports (Form 56-1), and (iii) the list of board of directors and major shareholders. This dataset ensures the uniqueness of the thesis. This thesis has made a significant contribution by providing empirically based policy implications and recommendations to enhance the efficiency performance and competitiveness of Thai listed manufacturing enterprises, of particular importance to both policy-makers and entrepreneurs of listed manufacturing enterprises.

[131] See hypotheses 1, 4, 5, 6, and 7 in Chapter 5 for more details.

A summary of key empirical results which have been reported and discussed in Chapter 6 will be provided in Section 8.2. This section reports the empirical findings relating to three main research questions, including 11 sub-research questions (see Section 1.2, Chapter 1). Finally, limitations of this study and suggestions for further studies are provided in Section 8.3.

8.2 Major research findings

8.2.1 Conclusions for the main research questions

This thesis has attempted to empirically explore three main research questions and 11 sub-research questions. The three main research questions focus on measuring the technical efficiency performance of Thai listed manufacturing enterprises, examining the significant factors contributing to their technical efficiency performance, as well as enhancing their technical efficiency performance through evidence based policy implications and recommendations. These are as follows:

(i) How do Thai listed manufacturing enterprises perform in terms of technical efficiency?

The first research question aimed to evaluate the technical efficiency performance of Thai listed manufacturing enterprises. In measuring the technical efficiency performance of Thai listed manufacturing enterprises both the SFA and DEA approaches were used. The average technical efficiency scores of Thai listed manufacturing enterprises obtained from the SFA and DEA approaches were found to be quite consistent, given by 0.812 and 0.887, respectively. According to the mean technical efficiency scores predicted by both estimation approaches, Thai listed manufacturing enterprises operated at a high level of technical efficiency, indicating that the mean technical efficiency for the SFA approach is 81.20 percent of the best practice frontier and 88.70 percent of the best practice frontier for the DEA approach (see Table 6.14, Chapter 6). However, empirical evidence from both estimation approaches revealed that Thai listed manufacturing enterprises operated under decreasing returns to scale over the period 2000 to 2008. For the SFA approach the production returns to scale, given by 0.9187, indicated the existence of decreasing returns to scale for Thai listed manufacturing enterprises (see Table 6.9, Chapter 6). Similarly, the DEA approach suggested that approximately 86 percent of Thai listed manufacturing enterprises, on average, operated under decreasing returns to scale.

For the SFA approach the output elasticities with respect to capital input, labour input, and intermediate inputs (or the elasticities of substitution), calculated from the estimated coefficients of the stochastic production function as indicated in Table 6.9, revealed that the production of Thai listed manufacturing enterprises is mainly contributed by intermediate inputs and labour input, with capital found to be the least important input. Similarly, empirical evidence from an estimated Translog production function, as shown in Table 6.7, confirmed the existence of labour-using and capital-saving technical progress for Thai listed manufacturing enterprises, indicating that the technical progress of Thai listed manufacturing enterprises relied on labour input over the period 2000 to 2008. Moreover, the rate of technical progress is found to be 0.0205 for Thai listed manufacturing enterprises, indicating that the rate of technical change only increased by 2.05 percent per year (see Table 6.9, Chapter 6). Therefore, the above findings indicate that even though their technical efficiency performance is high, they have relied on labour-intensive or low value added production activities and, therefore, they must move up to a higher production frontier to enhance their future technical efficiency performance. In other words, they should concentrate on upgrading their production technology or participating in higher value-adding production activities.

(ii) Which factors significantly contribute to the technical efficiency performance of Thai listed manufacturing enterprises?

This second research question was aimed at examining firm-specific and business environment factors which significantly influence the technical efficiency performance of Thai listed manufacturing enterprises. The significant findings from this research question are also useful in the conduct of policy analysis and recommendations to enhance the efficiency and competitiveness of Thai listed manufacturing enterprises. The thesis reviewed the literature regarding the important factors which significantly affect firm performance, including the technical efficiency of listed companies in Chapter 3. The methodology used to empirically examine this second research question was developed in Chapter 4. Two estimation methods were employed to empirically examine the significant factors affecting the technical efficiency performance of Thai listed manufacturing enterprises. For the SFA approach the Battese and Coelli (1995) model is applied, in which the stochastic Translog production function and the inefficiency effects model are estimated simultaneously. In addition, the two-stage DEA model is applied for the DEA approach. First, the output orientated model is applied assuming fixed input amounts and maximized output production, and variable returns to scale (VRS) linear programming is used to predict technical efficiency scores. Second, technical inefficiency scores are regressed against firm-specific and business environment variables using the maximum-likelihood Tobit model.

To answer this second main research question, sub-research questions relating to a number of firm-specific and business environment variables, which are crucial to improve the efficiency and competiveness of Thai listed manufacturing enterprises, are specifically addressed as follows:

(1) How do "*financial constraints (leverage) and liquidity*" impact on the technical efficiency of Thai listed manufacturing enterprises?

According to the first sub-research question, hypothesis 1 is developed from a review of the literature in Chapter 3 as follows:

Hypothesis 1: *Financial constraints (leverage) have a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises. Vice versa, the more liquidity the lower is the technical efficiency of Thai listed manufacturing enterprises.*

From Chapter 6 both estimation approaches revealed strong evidence that financial constraints (leverage) have a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises, and this evidence is also consistent with the findings of Sena (2006) and Mok et al. (2007). This suggests that financially constrained firms are likely to improve their technical efficiency through the effective control of input costs and financial resources. In addition, it is possible that Thai listed manufacturing enterprises which are found to have high leverage might be investing in capital intensive projects, since they expect to enhance their current and future production process or extend their production capacity (e.g., building new plant, acquiring new machinery and equipment). These capital intensive projects, however, require large funding (e.g., long-term loans received from financial institutions, or issuance of debentures). Therefore, they might be technically efficient but their leverage might be high due to new technology investment used for enhancing the efficiency and effectiveness of their current and future production. Vice versa, the empirical results from both estimation approaches also reveal that liquidity has a negative effect on the technical efficiency of Thai listed manufacturing enterprises, as suggested by Goldar et al. (2003), indicating that financially healthy firms are likely to neglect enhancing their technical efficiency due to an excess of financial liquidity. It is also possible that Thai listed manufacturing enterprises which have high liquidity might appear to be less technically efficient, since they might be stuck with old machinery and equipment and prefer not to invest in new technology.

(2) Which types of *"source of finance"* (internal or external financing) significantly affect the technical efficiency of Thai listed manufacturing enterprises?

In response to the second sub-research question, hypothesis 2 is developed from a review of the literature in Chapter 3 as follows:

Hypothesis 2: *External financing has a significant and positive relationship with a firm's technical efficiency for Thai listed manufacturing enterprises. Vice versa, internal financing has a significant and negative effect on a firm's technical efficiency for Thai listed manufacturing enterprises.*

The empirical results from the SFA approach suggest that external financing has a significant and negative association with the technical efficiency of Thai listed manufacturing enterprises, which is opposite to the statement of this hypothesis. Negative evidence is also found from the DEA approach, but it is not statistically significant. This negative finding is different from Kim (2003), but does not exert a significant impact on the technical efficiency of Thai listed manufacturing enterprises, since the magnitude of the estimated "external financing" coefficient is very small (close to zero). This negative result implies that Thai listed manufacturing firms which obtain external financing, are obligated to pay different interest payments subject to the amount of their loans and current economic conditions (e.g., financial institutions normally prefer to provide a floating interest rate which can be altered according to (i) interest rates announced by the Bank of Thailand and (ii) financial costs of each financial institution). More importantly, they are obligated to pay principle and interest to creditors on time, but might not be able to pay their loans and interest regularly due to unexpected incidences (e.g., Thai political unrest, global financial crisis, unexpected interest rate hike, and Thai currency appreciation). Therefore, interest payments known as the cost of external financing[132] may reduce the efficiency and competitiveness of Thai listed manufacturing enterprises.

On the other hand the empirical evidence from the SFA approach reveals that internal financing has a significant and negative impact on the technical efficiency of Thai listed manufacturing enterprises, suggesting that managers tend to utilize internal funds ineffectively due to a lack of external monitoring. This implies that the agency problem exists for the use of internal funds, since managers do not appear to maximize shareholders' interests or have strong incentives to abuse internal funds as suggested by Jensen (1986). Kim (2003, p134) also emphasized that this normally exists in several underdeveloped countries where firms' managerial skills are not fully strengthened and firm operation information is not fully disclosed to investors, and, therefore, managers may take every opportunity to maximize their benefits rather than the firm's value. A negative result is also found from the DEA approach, but it is not statistically significant.

(3) How does "*research and development*" (R&D) affect the technical efficiency of Thai listed manufacturing enterprises?

With respect to the third sub-research question, hypothesis 3 is developed from the literature review in Chapter 3 as follows:

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[132] The use of external and internal financing refers to the capital structure in the finance literature, which is the mix of concentrated debt and equity used by a firm (Beal et al., 2008). High cost of debt which can be captured by interest payments might lead to a firm's probability of bankruptcy due to the effects from (i) a decrease in the company's sales due to the deterioration of customers' confidence in the firm, (ii) a decrease in the company's productivity of workers and managers due to their concern for new job search, and (iii) a deterioration of creditors' confidence in the firm.

Hypothesis 3: *Research and development (R&D) has a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises.*

The empirical results from both estimation approaches reveal that research and development (R&D) has a significant and negative association with the technical efficiency of Thai listed manufacturing enterprises. This result is different from the expected positive result for this hypothesis. Such a negative finding, however, suggests that most listed manufacturing firms might misleadingly report their R&D activities in their annual report, since they prefer to keep a good public image and to use this for the purpose of corporate income tax reduction without seriously implementing these R&D activities.

(4) How does "*controlling ownership*" (concentrated ownership) influence the technical efficiency of Thai listed manufacturing enterprises?

Focusing on the fourth sub-research question, hypothesis 4 is developed from the literature review in Chapter 3 as follows:

Hypothesis 4: *Controlling ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

From Chapter 6 the empirical evidence from the SFA approach reveals that controlling ownership has a significant and positive impact on the technical efficiency of Thai listed manufacturing enterprises. This supports the agency theory that controlling shareholders are likely to perform better than dispersed shareholders, since a high level of ownership concentration is likely to alleviate the free rider problem of monitoring a firm's management and, therefore, reduce agency costs. A positive result is also found from the DEA approach, but it is not statistically significant. This positive result is also consistent with the empirical results of Yammeesri and Lodh (2003) and Wiwattanakantang (2001) for the case of Thai listed companies, except their results regarding the measurement of a firm's performance is based upon profitability and financial ratios.

(5) How does "*managerial ownership*" impact on the technical efficiency of Thai listed manufacturing enterprises?

To answer the fifth sub-research question hypothesis 5 is addressed with respect to a review of the literature in Chapter 3 as follows:

Hypothesis 5: *Managerial ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

There is strong evidence from the SFA and DEA estimation approaches that managerial ownership has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises, and this result is consistent with the finding of Liao et al. (2010). This indicates managerial ownership can help align the conflict of interests between shareholders and managers, and, therefore, the agency problem is reduced as suggested by Jensen and Meckling (1976). In other words, this result implies that managers, who receive direct benefits from the firm through dividends relative to the level of their cash flow or voting rights, are likely to monitor the firm carefully and effectively. On the other hand, managers who do not hold any ownership over a firm's cash flow or voting stocks lack the incentive to monitor the firm effectively, since they do not participate in profit sharing in the form of dividends.

(6) What is the impact of "*executive remuneration*" on the technical efficiency of Thai listed manufacturing enterprises?

Hypothesis 6 is developed from a review of the literature in Chapter 3 so as to answer the sixth sub-research question as follows:

Hypothesis 6: *Executive remuneration has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*

The empirical results from both estimation approaches reveal that executive remuneration has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises. This result indicates that listed manufacturing firms with higher levels of executive remuneration tend to be more technically efficient, since the amount of bonuses or increased salaries that executives (e.g., board of directors and managers) will receive is based upon the firm's annual performance (e.g., net profits). In some listed firms the amount of executive remuneration (e.g., bonuses) is based on the percentage of the firm's annual net profits. Therefore, there is a strong incentive for them to control input costs and maximize the firm's net profit. This finding is also consistent with the empirical results of Baek and Pagán (2002), and other empirical studies based on profitability and financial ratios as the measurement of a firm's performance (see Section 3.7, Chapter 3).

(7) Which "*types of owned firms*" (types of ownership) are more technically efficient ?

Hypothesis 7 is also developed from a review of the literature to answer the seventh sub research question as follows:

Hypothesis 7: *Foreign and family ownership have a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises; foreign-owned firms perform best in terms of technical efficiency relative to other ownership types for Thai listed manufacturing enterprises.*

There is strong evidence from both estimation approaches that foreign and family ownership exerts a significant and positive impact on the technical efficiency of Thai listed manufacturing enterprises. The reasons are that foreign ownership has superior technology, managerial expertise, good corporate governance and a strong foreign-market network (Kimura and Kiyota, 2007). Family ownership normally provides good monitoring over the firm since the close relationship among family members within the firm can reduce the agency problem as suggested by Fama and Jensen (1983). With respect to the magnitude of the estimated coefficients for each type of owned-firm, there is strong evidence from both estimation approaches that foreign-owned firms perform the best for Thai listed manufacturing enterprises, followed by family-owned firms, hybrid-owned firms and domestic-owned firms, given joint-owned firms as the base category. Focusing on foreign ownership the empirical evidence from hypothesis 7 is also consistent with many of the empirical studies (see Section 3.5.2, Chapter 3). For family ownership the empirical evidence is also similar with the empirical results of Yammeesri and Lodh (2003) and Wiwattanakantang (2001), except they measured a firm's performance based on profitability and financial ratios.

(8) How does "*exporting*" influence the technical efficiency performance of Thai listed manufacturing enterprises?

(9) What is the impact of "*technical efficiency*" on the export participation of Thai listed manufacturing enterprises?

The eighth and ninth sub-research questions aim to empirically explore the existence of the learning-by-exporting hypothesis and the self-selection hypothesis for the case of Thai listed manufacturing enterprises. According to a review of the literature in Chapter 3, hypothesis 8 is set up in order to empirically test the outcomes from these sub research questions.

Hypothesis 8: *A firm's exports have a significant and positive association with its technical efficiency (the learning-by-exporting hypothesis exists); A firm's technical efficiency has a significant and positive effect on the export participation (the self selection hypothesis exists) of Thai listed manufacturing enterprises.*

There is strong evidence from both estimation approaches that exporting has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises. This result reveals the existence of a learning-by-exporting hypothesis, indicating that exporting firms are also likely to improve their technical efficiency due to their learning-by-exporting experience (i.e., new product designs and production methods). This evidence is also consistent with a number of empirical studies, as summarized and provided in Table 3.3 (see Section 3.8, Chapter 3). Vice versa, there is evidence that a firm's technical efficiency predicted by the SFA approach has a significant and positive effect on its export participation for Thai listed manufacturing enterprises. In other words the self-selection hypothesis exists for Thai listed manufacturing enterprises. This implies that only efficient firms can participate in foreign markets, since they can cover sunk start-up costs which are additional costs when exporting to foreign markets (e.g., transportation costs, marketing costs, or production costs in developing existing products) and compete with foreign enterprises. The positive effect of a firm's technical efficiency predicted by the DEA approach on its export participation is also found for Thai listed manufacturing enterprises, but it is not statistically significant. The positive evidence from the self-selection hypothesis is also consistent with other empirical studies as shown in Table 3.3 of Chapter 3 (see Section 3.8, Chapter 3).

(10) How do other firm-specific variables such as (i) government assistance, (ii) firm size, (iii) firm age, and (iv) foreign cooperation influence the technical efficiency of Thai listed manufacturing enterprises?

Besides the sub research questions 1 to 9, including hypotheses 1 to 8 mentioned above, the tenth sub-research question focussing on other firm specific and business environment factors is also developed from a review of the literature review in Chapter 3. They include (i) firm size, (ii) firm age, (iii) government assistance, and (iv) foreign cooperation. The empirical results from Chapter 6 reveal the effects of these factors on the technical efficiency of Thai listed manufacturing enterprises as follows.

(i) Firm size: There is strong evidence from both estimation approaches that firm size has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.

(ii) Firm age: The empirical results from both estimation approaches reveal that firm age has a positive impact upon the technical efficiency of Thai listed manufacturing enterprises, but only the empirical evidence from the SFA reveals a significant result. This positive result implies that a firm’s technical efficiency is enhanced through a learning-by-doing experience.

(iii) Government assistance: The association between government assistance and technical efficiency for Thai listed manufacturing enterprises is found to be inconclusive, since both estimation approaches indicate significant results but their coefficients have opposite signs (positive for the SFA and negative for the DEA).

(iv) Foreign cooperation: The empirical results from both estimation approaches indicate that foreign cooperation has a negative impact on the technical efficiency of Thai listed manufacturing enterprises, but only the empirical result obtained from the SFA approach is statistically significant.

(iii) How can the overall technical efficiency performance of Thai listed manufacturing enterprises be enhanced?

The third main research question aims to provide suggestions on how to enhance the technical efficiency of Thai listed manufacturing enterprises. The empirical results for all of the three main research questions, including sub-research questions as previously mentioned, can be adopted for the conduct of evidence-based policy implications and recommendations to answer this third main research question. Moreover, the eleventh sub research question is addressed in order to provide more supporting information for the third main research question as follows:

(11) How can policies initiated by the Stock Exchange of Thailand (SET) and the government, directly or via other government agencies, be made to improve the efficiency and competitiveness of Thai listed manufacturing enterprises?

This thesis has provided policy implications and recommendations based on the empirical evidence obtained for the first and second main research questions, including hypotheses 1 to 8, as well as other selected firm specific factors (e.g., firm size and firm age) which significantly affect the technical efficiency of Thai listed manufacturing enterprises (see Chapter 7).

With respect to the empirical evidence obtained for the first main question, although the efficiency performance of Thai listed manufacturing enterprises is high they have relied on labour-intensive or low value adding production activities. These results also support the recommendations of World Bank-Thailand (2008) that measures to enhance productivity and competitiveness over the long term in all sectors (agriculture, industry, and services) are urgently needed. Therefore, Thai listed manufacturing firms are required to move up to a higher production frontier to enhance their future technical efficiency performance. The government, via the BOI, can play an important role in promoting productive investments for Thai listed manufacturing firms, such as upgrading their production technology and participating in higher value-adding production activities. In practice, the BOI introduced measures after 4th March 2009 to encourage investors to improve their production along with an increase in their revenues and the maintenance of their employment (The Board of Investment, 2010a). The BOI can, therefore, promote the privileged participation of Thai listed manufacturing firms which are interested in launching new products and upgrading their production technology. The SET can also assist the productive investments of Thai listed manufacturing firms, by facilitating fundraising which is to be specifically used for their productive investments.

Focusing on the empirical results for the second main research question based on hypothesis 1, listed manufacturing firms which have high leverage are likely to have high technical efficiency. This can imply that they control input costs and use financial resources effectively. Moreover, it is possible that listed manufacturing firms which have high leverage might be investing in capital intensive projects which require a large capital investment. Vice versa, listed manufacturing firms which have more liquidity, tend to have low technical efficiency. Therefore, the SET can help promote productive investments for Thai listed manufacturing firms by facilitating fundraising for their productive investments (see hypothesis 2, Section 7.2). The SET can help promote foreign and local investment in Thai listed manufacturing enterprises which prefer to invest in productive investment projects. The government, via the BOI, can help promote productive investments for Thai listed manufacturing firms. It is a good opportunity for Thai listed manufacturing enterprises to participate in BOI financial and non-financial privileges.

The empirical evidence for hypothesis 2 indicates that internal financing has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises, while external financing does not exert an important impact on technical efficiency due to a small estimated coefficient (close to zero). More importantly, it is not possible for Thai listed manufacturing enterprises to use only external or internal financing. Therefore, internal financing transactions should be fully disclosed to avoid an agency problem, as managers may use internal funds for their own interests or they may fail to maximize shareholders' benefits. Focusing on external financing, the reason why the use of external financing has a significant and negative impact on the technical efficiency of Thai listed manufacturing enterprises is that they are obligated to pay different interest payments relative to the amount of their loans and current economic conditions (e.g., financial institutions normally prefer to provide a floating interest rate which can be altered according to (i) interest rates announced by the Bank of Thailand and (ii) financial costs of each financial institution). Thus, the fluctuation of interest rates charged by financial institutions also directly impacts the cost of production of firms (or the input cost in firm production) and, therefore, may adversely affect the competitiveness and efficiency of Thai listed manufacturing firms. The use of external financing through loans also causes the obligation for Thai listed manufacturing firms to pay principle and interest to debtors on time. Furthermore, there is the possibility that Thai listed manufacturing firms may face financial difficulties, but they are forced to pay principle and interest to creditors. In this regard, they might not be able to use limited financial resources for their daily working capital. As a result this may also reduce the technical efficiency performance of Thai listed manufacturing firms. However, this negative effect is very small due to the very small magnitude of the estimated external financing coefficient (close to zero).

The use of equity instruments can also be useful in obtaining external financing, which can be conducted by issuing new shares to (i) existing shareholders (rights offering), (ii) a specific group of strategic investors (private placement), and (iii) the public (public offering). This is because listed manufacturing firms only pay dividends to shareholders when they gain profits, and therefore this provides more flexibility compared with a loan repayment. More importantly, providing information for minority shareholders with respect to their roles and voting rights is very important to establish a checks and balances mechanism which can reduce the agency problem. In practice, an independent financial analyst is required to provide a third party comment on their financial activities which directly affect shareholders' benefits (e.g., issuing debentures or shares). The government, via the SEC, therefore, can play an important role in promoting the reliability of these financial analysts. Strong and prompt penalties on those financial analysts, including listed manufacturing firms, who are fraudulent, should be strengthened to ensure compatibility with international standards.

The empirical evidence suggests a significant and negative association between research and development (R&D) and technical efficiency for Thai listed manufacturing enterprises. This indicates that Thai listed manufacturing firms misleadingly report R&D activities in their annual reports (see hypothesis 3 in

Chapter 6). There are two reasons why most listed manufacturing firms are likely to report R&D activities as follows: (i) R&D and job training expenses, including expenditure on the provision of equipment for the disabled, are allowed to increase at 200 percent from actual expenses for the purpose of corporate income tax reduction; (ii) They aim to maintain a good public image. However, they lack serious implementation of these activities. As a result the government, including the SET, should monitor their R&D and training activities very closely, as the R&D section has not been required to be disclosed in the annual report (Form 56-1) since 2008.

The empirical evidence for hypotheses 4 and 5 suggests that both controlling and managerial ownership are found to have a significant and positive effect on the technical efficiency of Thai listed manufacturing firms. To avoid possible agency problems caused by controlling and managerial ownership, the SET should promote a good corporate governance system. Focusing on managerial ownership the "Employee Stock Option Program (ESOP)" should be promoted, as this can promote the participation of managerial ownership However, the ESOP may cause control and price dilutions for existing shareholders. Minority shareholders play an important role in the monitoring of listed manufacturing firms' operations, and therefore knowledge of the roles and voting rights of minority shareholders should be promoted as this can establish a checks and balances mechanism between listed manufacturing firms' management and shareholders (see minority shareholders' voting rights in Section 7.5, Chapter 7).

The empirical evidence for hypothesis 6 indicates that executive remuneration has a significant and positive impact on the technical efficiency of Thai listed manufacturing firms. As a result, attractive executive remunerations based on the firm's performance should be promoted. Executive remuneration can be provided in a number of ways such as (i) salary, (ii) employee benefits and perquisites, and (iii) short-term incentives (e.g., bonus), and (iv) long-term incentives (e.g., stock options) (Ellig, 2002, p5). For any listed manufacturing enterprise a compensation committee should be established, and the members of the compensation committee should be completely independent from management. In addition, executive remuneration should be based on a listed manufacturing firm's financial performance. Available director compensation surveys or comments from a consulting firm should be considered as the benchmark, as these can help protect unreasonable executive compensation for Thai listed manufacturing firms. Finally, providing information for minority shareholders with respect to their roles and voting rights over Thai listed manufacturing enterprises is also very important, since executive remuneration must ultimately be approved by Thai listed manufacturing firms' shareholders.

The empirical evidence for hypothesis 7 indicates that foreign-owned firms perform the best, followed by family-owned firms and other types of firm ownership Therefore, foreign and family ownership should be promoted for Thai listed manufacturing firms. Foreign shareholding limits can be relaxed up to 100 percent if Thai listed and non-listed manufacturing firms are not in any of the three lists of prohibited businesses, and have been approved by the BOI. To legally increase the foreign ownership of Thai listed manufacturing enterprises, the BOI's privileges should be promoted. Alternatively, Non-Voting Depository Receipts (NVDRs) can be useful to avoid the foreign shareholding limit in the case where Thai listed manufacturing firms are not eligible to receive BOI privileges.

The most difficult task, however, is how to promote the confidence of foreign investors to invest in securities of Thai listed manufacturing firms. Hence, good corporate governance among Thai listed manufacturing enterprises should be strengthened. Accounting and auditing best practices, including rules and responsibilities of boards of directors, should be continuously strengthened to be in line with international standards. To promote family ownership Thai small and medium sized enterprises (SMEs) can be a potentially targeted group, since they are mostly operated by family members. They, however, prefer not to be listed in the SET, since they are afraid of losing their control and following SET and SEC rules and regulations. All information regarding how they can benefit from being listed in the SET and required procedures and criteria, should be fully disclosed. Family owned firms, however, may cause an agency problem, since they may implement policies which are beneficial to themselves (see Section 3.5.2, Chapter 3). Good corporate governance among family owned firms should be strengthened to avoid an agency problem as previously discussed.

The empirical evidence for hypothesis 8 (learning-by-exporting and self-selection hypotheses) indicates the existence of learning-by-exporting, implying that exporting helps improve the technical efficiency of Thai listed manufacturing enterprises. Therefore, the government should play an important role in promoting exporting for Thai listed manufacturing enterprises as well as other non-listed manufacturing firms, by implementing adequate policies, such as foreign trade policy as well as other policies (e.g., national development plans, monetary policy, fiscal policy, production and price controls, private investment regimes, and foreign exchange policy). More specifically, foreign trade policy which includes (i) trade promotion (e.g., export promotion and import regulation), (ii) trade development infrastructure (e.g., trade facilitation regulation, trade finance, and trade enterprises), and (iii) international trade relations (e.g., bilateral relations, international trade forums, and regional trade) as summarized in Figure 7.1 of Chapter 7 should be strengthened (see ESCAP, 2001).

A number of government agencies such as the Department of Export Promotion (DEP), the Board of Investment (BOI), Export and Import Bank of Thailand (EXIM Bank) also play a crucial role in promoting the government's foreign trade policy. With respect to the existence of the self-selection hypothesis, only efficient listed manufacturing firms are likely to participate in foreign markets due to high sunk costs arising from exporting and high competition in foreign markets. The efficiency and competitiveness of Thai listed manufacturing firms, therefore, should be strengthened. A number of firm-specific and business environment factors, which have been found to have a significant and positive impact on the technical efficiency of Thai listed manufacturing firms, can be promoted, such as (i) an increase in firm size, (ii) more controlling and managerial ownership, (iii) more foreign and family ownership participation, and (iv) attractive executive remuneration. Furthermore, strengthening good corporate governance, providing knowledge for minority shareholders, and improving the production technology should be focused upon for Thai listed manufacturing enterprises.

Besides the empirical evidence for hypotheses 1 to 8, increased firm size and firm age can improve the technical efficiency of Thai listed manufacturing firms and assist their participation in foreign markets. Therefore, the SET and SEC can promote an increase in firm size for Thai listed manufacturing enterprises. For example, fundraising used for productive investments (e.g., upgrading their production technology or participating in higher value-adding production activities) should be promoted and facilitated. In addition, listed manufacturing firms in the MAI can be encouraged to be listed in the SET if they meet the SET's listing criteria. Focusing on firm age, the SET and SEC can encourage long established manufacturing firms to be listed in the SET, but they need to be selective based on their ongoing operating performance. In addition, young listed manufacturing firms may lack sufficient operational experience, financial resources, networking, and product reputation (brand name). As a result, policies which aim to help young listed manufacturing firms to enhance their technical efficiency and participate in foreign markets are also necessary, such as (i) promoting cross-learning between young firms and old firms, (ii) providing business training for young firms, (iii) providing tax holiday[133] for young firms, and (iv) attracting foreign direct investment.

In conclusion, the SET and the government, via a number of government agencies (e.g., the Office of Securities and Exchange Commission (SEC), the Board of Investment of Thailand (BOI), the Department of Export Promotion (DEP), the Revenue Department (RD), the Department of Business Development (DBD), and the Export and Import Bank of Thailand (EXIM bank)), can play an important role in enhancing the technical efficiency of Thai listed manufacturing firms through a number of policy implementations and recommendations as summarized in Table 7.5 of Chapter 7. The SET and SEC should continuously promote good corporate governance among Thai listed manufacturing enterprises, in line with international corporate governance standards, through (i) reliable and transparent disclosure of Thai listed manufacturing enterprises' information, (ii) adoption of the institutional framework for best accounting and auditing practices, (iii) adequate rules and responsibilities of board of directors, and (iv) prompt and strong punishment for illegal activities caused by Thai listed manufacturing firms including other related parties (e.g., financial analysts).

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[133] In Thailand, tax holiday currently refers to tax privileges that firms obtained from the Board of Investment (BOI).

Moreover, the SET and SEC should (i) pay close attention to Thai listed manufacturing enterprises' transactions affecting the firm's shareholders so as to ensure compliance with their rules and regulations as well as international corporate governance standards, (ii) provide training courses related to updated rules and regulations for newly and existing listed manufacturing enterprises, including related parties, and (iii) facilitate fundraising of Thai listed manufacturing enterprises to be used for productive investment (e.g., upgrading production technology and developing new products). These policy implications and recommendations, therefore, are important in improving the technical efficiency performance of Thai listed manufacturing firms. More importantly, providing information for minority shareholders regarding their roles and voting rights is very important for a checks and balances mechanism, to avoid an agency problem, since Thai listed manufacturing enterprises' transactions, which directly affect companies and shareholders' benefits, must be approved by shareholders in the shareholders' meeting.

Minority shareholders, therefore, can play an important role in closely monitoring any agenda proposed by the company's management, and appointing an inspector(s) to investigate the company's operations and financial status. Other government agencies, especially the BOI, can also play an important role in promoting (i) the performance of Thai listed manufacturing enterprises, (ii) foreign investment participation, (iii) exporting of Thai listed manufacturing enterprises, and (iv) serious R&D participation of Thai listed manufacturing enterprises. The government can encourage Thai listed manufacturing enterprises, as well as foreign companies, to participate in production and product improvement as well as productive investment, for example, by providing BOI financial and non-financial privileges. They can be useful for the recommendation of hypothesis 1 (leverage and liquidity), hypothesis 3 (R&D), hypothesis 7 (foreign and family ownership), and hypothesis 8 (exporting). All of the policy implications and recommendations have been summarized and provided in Table 7.5 of Chapter 7. All of the main research questions, sub-research questions, hypotheses and major conclusions are summarized in Table 8.1.

Table 8.1: Summary of main research and sub-research questions, hypotheses, and conclusions

Main research and sub-research questions	Hypotheses / Conclusions	
(i) How do Thai listed manufacturing enterprises perform in terms of technical efficiency?	• The mean Technical efficiency (TE) scores obtained from the SFA and DEA are 0.812 and 0.877, respectively (see Table 6.14, Chapter 6). • Thai listed manufacturing firms operated under decreasing returns to scale (DRS). - For the SFA approach the production returns to scale is 0.9187, indicating DRS (see Table 6.9, Chapter 6). - The DEA approach also suggests that approximately 86 percent of Thai listed manufacturing enterprises, on average, operated under decreasing returns to scale (see Table 6.15, Chapter 6). • The technical progress of Thai listed manufacturing enterprises had relied on labour input, over the period 2000 to 2008 (see Table 6.7, Chapter 6). • The rate of technical progress was 0.0205, indicating that it increased at 2.05 percent per year (see Table 6.9, Chapter 6). • The above findings are consistent in concluding that Thai listed manufacturing firms have relied on labour-intensive or low value added production activities, and, therefore, are required to move up to a higher production frontier.	
(ii) Which factors significantly contribute to the technical efficiency performance of Thai listed manufacturing enterprises?		
Sub research questions for question (ii):		
(1) How do "financial constraints (leverage) and liquidity" impact on the technical efficiency of Thai listed manufacturing enterprises?	**Hypothesis 1:** *Financial constraints (leverage) have a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises. Vice versa, the more liquidity the lower is the technical efficiency of Thai listed manufacturing enterprises.*	• Both the SFA and DEA approaches reveal that financial constraints (leverage) has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises. Vice versa, the empirical evidence from both estimations also reveal that liquidity has a significant and negative effect on the technical efficiency of Thai listed manufacturing enterprises (see Tables 6.11, 6.13, 6.17, Chapter 6).
(2) Which types of *"source of finance (internal or external financing)"* significantly affect the technical efficiency of Thai listed manufacturing enterprises?	**Hypothesis 2:** *External financing has a significant and positive relationship with a firm's technical efficiency for Thai listed manufacturing enterprises. Vice versa, internal financing has a significant and negative effect on a firm's technical efficiency for Thai listed manufacturing enterprises.*	• The empirical evidence from the SFA approach suggests that external financing has a significant and negative association with the technical efficiency of Thai listed manufacturing enterprises, which is opposite to the statement of this hypothesis. A negative relationship is also found from the DEA approach, but it is not statistically significant (see Tables 6.11, 6.13, 6.17, Chapter 6).

Main research and sub-research questions	Hypotheses / Conclusions	
		• This negative finding, however, does not exert a significant impact on the technical efficiency of Thai listed manufacturing enterprises, since the magnitude of the estimated "external financing" coefficient is very small (close to zero) (see Tables 6.11, 6.13, 6.17, Chapter 6).
(3) How does "*research and development (R&D)*" affect the technical efficiency of Thai listed manufacturing enterprises?	**Hypothesis 3**: *Research and development (R&D) has a significant and positive relationship with the technical efficiency of Thai listed manufacturing enterprises.*	• The empirical results from both estimation approaches reveal that research and development (R&D) has a significant and negative association with the technical efficiency of Thai listed manufacturing enterprises. This result is different from the expected positive result for this hypothesis (see Tables 6.11, 6.13, 6.17, Chapter 6).
(4) How does "*controlling ownership (concentrated ownership)*" influence the technical efficiency of Thai listed manufacturing enterprises?	**Hypothesis 4:** *Controlling ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*	• The empirical evidence from the SFA approach obtained from Chapter 6 reveals that controlling ownership has a significant and positive impact on the technical efficiency of Thai listed manufacturing firms. A positive result is also found from the DEA approach, but it is not statistically significant (see Tables 6.11, 6.13, 6.17, Chapter 6).
(5) How does "*managerial ownership*" impact on the technical efficiency of Thai listed manufacturing enterprises?	**Hypothesis 5:** *Managerial ownership has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*	• There is strong evidence from the SFA and DEA estimation approaches that managerial ownership has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises (see Tables 6.11, 6.13, 6.17, Chapter 6).
(6) What is the impact of "*executive remuneration*" on the technical efficiency of Thai listed manufacturing enterprises?	**Hypothesis 6:** *Executive remuneration has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises.*	• The empirical results from both estimation approaches reveal that executive remuneration has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises (see Tables 6.11, 6.13, 6.17, Chapter 6).
(7) Which "*types of owned firms (types of ownership)*" are more technically efficient?	**Hypothesis 7:** *Foreign and family ownership have a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises; foreign-owned firms perform best in terms of technical efficiency relative to other ownership types for Thai listed manufacturing enterprises.*	• There is strong evidence from both estimation approaches that foreign and family ownership exerts a significant and positive impact on the technical efficiency of Thai listed manufacturing enterprises.

Main research and sub-research questions	Hypotheses / Conclusions	
		• With respect to the magnitude of the estimated coefficients for each type of owned-firm, there is strong evidence from both estimation approaches that foreign-owned firms perform the best, followed by family-owned firms, hybrid-owned firms and domestic-owned firms, given joint-owned firms as the base category (see Tables 6.11, 6.13, 6.17, Chapter 6).
(8) How does "*exporting*" influence the technical efficiency performance of Thai listed manufacturing enterprises? (9) What is the impact of "*technical efficiency*" on the exporting participation of Thai listed manufacturing enterprises?	**Hypothesis 8:** *A firm's exports have a significant and positive association with its technical efficiency (the learning by exporting hypothesis exists); A firm's technical efficiency has a significant and positive effect on its export participation (the self selection hypothesis exists) for Thai listed manufacturing enterprises.*	• There is strong evidence from both estimation approaches that exporting has a significant and positive association with the technical efficiency of Thai listed manufacturing enterprises. • Vice versa, there is evidence that a firm's technical efficiency predicted by the SFA approach has a significant and positive effect on its export participation for Thai listed manufacturing enterprises (see Tables 6.11, 6.13, 6.17, Chapter 6).
(10) How do other firm-specific variables such as (i) government assistance, (ii) firm size, (iii) firm age, and (iv) foreign cooperation influence the technical efficiency of Thai listed manufacturing enterprises		• Firm size: There is strong evidence from both estimation approaches that firm size has a significant and positive effect on the technical efficiency of Thai listed manufacturing enterprises (see Tables 6.11, 6.13, 6.17, Chapter 6). • Firm age: The empirical results from both estimation approaches reveal that firm age has a positive impact on the technical efficiency of Thai listed manufacturing enterprises, but only the empirical evidence from the SFA reveals a significant result. (see Tables 6.11, 6.13, 6.17, Chapter 6). • Government assistance: The association between government assistance and technical efficiency for Thai listed manufacturing enterprises is found to be inconclusive, since both estimation approaches reveal significant results but their coefficients are opposite (positive for the SFA and negative for the DEA) (see Tables 6.11, 6.13, 6.17, Chapter 6).

Main research and sub-research questions	Hypotheses / Conclusions
	• Foreign cooperation: The empirical results from both estimation approaches indicate that foreign cooperation has a negative impact on the technical efficiency of Thai listed manufacturing enterprises, but only the empirical result obtained from the SFA approach is statistically significant (see Tables 6.11, 6.13, 6.17, Chapter 6).
(iii) How can the overall technical efficiency performance of Thai listed manufacturing enterprises be enhanced? **Sub research question for (iii):** (11) How can policies initiated by the Stock Exchange of Thailand (SET) and the government, directly or via other government agencies, be made to improve the efficiency and competitiveness of Thai listed manufacturing enterprise?	• The SET and the government, via a number of government agencies (e.g., the Office of Securities and Exchange Commission (SEC), the Board of Investment of Thailand (BOI), the Department of Export Promotion (DEP), the Revenue Department (RD), the Department of Business Development (DBD), and the Export and Import Bank of Thailand (EXIM bank)), can play an important role in enhancing the technical efficiency of Thai listed manufacturing firms through a number of policy implementations and recommendations, as summarized in Table 7.5 of Chapter 7. • The SET and SEC should continuously promote good corporate governance among Thai listed manufacturing enterprises, in line with international corporate governance standards, through (i) reliable and transparent disclosure of Thai listed manufacturing enterprises' information, (ii) adoption of the institutional framework for best accounting and auditing practices, (iii) adequate rules and responsibilities of board of directors, and (iv) prompt and strong punishment for illegal activities caused by Thai listed manufacturing firms including other related parties (e.g., financial analysts). • Moreover, the SET and SEC should (i) pay close attention to Thai listed manufacturing enterprises' transactions affecting the firm's shareholders, so as to ensure compliance with their rules and regulations as well as international corporate governance standards, (ii) provide training courses related to updated rules and regulations for newly and existing listed manufacturing enterprises, including related parties, and (iii) facilitate the fundraising of Thai listed manufacturing enterprises, to be used for productive investment (e.g., upgrading production technology and developing new products). • More importantly, provide information for minority shareholders regarding their roles and voting rights is very important for a checks and balances mechanism, to avoid an agency problem, since Thai listed manufacturing enterprises' transactions, which directly affect companies and shareholders' benefits must be approved by shareholders in the shareholders' meeting. • Other government agencies, especially the BOI, also play an important role in promoting (i) the performance of Thai listed manufacturing enterprises, (ii) foreign investment participation, (iii) exporting of Thai listed manufacturing enterprises, and (iv) serious R&D participation of Thai listed manufacturing enterprises. The government can encourage those Thai listed manufacturing enterprises as well as foreign companies to participate in their production and product improvement as well as productive investment, for example, by providing BOI financial and non-financial privileges.

8.3 Limitations and further studies

This thesis has provided an analysis of the technical efficiency performance of Thai listed manufacturing enterprises. This thesis, however, has research limitations which need to be addressed in future research. The empirical analysis of this thesis is also limited to the post Asian financial crisis period, between 2000 and 2008. It would be more interesting if this study compared the technical efficiency performance between the pre and post Asian financial crisis. However, data before 1996 is not available, since listed companies have only been required to submit their annual reports since 1996. Even though the listed companies' annual reports have been available since 1996, the structure of their annual reports during 1999 to 2000 were not consistent. The reports do not provide enough information to conduct the empirical analysis conducted in this thesis, which covers all important firm-specific and business environment factors necessary for evaluation of the technical efficiency improvement of Thai listed manufacturing enterprises.

This study is unique as it is the first to examine the technical efficiency performance of Thai listed manufacturing enterprises. A sample of 178 Thai listed manufacturing enterprises covering the period 2000 to 2008 was used to compile a unique database for these firms. For future research it is also interesting to examine the technical efficiency performance of Thai non-listed manufacturing enterprises as well as Thai manufacturing small and medium sized enterprises (SMEs), which were not included in the study, as these are beyond the scope of the study.

Data availability is also a further limitation of this study, as this affects the choice of different proxies for the variables used to conduct the empirical analysis of this thesis. For example, the use of R&D expenditure is much more appropriate that a dummy R&D variable, since it can capture the level of R&D concentration for each Thai listed manufacturing enterprise. Most Thai listed manufacturing enterprises do not report their R&D expenditure, as they only describe their R&D activities with the objective of generating a good public image. Therefore, a dummy for R&D was used instead to conduct the empirical analysis for hypothesis 3.

With respect to the evidence of rent-seeking in Thailand the connection between large family-owned firms and politicians has been documented in a number of articles. Doner and Ramsay (2002, p187) stated that "*Systematic government policy bias favouring large firms and a few entrepreneurs is also evident in industrial policy*".

Doner and Ramsay (2002, p158) also stated that "*Several families who established leading textile firms between 1946 and 1960 were still among the major textile groups in the late 1970s. Their early political connections gave them advantages which they parlayed into joint ventures with Japanese companies (e.g. the Adireksan, Bhotiranankun, Sinpatanasakul, and Assakul families*)".

Rock (2002, p188) also mentioned that "*As in the banking sector, the effect of this bias has been the domination of Thai industry by large firms combined into a small number of family-centred conglomerates. By the early 1980s, large firms constituted a mere 1.6 percent of all industrial establishments, but owned 54 percent of all industrial assets and accounted for 41 percent of industrial employment. These large firms were overwhelmingly controlled by a small number of family-owned conglomerates*".

Phongpaichit and Baker (2001, p229) also pointed out that "*Corruption of this sort was not new. But the boom economy made the sums larger. And the shift of power from bureaucracy to business changed the beneficiaries. For many Bangkokians, both businessman and bureaucrat, the provincial politicians seemed greedy upstarts. They had been pulled into politics as an extension of their business interests*".

A study on how large family-owned firms gain advantages from their political connections which then affect their business performance is worth further examination. However, this is beyond the scope of this thesis due to the limitation of data sources.

Focusing on productivity and efficiency techniques the "bootstrap" technique is also of interest, such as the two-stage double-bootstrap Data Envelopment Analysis (DEA) as developed by Simar and Wilson (2007). This could be considered for future research. Focusing on the SFA approach, a meta-frontier production function model introduced by Battese et al. (2004) could also be considered for future research since the metafrontier model can be used to calculate comparable technical efficiencies for firms with different production technologies. However, this technique does not allow for the effects of business environment and firm-specific factors on a firm's technical efficiency.

In addition, the analysis of international comparative technical efficiency performance should be also conducted for further research. In conclusion, all of these recent research studies are worthy of being considered but they are beyond the scope of this thesis, and, therefore, have been left for future research.

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Appendix 1.1: The characteristics of selected firm-specific factors for the top 10 best manufacturing firms in 2008

Security Name	Company Name	Sub-Sector	TE Score	Ownership Type	Executive Pay (%)	Control. Own. (%)	Managerial Own. (%)	D/A Ratio	Current Ratio	Export (%)	FDI (%)
					Selected Firm-Specific Factors						
All Manufacturing											
TCCC	Thai Central Chemical Plc.	3.5	0.955	Foreign	7.71	89.91	0.00	0.70	1.15	4.56	46.08
AMC	Asia Metal Plc.	3.2	0.948	Family	15.45	58.82	37.82	0.33	1.83	5.00	0.00
GC	Global Connections Plc.	3.5	0.945	Hybrid	50.25	63.42	71.79	0.55	1.48	2.00	0.00
CTW	Charoong Thai Wire & Cable Plc.	3.2	0.938	Foreign	13.83	61.27	2.53	0.44	1.71	15.24	45.62
IRP	Indorama Polymers Plc.	3.5	0.935	Foreign	10.56	82.61	0.06	0.75	0.85	94.00	22.98
LHK	Lohakit Metal Plc.	3.2	0.931	Family	23.49	72.17	11.26	0.54	1.47	6.00	0.00
TCB	Thai Carbon Black Plc.	3.5	0.930	Foreign	12.05	55.19	0.37	0.15	2.86	46.00	43.29
SSSC	Siam Steel Service Center Plc.	3.2	0.927	Hybrid	6.64	65.84	4.29	0.69	1.06	0.00	45.36
SPG	The Siam Pan Group Plc.	3.1	0.925	Family	22.83	74.98	50.74	0.09	9.10	48.68	18.00
PERM	Permsin Steel Works Plc.	3.2	0.920	Family	37.33	64.39	54.91	0.54	1.24	0.00	0.00
	Average		**0.935**		**20.01**	**68.86**	**23.38**	**0.48**	**2.28**	**22.15**	**22.13**
(1) Agro & Food Industry											
STA	Sri Trang Argo-Industry Plc.	1.1	0.908	Family	7.40	54.25	42.56	0.64	0.92	79.30	5.06
TUF	Thai Union Frozen Products Plc.	1.2	0.907	Family	1.26	32.19	32.87	0.59	1.78	90.77	34.43
PPC	Pak Food Plc.	1.1	0.903	Family	2.74	63.56	80.76	0.76	0.90	95.00	0.00
SSC	Serm Suk Plc.	1.2	0.896	Foreign	4.98	59.41	7.04	0.33	1.81	0.00	18.59
ASIAN	Asian Seafoods Coldstorage Plc.	1.1	0.894	Family	2.73	66.51	56.22	0.69	0.94	81.00	0.00
CPF	Charoen Pokphand Foods Plc.	1.1	0.891	Family	1.13	48.58	0.71	0.58	0.01	32.67	17.83
SSF	Surapoon Foods Plc.	1.1	0.888	Family	4.03	68.34	63.70	0.25	2.08	91.19	3.49
CHOTI	Kiang Huat Sea Gull Trading Plc.	1.1	0.884	Family	3.06	62.68	36.76	0.22	3.54	98.54	19.40
GFPT	GFPT Plc.	1.1	0.882	Family	2.34	57.12	52.16	0.50	0.83	24.57	3.32
RANCH *	Bangkok Ranch Plc.	1.1	0.880	Foreign	8.59	97.25	0.80	0.58	1.21	45.00	48.25
	Average		**0.893**		**3.83**	**60.99**	**37.36**	**0.51**	**1.40**	**63.80**	**15.04**
(2) Consumer Products											
SIAM	Siam Steel International Plc.	2.2	0.878	Joint	5.53	77.86	33.90	0.26	2.32	25.47	16.66
DSGT	DSG International (Thailand) Plc.	2.3	0.870	Foreign	15.09	85.69	4.60	0.41	1.71	46.15	73.30
SUC	Saha-Union Plc.	2.1	0.865	Family	1.75	32.54	3.68	0.26	1.74	45.61	2.40
SABINA	Sabina Plc.	2.1	0.860	Family	7.54	87.28	74.60	0.29	2.58	49.09	0.00
PRANDA	Pranda Jewellery Plc.	2.1	0.851	Family	3.08	43.26	26.83	0.34	2.74	50.74	24.51
PAF	Pan Asian Footwear Plc.	2.1	0.845	Family	0.87	55.27	3.81	0.65	0.80	80.44	1.84
OGC	Ocean Glass Plc.	2.2	0.843	Family	14.38	60.09	7.82	0.46	2.11	74.82	6.37
BATA*	Bata (Thailand) Plc.	2.1	0.837	Foreign	9.98	90.55	0.64	0.44	1.49	3.80	85.70
S & J	S&J International Enterprises Plc.	2.3	0.829	Family	6.79	56.70	11.38	0.36	1.10	33.36	0.77
SITHAI	Srithai Superware Plc.	2.2	0.827	Hybrid	4.78	33.65	26.67	0.32	1.49	3.58	14.62
	Average		**0.851**		**6.98**	**62.29**	**19.39**	**0.38**	**1.81**	**41.31**	**22.62**
(3) Industries											
TCCC	Thai Central Chemical Plc.	3.5	0.955	Foreign	7.71	89.91	0.00	0.70	1.15	4.56	46.08
AMC	Asia Metal Plc.	3.2	0.948	Family	15.45	58.82	37.82	0.33	1.83	5.00	0.00
GC	Global Connections Plc.	3.5	0.945	Hybrid	50.25	63.42	71.79	0.55	1.48	2.00	0.00
CTW	Charoong Thai Wire & Cable Plc.	3.2	0.938	Foreign	13.83	61.27	2.53	0.44	1.71	15.24	45.62
IRP*	Indorama Polymers Plc.	3.5	0.935	Foreign	10.56	82.61	0.06	0.75	0.85	94.00	22.98
LHK	Lohakit Metal Plc.	3.2	0.931	Family	23.49	72.17	11.26	0.54	1.47	6.00	0.00
TCB	Thai Carbon Black Plc.	3.5	0.930	Foreign	12.05	55.19	0.37	0.15	2.86	46.00	43.29
SSSC	Siam Steel Service Center Plc.	3.2	0.927	Hybrid	6.64	65.84	4.29	0.69	1.06	0.00	45.36
SPG	The Siam Pan Group Plc.	3.1	0.925	Family	22.83	74.98	50.74	0.09	9.10	48.68	18.00
PERM	Permsin Steel Works Plc.	3.2	0.920	Family	37.33	64.39	54.91	0.54	1.24	0.00	0.00
	Average		**0.935**		**20.01**	**68.86**	**23.38**	**0.48**	**2.28**	**22.15**	**22.13**
(4) Other Sectors											
CCET	Cal-Comp Electronics (Thailand)	6	0.915	Foreign	1.49	76.45	2.22	0.75	1.13	95.41	2.96
DELTA	Delta Electronics (Thailand) Plc.	6	0.905	Foreign	0.34	75.60	2.60	0.37	2.31	35.01	0.87
VNG	Vanachai Group Plc.	5	0.884	Family	6.31	55.99	18.99	0.63	2.48	60.50	3.36
SVI	SVI Plc.	6	0.883	Foreign	8.99	72.67	3.36	0.33	2.63	95.60	0.97
METCO	Muramoto Electron (Thailand) Plc.	6	0.882	Foreign	1.23	75.33	2.54	0.36	1.95	54.08	0.91
APRINT	Amarin Printing and Publishing Plc.	4	0.871	Family	14.57	62.31	47.61	0.18	2.95	0.00	9.26
HANA	HANA Microelectronics Plc.	6	0.870	Foreign	1.09	44.47	15.44	0.13	4.40	53.44	2.01
TYM	Thai Yuan Metal Plc.	5	0.862	Family	22.08	56.75	49.25	0.46	1.89	0.00	0.00
TSTH	Tata Steel (Thailand) Plc.	5	0.861	Foreign	9.82	77.36	0.02	0.29	4.35	8.50	76.16
PAP	Pacific Pipe Plc.	5	0.856	Family	23.18	66.06	23.65	0.30	1.78	7.00	0.00
	Average		**0.879**		**8.91**	**66.30**	**16.57**	**0.38**	**2.59**	**40.95**	**9.65**

Source: Author's estimates

Note: * These companies decided not to be delisted from the SET after 2008; TE scores are predicted by the SFA approach.

Appendix 1.2: The characteristics of selected firm-specific factors for the top 10 least manufacturing firms in 2008

Security Name	Company Name	Sub-Sector	TE Score	Ownership Type	Executive Pay (%)	Control. Own. (%)	Managerial Own. (%)	D/A Ratio	Current Ratio	Export (%)	FDI (%)
					Selected Firm-Specific Factors						
All manufacturing											
TTL	TTL Industries Plc.	2.1	0.026	Joint	12.81	61.61	7.77	0.09	10.44	33.70	25.00
TONHUA	Tong Hua Communications Plc.	4	0.342	Family	17.95	65.08	44.59	0.04	10.15	0.00	0.00
FANCY	Fancy Wood Industries Plc.	2.2	0.367	Family	6.02	54.06	42.12	0.01	46.20	91.18	25.35
TPP	Thai Packaging & Printing Plc.	3.3	0.38	Hybrid	15.32	45.74	0.08	0.05	8.63	0.00	21.81
EIC	Electronics Industry Plc.	6	0.538	Family	20.95	69.18	4.35	0.02	28.67	90.63	3.11
TBSP	Thai British Security Printing Plc.	4	0.541	Domestic	8.55	84.39	1.08	0.15	3.68	0.00	0.00
BNC	The Bangkok Nylon Plc.	2.1	0.581	Hybrid	11.92	51.12	14.95	0.14	5.00	43.03	8.20
CM	Chiangmai Frozen Foods Plc.	1.1	0.583	Joint	20.03	46.38	11.01	0.06	9.78	81.70	26.24
DISTAR**	Distar Electric Corporation Plc.	3.1	0.584	Family	17.8	49.38	16.13	0.46	1.01	0.00	9.19
SAWANG	Sawang Export Plc.	2.1	0.596	Family	24.38	78.06	25.99	0.09	10.20	84.59	0.00
	Average				**15.57**	**60.50**	**16.81**	**0.11**	**13.38**	**42.48**	**11.89**
(1) Agro & Food Industry											
CM	Chiangmai Frozen Foods Plc.	1.1	0.583	Joint	20.03	46.38	11.01	0.06	9.78	81.70	26.24
APURE	Agripure Holdings Plc.	1.2	0.75	Hybrid	10.41	18.52	0	0.70	0.71	88.00	1.08
TRS	Trang Seafood Products Plc.	1.1	0.762	Family	17.94	50.83	46.4	0.86	0.38	89.60	0.00
TLUXE	Thailuxe Enterprises Plc.	1.1	0.767	Hybrid	20.37	32.34	13.25	0.17	2.91	5.93	13.39
PR	President Rice Products Plc.	1.2	0.784	Hybrid	17.43	55.22	23.65	0.10	1.35	33.49	5.89
TWFP	Thai Wah Food Products Plc.	1.2	0.804	Foreign	14.51	65.78	15.4	0.23	1.68	16.00	15.80
S&P	S&P Syndicate Plc.	1.2	0.816	Family	2.09	47.55	21.88	0.22	2.19	15.25	4.67
SORKON	S. Khonkaen Foods Plc.	1.2	0.816	Family	5.54	74.76	41.31	0.77	0.64	0.00	0.00
PRG	Patum Rice Mill and Granary Plc,	1.1	0.819	Domestic	13.08	94.11	0	0.33	0.93	14.57	0.00
PM	Premier Marketing Plc.	1.2	0.831	Family	8.64	70.97	0	0.45	1.01	35.58	1.54
	Average		**0.773**		**13.00**	**55.65**	**17.29**	**0.39**	**2.16**	**38.01**	**6.86**
(2) Consumer Products											
TTL	TTL Industries Plc.	2.1	0.026	Joint	12.81	61.61	7.77	0.09	10.44	33.70	25.00
FANCY	Fancy Wood Industries Plc.	2.2	0.367	Family	6.02	54.06	42.12	0.01	46.20	91.18	25.35
BNC	The Bangkok Nylon Plc.	2.1	0.581	Hybrid	11.92	51.12	14.95	0.14	5.00	43.03	8.20
SAWANG	Sawang Export Plc.	2.1	0.596	Family	24.38	78.06	25.99	0.09	10.20	84.59	0.00
CEI	Compass East Industry (Thailand) Plc.	2.2	0.652	Foreign	35.75	71.46	1.89	0.12	8.08	68.80	62.05
TTI	Thai Textile Industry Plc.	2.1	0.696	Joint	3.76	34.02	34.66	0.44	1.08	31.64	10.08
JCT	Jack Chia Industries Plc.	2.3	0.731	Family	22.79	59.61	22.89	0.08	6.83	0.34	0.00
PG	People's Garment Plc.	2.1	0.735	Family	9.93	55.10	5.48	0.12	5.76	12.28	0.59
WACOAL	Thai Wacoal Plc.	2.1	0.738	Joint	5.79	70.95	3.31	0.11	5.38	26.33	35.82
TOG	Thai Optical Group Plc.	2.3	0.742	Family	9.94	42.39	19.51	0.11	6.25	93.48	16.09
	Average		**0.586**		**14.31**	**57.84**	**17.86**	**0.13**	**10.52**	**48.54**	**18.32**
(3) Industries											
TPP	Thai Packaging & Printing Plc.	3.3	0.380	Hybrid	15.32	45.74	0.08	0.05	8.63	0.00	21.81
DISTAR**		3.1	0.584	Family	17.80	49.38	16.13	0.46	1.01	0.00	9.19
AMAC		3.2	0.673	Hybrid	7.16	50.45	41.02	0.55	1.50	24.32	8.36
TNPC	Thai Nam Plastic Plc.	3.1	0.707	Domestic	10.02	37.15	4.94	0.56	1.68	4.05	0.50
YCI	Yong Thai Plc.	3.5	0.747	Foreign	55.45	45.54	38.30	0.45	1.30	0.00	15.41
NIPPON	Nippon Pack (Thailand) Plc.	3.3	0.772	Family	44.21	73.81	49.21	0.13	4.41	0.00	2.64
TCJ	T.C.J. Asia Plc.	3.2	0.798	Family	10.48	59.04	0.19	0.46	1.22	0.40	0.00
NEP	NEP Realty and Industry Plc.	3.3	0.802	Domestic	30.17	58.00	0.78	0.28	0.39	0.00	6.87
CITY	City Steel Plc.	3.2	0.808	Family	15.35	65.66	52.86	0.05	11.16	1.64	0.00
UP	Union Plastic Plc.	3.5	0.830	Family	5.53	71.90	0.03	0.24	2.18	0.00	0.00
	Average		**0.710**		**21.15**	**55.67**	**20.35**	**0.32**	**3.35**	**3.04**	**6.48**
(4) Other Sectors											
TONHUA	Tong Hua Communications Plc.	4	0.342	Family	17.95	65.08	44.59	0.03	10.15	0.00	0.00
EIC	Electronics Industry Plc.	6	0.538	Family	20.95	69.18	4.35	0.02	28.67	90.63	3.11
TBSP	Thai British Security Printing Plc.	4	0.541	Domestic	8.55	84.39	1.08	0.15	3.68	0.00	0.00
TCMC	Thailand Carpet Manufacturing Plc.	5	0.622	Joint	9.1	62.25	31.51	0.35	1.66	52.33	27.16
AKR	Ekarat Engineering Plc.	6	0.642	Hybrid	0	35.56	16.23	0.61	1.20	5.90	1.53
KCE	KCE Electronics Plc.	6	0.667	Hybrid	2.74	25.63	3.98	0.75	0.48	99.35	3.15
EPCO	Eastern Printing Plc.	4	0.669	Hybrid	14.3	54.87	0.17	0.13	6.31	0.00	14.81
GEN	General Engineering Plc.	5	0.684	Hybrid	17.92	33.77	4.84	0.39	1.53	0.00	0.00
SUPER	Superblock Plc.	5	0.69	Family	13.44	53.05	45.52	0.50	0.77	1.51	0.00
SPPT	Single point Parts Plc.	6	0.728	Family	11.83	60.3	1.4	0.38	1.12	0.00	0.89
	Average		**0.612**		**11.68**	**54.41**	**15.37**	**0.33**	**5.56**	**24.97**	**5.06**

Source: Author's estimates

Note: * These companies decided not to be delisted from the SET after 2008; *AMAC has changed its name to Max Metal Corporation Plc. (MAX) on 27th May 2010; ** DISTAR has changed its name to Karmarts Plc. (KAMART) on 10th May 2011

Appendix 2: Spearman rank-order correlation test

All Thai listed manufacturing firms			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.562**
		Sig. (2-tailed)	.	0.000
		N	1309	1309
	DEA VRS	Correlation Coefficient	0.562**	1.000
		Sig. (2-tailed)	0.000	.
		N	1309	1309
(5) Agro & Food Industry sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.613**
		Sig. (2-tailed)	.	.
		N	323	323
	DEA VRS	Correlation Coefficient	0.613*	1.000
		Sig. (2-tailed)	0.000	.
		N	323	323
(6) Consumer Products sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.504**
		Sig. (2-tailed)	.	0.000
		N	252	252
	DEA VRS	Correlation Coefficient	0.504**	1.000
		Sig. (2-tailed)	0.000	.
		N	252	252
(7) Industrials sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.477**
		Sig. (2-tailed)	.	0.000
		N	397	397
	DEA VRS	Correlation Coefficient	0.477**	1.000
		Sig. (2-tailed)	0.000	.
		N	397	397
(8) Other Sectors sub-sector			**SFA**	**DEA VRS**
Spearman's rho	**SFA**	Correlation Coefficient	1.000	0.428**
		Sig. (2-tailed)	.	0
		N	337	337
	DEA VRS	Correlation Coefficient	0.428**	1.000
		Sig. (2-tailed)	0.000	.
		N	337	337

Source: Author's estimates

Note: ** Correlation is significant at the 0.01 level (2-tailed); See footnote 93 for the reason in conducting Spearman rank-order correlation test as shown in Appendix 2.

Appendix 3.1: The list of top 10 best and least Thai listed manufacturing firms in 2008

Name	Sub-Sector	TE Score	Own. Type	Major Shareholders									
				1st	%	2nd	%	3rd	%	4th	%	5th	%
The Top 10 Best Performers													
TCCC	3.5	0.955	Foreign	*Sojitz Corporation*	43.92	ISTS (Thailand) Co., Ltd.	39.53	Thailand Securities Depository Co., Ltd.	3.03	Bangkok Steel Industry Plc.	2.28	*Central Glass Co., Ltd.*	2.16
AMC	3.2	0.948	Family	Yongvongphaiboon Family	33.82	Lady Patama Leeswadtrakul	16.67	Mr. Win Suteerachai	8.33	Mr. Chanatip Triwut	4.17	Miss. Orawan Phongthanyalak	2.19
GC	3.5	0.945	Hybrid	Mr. Somchai Kulimakin	23.25	Mr. Aikachai Sirijuntanan	14.21	Mr. Sumruay Tichachol	13.56	Mr. Bhija Jriyasetapong	13.06	Mr. Siri Thirawattanawong	7.71
CTW	3.2	0.938	Foreign	*Pacific Electric Wires & Cable*	43.21	Italian-Thai Development Plc.	14.39	*Mellon Bank ,N.A.*	8.80	*Thai NVDR Co., Ltd.*	7.92	Bangkok Insurance Plc.	6.61
IRP	3.5	0.935	Foreign	*Indorama Ventures Limited*	42.81	*Indorama Holdings Limtied*	26.48	*Indorama Synthetics (India) Limited*	6.55	*Somers (U.K.) Ltd.*	6.16	*Thai NVDR Co., Ltd.*	4.01
LHK	3.2	0.931	Family	Akarapongpisak Family	67.50	Mr. Nucha Watnopas	7.50	Seamico Securities Plc.	3.75	Mrs. Titima Eiampikul	1.34	Mrs. Athaya Chaikulngamdee	1.27
TCB	3.5	0.930	Foreign	*Thai Rayon Pcl.*	24.98	*Everlon International Holding*	12.56	Mr.Veeraphan Theepsuwan	8.34	*PT Indo Bharat Rayon*	7.77	*Mirapa Limited*	4.67
SSSC	3.2	0.927	Hybrid	*Okuya & Co., Ltd.*	28.00	Siam steel International Pcl.*	21.01	Kunanantakul Family*	8.47	*Metal One Corporation*	7.00	*Northtrust Nominees Co., Ltd.*	5.51
SPG	3.1	0.925	Family	Rotrakarn Family	50.74	Jittivanich Family	16.26	*Banc of America Securities*	12.78	*Banc Boston Investment Inc.*	5.22	Miss. Pornsri Tantanachai	4.42
PERM	3.2	0.920	Family	Yongvongpaibul Family	35.31	Sutreerachai Family	23.84	Sereedeelert Family	19.27	Batsomboon Family	3.77	Ngaowisitkul Family	2.33
The Top 10 Least Performers													
TTL	2.1	0.026	Joint	Thai T C Co., Ltd.	25.34	*Prominent Apparel Limited*	25.00	Krungthai Panich Insurance Co., Ltd.	4.44	Mr. Sombat Panichewa	3.52	Sri Peenong Co., Ltd.	3.31
TONHUA	4	0.342	Family	Kyavatanakij Family	43.24	Sakorn and Son Co., Ltd.	5.00	Mrs. Somruthai Jitpukdeebodintra	0.85	Mr. Tawat Tantimedh	0.58	Mr. Suchart Akharaputtiporn	0.52
FANCY	2.2	0.367	Family	Leelaprad Family	31.44	*Credit Agricole (Suisse) SA*	11.81	Mr. Piti Tanpatanarat	10.81	*Chase Nominees Limited 42*	7.52	Mrs. Portip Chupinijsak	6.85
TPP	3.3	0.380	Hybrid	Sangthong International Co., Ltd.	16.00	*Quam Securities Nominee (Singapore) PTE Ltd.*	8.41	Bangkok Commercial Asset Management Co., Ltd.	8.20	*Predential TS Life Assurance Plc.*	8.00	*TS Life Capital Co., Ltd.*	6.86
EIC	6	0.538	Family	Mr. Sarawuth Jinwuth	51.00	Mr. Witthaya Chakpet	5.75	Mr. Sa-Nga Wanasinchai	5.00	Thai NVDR Co., Ltd.	4.94	Mr.s Tippawan Chakphet	3.83
TBSP	4	0.541	Domestic	GCG Paper Plc.	49.79	T.K.S. Technology Plc.	19.89	Toungsombat Family	7.12	Mrs. Nunthiya Santikarn	4.93	Mr. Sukit Thong-anan	4.93
BNC	2.1	0.581	Hybrid	Sahathai Pattanapan Co., Ltd.	16.08	Mitsiam International Co., Ltd.	14.44	Saha Pathana-Inter Holding Plc.	11.11	Inter System Co., Ltd.	7.59	Mr. Samreang Manoonphon	7.55
CM	1.1	0.583	Joint	Northern Agricultural Co., Ltd.	17.51	Itochu Corporation	13.23	Itochu (Thailand) Co., Ltd.	6.77	Mr. Suppachai Saharattanachaiwong	4.78	Mr. Lan Mu Chiu	4.59
DISTAR	3.1	0.584	Family	Teekakirikul Family*	24.93	My Bus Co., Ltd.*	4.18	*Phillip Securities PTE Ltd.*	8.01	Mrs. Chalaw Wattanasombat	6.09	Mrs. Wanida Sae-Jiw	5.47
SAWANG	2.1	0.596	Family	Maneepairot Family	76.88	Mr.Kamonporn Mekworawut	4.24	Mr. Watanasak Laomanutsak	4.17	Mrs. Chanpen Sorakraikitikul	3.30	Thai NVDR Co., Ltd.	1.15

Source: Author

Note: * indicates that they are family related; Italic font indicates foreign shareholders; The name of Thai shareholders was originally in Thai, and was translated by the author by using other sources (e.g., Facebook, Google, the SET's website, companies' website).

Appendix 3.2: The list of top 10 best and least Thai listed manufacturing firms of the Agro & Food Industry sub-sector in 2008

Name	Sub-Sector	TE Score	Own. Type	Major Shareholders									
				1st	%	2nd	%	3rd	%	4th	%	5th	%
The Top 10 Best Performers													
STA	1.1	0.908	Family	Sri Trang Holding Co., Ltd.*	24.48	Sincharoenkul Family*	25.05	Mr. Aram Sirisuwat	3.42	Mr. Prasit Panichkul	1.20	Mr. Poung cheadkeatkamjay	0.92
TUF	1.2	0.907	Family	Chansiri Family	26.07	Niruttinanon Family	8.19	Chase Nominees Limited 42	7.63	BNY Mellon	4.35	Thai NVDR Co.Ltd.	3.27
PPC	1.1	0.903	Family	Areecharoenlert Family	68.73	Kankwatanawan Family	19.93	Bangkok Insurance Plc.	0.88	Mr. Somchai Meansuk	0.57	-	-
SSC	1.2	0.896	Foreign	*Pepsi-Cola (Thai) Trading*	24.98	*Seven-Up Netherland, B.U.*	16.63	Mr. Nithi Osathanugrah	8.84	Thai NVDR Co., Ltd.	4.92	Bangkok Reinvest Co., Ltd.	4.04
ASIAN	1.1	0.894	Family	Amornrattanachaikul Family	63.84	Capital Rice Co., Ltd.	15.32	Mr. Chan Amarest	3.28	Miss Sirirat Tantichalermsin	2.39	Thai NVDR Co., Ltd.	2.10
CPF	1.1	0.891	Family	Charoen Pokphand Group	41.16	Mellon Bank, N.A.	4.72	Thai NVDR Co., Ltd.	3.58	Nortrust Nominees LTD.-NTGS	3.46	Nortrust Nominees LTD.	1.55
SSF	1.1	0.888	Family	Mr. Surapon Vongvadhanaroj	39.05	Thai Securities Depository Co., Ltd for Depositor (Thai)	23.32	Mr. Sithichai Kraisithisirin	13.12	Mr. Chokchai Jiengwareewong	11.34	Thai Securities Depository Co., Ltd for Depositor (Foreign)	2.67
CHOTI	1.1	0.884	Family	Laoteppitaks Family*	*26.49*	Chotiwat Holding Co., Ltd.*	26.00	*H'ng Kim Chang & Son .SDN.BHD*	13.31	*Mr. H'ng Cheow Teik*	6.09	Mr. Watshira Tayanaraporn	5.00
GFPT	1.1	0.882	Family	Sirimongkolkasem Family	56.16	นายอนุชา กิจธนามงคลชัย	4.38	*Thai NVDR Co., Ltd.*	3.06	Albouys Nominees Limited	2.72	Mr. Somkiet Limsong	1.90
RANCH	1.1	0.880	Foreign	*London 8 Co., Ltd.*	46.90	Thongchai Co., Ltd.	31.10	Middle Village Co., Ltd.	15.90	Thai NVDR Co., Ltd	2.60	Citibank Nominees Singapore	0.70
The Top 10 Least Performers													
CM	1.1	0.583	Joint	Northern Agricultural Co., Ltd.	17.51	*Itochu Corporation*	13.23	Itochu (Thailand) Co., Ltd.	6.77	Mr. Suppachai Saharattanachaiwong	4.78	*Mr. Lan Mu Chiou*	4.59
APURE	1.2	0.750	Hybrid	Miss Suchitra Thamtikanon	4.35	Mr. Taweesak Watchara-rakkawong	3.43	*Thai NVDR Co., Ltd.*	2.44	Mr. Somkiet Thanaporn-sangsut	1.79	Mr. Chatchalerm Chalerm-chaiwat	1.36
TRS	1.1	0.762	Family	Hoontrakul Family	25.61	Hoonpongsimanon Family	26.86	Mr. Teaktin Sae-Jiw	4.38	Mr. Ekachai Satranuwat	3.91	Mr. Damrong Booncharoen	3.80
TLUXE	1.1	0.767	Hybrid	Seneepakornkai Family	18.47	*Group of Mr. Wu Yu Thing*	14.56	Jetanalin Family	10.92	*Symtel International Investment Corp*	6.99	*Group of Mr. Ying Fu Chang*	3.77
PR	1.2	0.784	Hybrid	President Holding Co., Ltd.*	32.52	Paniangvait Family*	14.94	Poonsakudomsin Family*	7.19	Tatiyakkavee Family *	6.77	Tanayongpibul Family	3.66
TWFP	1.2	0.804	Foreign	*Universal Starch Plc.**	42.08	*Ho Family**	16.53	*Chang Fung Co., Ltd.**	7.1	UBS AG Hong Kong Branch	5.23	Kim Eng Securities PTE.LTD.	3.47
S&P	1.2	0.816	Family	Siraoon & Riwa Family	36.27	*Minor International Plc.*	20.84	Social Investment Fund	9.55	*Credit Suisse Securities (Europe)*	3.93	Mrs. Supapan Pichainaron-songkham	3.31
SORKO	1.2	0.816	Family	Rujirasopn Family	41.18	SKK Food Co., Ltd.	20.57	Metro Agro Industry Co., Ltd.	13.01	Mahachai Food Processing.	4.86	Thai Food Industry Co., Ltd.	4.75
PRG	1.1	0.819	Domestic	MBK Plc.	74.52	Thanachart Capital Plc.	9.79	Thanachart Plc.	4.4	Thanachart Life Assurance Co., Ltd.	3.27	Thanachart Insurance Co., Ltd.	2.13
PM	1.2	0.831	Family	Premier Fission Capital Co., Ltd.*	65.38	Bangkok Insurance Plc.	1.62	TAIB-JAIC Asian Balanced Private Equity Fund	1.54	Premier Pet Products Co., Ltd.*	1.54	Thai Capital Fund	0.89

Appendix 3.3: The list of top 10 best and least Thai listed manufacturing firms of the Consumer-Products sub-sector in 2008

Name	Sub-	TE	Own	Major Shareholders									
		Score	Type	1st	%	2nd	%	3rd	%	4th	%	5th	%
The Top 10 Best Performers													
SIAM	2.2	0.878	Joint	Kunanatakul Family	34.58	Mr. Pongsak Pongpandecha	30.11	*Morgan Stanley & Co. International Plc.*	13.66	*Thai NVDR Co., Ltd.*	2.33	*Lehman Brothers International (Europe)*	2.24
DSGT	2.3	0.870	Foreign	*DSG International Limited*	65.74	*Somers(U.K.) Limited*	5.18	Anuwongnukroh Family	9.20	*DSG International (Thailand)*	3.14	*Thai NVDR Co., Ltd.*	2.05
SUC	2.1	0.865	Family	Darakananda Family	39.22	Bangkok Bank Plc.	4.11	Mr. Karmton Punsak-Udomsin	2.72	Sinbualuang Leasing Co., Ltd.	2.72	South Eastern Life Insurance	1.95
SABINA	2.1	0.860	Family	Thanalongkorn Family	74.59	Mrs. Wannee Thonglak	4.03	Mr. Anurak Tangkaravakun	3.68	Mrs. Rachanee Wiwatchaiyabanbundit	3.02	Mr. Soras Eimamornpan	3.02
PRANDA	2.1	0.851	Family	Tiasuwan Family	28.03	*AG London Branch-NRB*	6.64	*Fortis Global Custody Services, N.V.*	6.36	*Mellon Bank, N.A.*	4.03	*Norbax Inc.*	3.41
PAF	2.1	0.845	Family	PA Capital Co., Ltd.*	18.90	Bangkok Rubber Plc.*	18.90	International Curity Footware Co., Ltd.	7.20	Footware Tech 1530 Co., Ltd.	5.80	SAHA Patthana Inter-Holding Plc. (Chokwatana Family)*	
OGC	2.2	0.843	Family	Ocean Holding Co., Ltd. *	32.82	Assakul Family*	27.10	Thai NVDR Co., Ltd.	6.13	Mrs. Nutsara Banyatpiyaphod*	5.81	Toko-Sasaki Glass Co., Ltd.	2.96
BATA	2.1	0.837	Foreign	Bafin (Nederland) B.V.	85.70	Sawatyanon Family	4.12	Thai NVDR Co., Ltd.	2.07	Bangkok Insurance Co., Ltd.	1.09	Mr. Sirat Thumrongrat	0.62
S & J	2.3	0.829	Family	SAHA Pattana Inter-Holding Plc*.	15.57	I.C.C. International Co., Ltd.*	14.81	I.D.F. Co., Ltd. *	11.00	Chokwatana Family*	10.41	Wittanasit Co., Ltd.	8.82
SITHAI	2.2	0.827	Hybrid	Lertsumitkul Family	24.40	Angubolkul Family	13.48	Mrs. Mayuree Siriwajanakul	5.43	Sri Thai Superwear Plc.	5.15	Pershing LLC-Customers Keeping	4.77
The Top 10 Least Performers													
TTL	2.1	0.026	Joint	Thai T C Co., Ltd.	25.34	*Prominent Apparel Limited*	25.00	Krungthai Panich Insurance Co., Ltd.	4.44	Mr. Sombat Panichewa	3.52	Sri Peenong Co., Ltd.	3.31
FANCY	2.2	0.367	Family	Leelaprad Family	31.44	*Credit Agricole (Suisse) SA*	11.81	Mr. Piti Tanpatanarat	10.81	*Chase Nominees Limited 42*	7.52	Mrs. Portip Chupinijsak	6.85
BNC	2.1	0.581	Hybrid	Sahathai Pattanapan Co., Ltd.	16.08	Mitsiam International Co., Ltd.	14.44	Saha Pathana-Inter Holding Plc.	11.11	Inter System Co., Ltd.	7.59	Mr. Samreang Manoonphon	7.55
SAWANG	2.1	0.596	Family	Maneepairot Family	76.88	Mr.Kamonporn Mekworawut	4.24	Mr. Watanasak Laomanutsak	4.17	Mrs. Chanpen Sorakraikitikul	3.30	Thai NVDR Co., Ltd.	1.15
CEI	2.2	0.652	Foreign	*Summax Investment Limited*	51.00	*Thai NVDR Co., Ltd.*	9.24	*Credit Suisse Singapore Branch*	6.16	Mr. Thanit Labpanichpoonpon	2.71	*Miss Yuhua Yan*	2.35
TTI	2.1	0.696	Joint	Chuenchoochit Family	15.71	Boonnamsap Family	9.89	*Thai Textile International Co., Ltd.*	8.11	Gold Mine Garment Co., Ltd.	4.00	*Merrill Lynch, Pierce, Fenner & Smith*	4.00
JCT	2.3	0.731	Family	Aroonvatanaporn Family*	54.82	Chairapruk Family*	26.34	Pharma Care Co., Ltd.*	4.92	Mrs. Chantira Chotinantaset	1.59	*Thai NVDR Co., Ltd.*	1.35
PG	2.1	0.735	Family	Thanulux Plc.	14.05	Saha Pathana Inter-Holding Plc.*	12.75	Mr. Somleang Manoonpol	11.91	Saha Pathanapibul Plc.*	8.82	Chokwatana Family*	7.83
WACOAL	2.1	0.738	Joint	*Wacoal Corporation m*	33.61	Saha Pathana Inter-Holding Plc.*	21.26	Saha Pathanapibul Plc.*	7.57	I.C.C. International Plc.*	4.77	I.D.F Co., Ltd.	3.74
TOG	2.3	0.742	Family	Pracharktum Family	61.68	Specsavers Asia Pacific Holding	12.50	The Body of Person Sasas-Ketnapa	1.74	Mrs. Wilai Chaiamnouy	1.38	Sin Kwang Optical Pte Ltd	1.25

Appendix 3.4: The list of top 10 best and least Thai listed manufacturing firms of the Industries sub-sector in 200

Name	Sub-Sector	TE Score	Own. Type	Major Shareholders									
				1st	%	2nd	%	3rd	%	4th	%	5th	%
The Top 10 Best Performers													
TCCC	3.5	0.955	Foreign	*Sojitz Corporation*	43.92	ISTS (Thailand) Co., Ltd.	39.53	Thailand Securities Depository Co., Ltd.	3.03	Bangkok Steel Industry Plc.	2.28	*Central Glass Co., Ltd.*	2.16
AMC	3.2	0.948	Family	Yongvongphaiboon Family	33.82	Lady Patama Leeswadtrakul	16.67	Mr. Win Suteerachai	8.33	Mr. Chanatip Triwut	4.17	Miss. Orawan Phongthanyalak	2.19
GC	3.5	0.945	Hybrid	Mr. Somchai Kulimakin	23.25	Mr. Aikachai Sirijuntanan	14.21	Mr. Sumruay Tichachol	13.56	Mr. Bhija Jriyasetapong	13.06	Mr. Siri Thirawattanawong	7.71
CTW	3.2	0.938	Foreign	*Pacific Electric Wires & Cable*	43.21	Italian-Thai Development Plc.	14.39	*Mellon Bank ,N.A.*	8.80	*Thai NVDR Co., Ltd.*	7.92	Bangkok Insurance Plc.	6.61
IRP	3.5	0.935	Foreign	*Indorama Ventures Limited*	42.81	*Indorama Holdings Limtied*	26.48	*Indorama Synthetics (India) Limited*	6.55	*Somers (U.K.) Ltd.*	6.16	*Thai NVDR Co., Ltd.*	4.01
LHK	3.2	0.931	Family	Akarapongpisak Family	67.50	Mr. Nucha Watnopas	7.50	Seamico Securities Plc.	3.75	Mrs. Titima Eiampikul	1.34	Mrs. Athaya Chaikulngamdee	1.27
TCB	3.5	0.930	Foreign	*Thai Rayon Pcl.*	24.98	*Everlon International Holding*	12.56	Mr.Veeraphan Theepsuwan	8.34	*PT Indo Bharat Rayon*	7.77	*Mirapa Limited*	4.67
SSSC	3.2	0.927	Hybrid	*Okuya & Co., Ltd.*	28.00	Siam steel International Pcl.*	21.01	Kunanantakul Family*	8.47	*Metal One Corporation*	7.00	*Northtrust Nominees Co., Ltd.*	5.51
SPG	3.1	0.925	Family	Rotrakarn Family	50.74	Jittivanich Family	16.26	*Banc of America Securities*	12.78	*Banc Boston Investment Inc.*	5.22	Miss. Pornsri Tantanachai	4.42
PERM	3.2	0.920	Family	Yongvongpaibul Family	35.31	Sutreerachai Family	23.84	Sereedeelert Family	19.27	Batsomboon Family	3.77	Ngaowisitkul Family	2.33
The Top 10 Least Performers													
TPP	3.3	0.380	Hybrid	Sangthong International Co., Ltd.	16.00	*Quam Securities Nominee (Singapore) PTE Ltd.*	8.41	Bangkok Commercial Asset Management Co., Ltd.	8.20	*Predential TS Life Assurance Plc.*	8.00	*TS Life Capital Co., Ltd.*	6.86
DISTAR	3.1	0.584	Family	Teekakirikul Family*	24.93	My Bus Co., Ltd.*	4.18	*Phillip Securities PTE Ltd.*	8.01	Mrs. Chalaw Wattanasombat	6.09	Mrs. Wanida Sae-Jiw	5.47
AMAC	3.2	0.673	Hybrid	Mr. Chamni Janchai	12.12	Mr. Suthisak Losawat	9.69	*KTB Network Co., Ltd.*	7.27	*ASAM Investment Advisory*	4.85	Mr. Wisut Katchamaporn	4.36
TNPC	3.1	0.707	Domestic	Siam City Bank Plc.	9.85	Bangkok Bank Plc.	9.81	Krung Thai Bank Plc.	9.81	TMB Bank Plc.	5.75	Mr. Ponpum Sawangwan	5.08
YCI	3.5	0.747	Foreign	Mr. Prasertsak Suwanpotipra	12.72	*Mr. La Chi Anh**	12.57	*Mr. La Stephane**	8.68	Mr. Apichai Jwatcharanukul	7.19	*Mr. La Chi Dinh**	5.60
NIPPON	3.3	0.772	Family	Chaisathaporn Family	49.24	Kiatnakin Bank Plc.	11.01	Patee Co, Ltd.	6.56	Thana Thai Securities Plc.	4.15	North Star Plc.	4.10
TCJ	3.2	0.798	Family	Chatjuthamard Family	54.63	Mr. Vichien Srimuninnimit	4.97	Miss Voramas Raksriakson	3.59	Mr. Phirat Imchokchai	2.70	Mr. Vinai Klongprakij	2.12
NEP	3.3	0.802	Domestic	Miss Narueporn Kanchanajaree	24.22	Ministry of Finance	21.79	*HSBC Private Bank (SUISSE) SA*	4.99	Mrs. Phatrasamon Pachaiyanan	4.06	Miss Chawee Siwarpex	2.94
CITY	3.2	0.808	Family	Phongratanadechachai Family	72.19	*Thai NVDR Co., Ltd.*	3.68	Mrs. Jaruwan Thaveechoksapsin	1.96	Mr. Bundit Pongratanadachachai	1.70	Miss Phonsri Wongketnak	1.51
UP	3.5	0.830	Family	Saha-Union Plc.*	49.52	Srithai Superware Plc.	9.60	Bangkok Insurance Plc.	8.32	Thongthai Family	6.15	Mr. Sumet Darakananda*	1.58

Appendix 3.5: The list of top 10 best and least Thai listed manufacturing firms of the Other Sectors sub-sector in 2008

Name	Sub-	TE Score	Own Type	Major Shareholders									
				1st	%	2nd	%	3rd	%	4th	%	5th	%
The Top 10 Best Performers													
CCET	6	0.915	Foreign	*Kinpo Electronics Inc.*	39.56	*Far Eastern International Bank*	19.43	*Case Nominees Limited 42*	7.07	*Campal Electronics Inc.*	6.47	*Kingbolt International Singapore PTE. LTD.*	6.15
DELTA	6	0.905	Foreign	Citibank Nominees Singapore (for Deltron Holding Ltd.)	27.67	Citibank Nominees Singapore Ltd Pte-S.A. PBG Clients SG	19.43	Citibank Nominees Singapore (for Detlta International Holding lnc.)	15.39	Delta Electronics Inc.	5.54	State Street Bank and Trust Company For London	3.73
VNG	5	0.884	Family	Vanachai Group*	44.69	Sahawat Family*	12.64	Jaroennawarat Family*	4.21	Sinnsupawee Assets Management	3.29	Goldman Sachs International	2.70
SVI	6	0.883	Foreign	*DBS Vickers Securities Singapore*	59.34	*UBS AG Singapore, Branch*	5.77	*Thai NVDR Co., Ltd.*	3.3mot	Mr. Pongsak Lothongkam	2.85	Hankaivilai Family	2.03
METCO	6	0.882	Foreign	*Muramoto Industry Co., Ltd.*	62.64	*TSD Co., Ltd. for Depositor (Thai investors)*	19.75	*TSD Co., Ltd. for Depositor (Foreign investors)*	9.46	*Mr. Keisuke Maramoto*	2.25	*Mr. Kohei Muramoto*	1.38
APRINT	4	0.871	Family	Utakapan Family	55.17	*Street Bank and Trust Company For London*	4.21	Juldis Development Plc.	2.93	*Chase Nominees Limited 1*	2.63	*Aberteen Growth Fund*	2.36
HANA	6	0.870	Foreign	*OMAC (HK) Limited*	30.52	*Street Bank and Trust Company For London*	10.54	*HSBC Private Bank (Suisse) SA*	3.41	*BNP Paraibas Securities Services Lxembourg*	3.29	*Fortis Global Custody Services N.V.*	2.95
TYM	5	0.862	Family	Jirapongtrakul Family*	45.00	Mr. Booncherd Santudpanich*	8.00	Mr. Panu Jarupirut*	7.50	Mr. Karu Kanavuttakul	4.00	Mr. Nirun Ngamchamnanrit	3.39
TSTH	5	0.861	Foreign	*NatSteel Asia PTE. LTD.*	42.12	*Tata Steel Ltd.*	24.99	Sukhumvit Assets Management Co.,Ltd.	5.64	Bangkok Bank Plc.	3.52	Petchburi Assets Management	2.27
PAP	5	0.856	Family	Tang Mong Seng Holding *	39.05	Lekapojpanich Family *	36.83	Mrs. Pranee Kuwuttayakorn	2.81	*Thai NVDR Co., Ltd.*	1.38	Mr. Reangkiet Chantaravareerat	1/04
The Top 10 Least Performers													
TONHUA	4	0.342	Family	Kyavatanakij Family	43.24	Sakorn and Son Co., Ltd.	5.00	Mrs. Somruthai Jitpukdeebodintra	0.85	Mr. Tawat Tantimedh	0.58	Mr. Suchart Akharaputtiporn	0.52
EIC	6	0.538	Family	Mr. Sarawuth Jinwuth	51.00	Mr. Witthaya Chakpet	5.75	Mr. Sa-Nga Wanasinchai	5.00	Thai NVDR Co., Ltd.	4.94	Mr.s Tippawan Chakphet	3.83
TBSP	4	0.541	Domestic	GCG Paper Plc.	49.79	T.K.S. Technology Plc.	19.89	Toungsombat Family	7.12	Mrs. Nunthiya Santikarn	4.93	Mr. Sukit Thong-anan	4.93
TCMC	5	0.622	Joint	Srivikorn Family*	32.99	Depa Interiors LLC	25.98	Teepsuwan Family*	11.81	Mr. Thamrong Issariyametikul	6.78	Miss Waree Kitbumrung	4.05
AKR	6	0.642	Hybrid	KV Asset Co., Ltd.	12.66	Mr. Manus Kamneadngam	10.78	Mr. Jullajit Boonyaket	7.83	Miss Podjanalai Boonkan	4.10	Mr Suwan Panyapas	3.96
KCE	6	0.667	Hybrid	Ongkosit Family*	6.43	Mr. Jessada Lertnantapanya	5.41	Mr. Panya Senadisai	5.41	Mrs. Siripan Santanapan*	1.15	Mr. Kriangkrai Akarawong	0.81
EPCO	4	0.669	Hybrid	S. Pack & Print Plc.	24.94	Asia Special Situation MT	14.81	Chinsupakul Family	10.39	Miss Sarinthip Pibulchinda	3.85	Mrs Marisa Na Nakorn	3.16
GEN	5	0.684	Hybrid	Sunshine Corporation Plc.	11.61	Mida Asset Plc.	8.51	Distars Chain Co., Ltd.	7.68	Thai NVDR Co., Ltd.	3.41	Mr. Dejkachorn Jeravijaranayankul	2.56
SUPER	5	0.690	Family	Mrs. Daranee Attanandana*	22.46	Lochaya Family*	28.67	Miss Panisara Thengtam*	11.10	Advance Asset Management Service *	6.60	Weerawan Family*	4.01
SPPT	6	0.728	Family	Polpipattanapong Family	46.39	Mr. Paritas Suthasatitchai	8.00	Mr. Thanongchay Chartpanit	7.98	Mrs. Ariya Kriangkraikul	7.44	Mr. Suebtrakul Bintep	5.02

Appendix 4.1: Maximum-likelihood Probit estimates for export participation of listed manufacturing firms (using SFA technical inefficiency scores)

Dependent variable: Export Participation	**All Manufacturing**	**Agro & Food Industry**	**Consumer Products**	**Industrials**	**Other Sectors[a]**
Observation with Dependent variable = 0	281	46	2	96	137
Observation with Dependent variable = 1	1028	277	250	301	200
Total observations	1309	323	252	397	337
Independent variables:					
Constant	-1.235**	-1.443	-185.511*	-1.117	-3.088*
	(0.683)	(1.742)	(67.111)	(1.324)	(0.895)
Firm Size	0.193*	0.183*	14.693*	0.231*	0.378*
	(0.038)	(0.087)	(5.209)	(0.070)	(0.059)
Firm Age	-0.225*	-0.057	4.117*	-0.449*	-0.693*
	(0.092)	(0.304)	(1.893)	(0.161)	(0.147)
Technical Inefficiency (SFA)	-1.285*	0.378	-54.888*	-3.030*	-1.230
	(0.341)	(1.502)	(16.124)	(0.648)	(0.860)
Leverage	0.064*	-0.110	-7.063*	0.664*	-0.228
	(0.023)	(0.201)	(2.413)	(0.241)	(0.209)
Foreign Investment	0.010*	0.001	1.617*	0.001	0.016*
	(0.002)	(0.007)	(0.528)	(0.005)	(0.003)
McFadden R-squared	0.082	0.016	0.757	0.191	0.251
LR statistic	111.04	4.259	17.653	83.696	114.076
Probability (LR statistic)	0.000	0.513	0.003	0.000	0.000

Source: Author's estimates

Note: Huber/White Robust Standard Errors (S.E.) are in parentheses; * and ** indicate that the coefficients are statistically significant at the 5% and the 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Electronic components).

Appendix 4.2: Maximum-likelihood Probit estimates for export participation of listed manufacturing firms (using DEA technical inefficiency scores)

Dependent variable: Export Participation	**All Manufacturing**	**Agro & Food Industry**	**Consumer Products**	**Industrials**	**Other Sectors[a]**
Observation with Dependent variable = 0	281	46	2	96	137
Observation with Dependent variable = 1	1028	277	250	301	200
Total observations	1309	323	252	397	337
Constant	-1.868*	2.278	8.336	-3.180*	-5.042*
	(0.725)	(1.558)	(8.689)	(1.241)	(1.136)
Firm Size	0.222*	-0.045	0.169	0.312*	0.482*
	(0.042)	(0.095)	(0.372)	(0.072)	(0.070)
Firm Age	-0.226*	0.037	-2.036	-0.211	-0.754*
	(0.095)	(0.312)	(1.373)	(0.153)	(0.148)
Technical Inefficiency (DEA)	-0.281	-5.751*	-4.797	-3.760*	2.765
	(0.779)	(2.099)	(4.631)	(1.191)	(1.723)
Leverage	0.045*	-0.014	-2.740*	0.605*	-0.274
	(0.022)	(0.188)	(1.206)	(0.276)	(0.229)
Foreign Investment	0.010*	0.002	0.934	0.000	0.016*
	(0.002)	(0.006)	(0.611)	(0.004)	(0.003)
McFadden R-squared	0.069	0.037	0.492	0.147	0.252
LR statistic	94.284	9.704	11.471	64.672	114.883
Prob (LR statistic)	0.000	0.084	0.043	0.000	0.000

Source: Author's estimates
Note: Huber/White Robust Standard Errors (S.E.) are in parentheses; * and ** indicate that the coefficients are statistically significant at the 5% and the 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Electronic components).

Appendix 4.3: Comparison of the results of maximum-likelihood estimates for parameters between SFA technical inefficiency scores and DEA technical inefficiency scores

Dependent variable: Technical inefficiency	**All Manufacturing**		**Agro & Food Industry**		**Consumer Products**		**Industrials**		**Other Sectors [a]**	
	SFA	**DEA**	**SFA**	**DEA**	**SFA**	**DEA**	**SFA**	**DEA**	**SFA**	**DEA**
Independent variables :										
Constant	-**	-*	-	+	-*	+	-	-*	-*	-*
Firm Size	+*	+*	+*	-	+*	+	+*	+*	+*	+*
Firm Age	-*	-*	-	+	+*	-	-*	-	-*	-*
Technical Inefficiency	-*	-	+	-*	-*	-	-*	-*	-	+
Leverage	+*	+*	-	-	-*	-*	+*	+*	-	-
Foreign Investment	+*	+*	+	+	+*	+	+	+	+*	+*

Source: Author's estimates
Note: * and ** indicate that the coefficients are statistically significant at the 5% and the 10 % levels, respectively; [a] includes Publishing, Construction Materials, and Technology (Electronic components).