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Factors affecting the technical inefficiency of Thai manufacturing and exporting small and medium sized enterprises: A stochastic frontier analysis (SFA)

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Abstract
This study employs a stochastic frontier analysis (SFA) and technical inefficiency effects model to predict the technical efficiency of 3,168 Thai manufacturing and exporting SMEs, analyze their returns to scale and key factors impacting on their technical efficiency. Analysis of cross-sectional data from a 2007 census of Thai manufacturing SMEs indicates that their average technical efficiency is approximately 69.72 percent, signifying a moderate level of technical inefficiency which is reducing potential output. With respect to each group of manufacturing and exporting SMEs, SMEs exporting to East Asia have a level of technical efficiency of 0.7081, followed by SMEs exporting to ASEAN (0.7038), North & South America (0.7005), OCEANIA (0.6979), South Asia (0.6828), Europe (0.6764), and Middle East & Africa (0.6679). Thai manufacturing and exporting SMEs extensively rely on labour rather than capital to increase their output, including almost all exporting SME groups, except those exporting to North & South America. Furthermore, the production of Thai manufacturing and exporting firms exhibit decreasing returns to scale (0.8837), including the production of SMEs exporting to ASEAN (0.9027), East Asia (0.9200), South Asia (0.7935), Europe (0.6487), North & South America (0.52118), and Middle East & Africa (0.7672). The production of Thai manufacturing SMEs exporting to Oceania, however, has increasing returns to scale (1.1965). The inefficiency effects model reveals that firm size, firm age, foreign ownership, location and government assistance are firm-specific factors that significantly affect the technical inefficiency of production. Finally, evidence-based policies are also provided to facilitate improvement in the technical efficiency performance of Thai manufacturing and exporting SMEs.

Keywords
medium, small, exporting, manufacturing, thai, inefficiency, sized, technical, factors, enterprises, stochastic, frontier, analysis, sfa, affecting

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Factors Affecting the Technical Inefficiency of Thai Manufacturing and Exporting Small and Medium Sized Enterprises: A Stochastic Frontier Analysis (SFA)

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ABSTRACT

This study employs a stochastic frontier analysis (SFA) and technical inefficiency effects model to predict the technical efficiency of 3,168 Thai manufacturing and exporting SMEs, analyze their returns to scale and key factors impacting on their technical efficiency. Analysis of cross-sectional data from a 2007 census of Thai manufacturing SMEs indicates that their average technical efficiency is approximately 69.72 percent, signifying a moderate level of technical inefficiency which is reducing potential output. With respect to each group of manufacturing and exporting SMEs, SMEs exporting to East Asia have a level of technical efficiency of 0.7081, followed by SMEs exporting to ASEAN (0.7038), North & South America (0.7005), OCEANIA (0.6979), South Asia (0.6828), Europe (0.6764), and Middle East & Africa (0.6679). Thai manufacturing and exporting SMEs extensively rely on labour rather than capital to increase their output, including almost all exporting SME groups, except those exporting to North & South America. Furthermore, the production of Thai manufacturing and exporting firms exhibit decreasing returns to scale (0.8837), including the production of SMEs exporting to ASEAN (0.9027), East Asia (0.9200), South Asia (0.7935), Europe (0.6487), North & South America (0.52118), and Middle East & Africa (0.7672). The production of Thai manufacturing SMEs exporting to Oceania, however, has increasing returns to scale (1.1965). The inefficiency effects model reveals that firm size, firm age, foreign ownership, location and government assistance are firm-specific factors that significantly affect the technical inefficiency of production. Finally, evidence-based policies are also provided to facilitate improvement in the technical efficiency performance of Thai manufacturing and exporting SMEs.

Key words: Stochastic Frontier Production; Technical Efficiency; Small and Medium Sized Enterprises; Thai Manufacturing

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I. INTRODUCTION

Strong export performance is normally known as one of the crucial factors in driving a country's economic growth, since exports can improve a firm's production efficiency to overcome higher trade barriers and address different market tastes in competitive international markets. Thai small and medium sized enterprises (SMEs), however, are still not fully competitive, especially in foreign markets which require efficient production, good management structures, market capabilities, product and service development to meet international standards, high quality of labour and products, up-to-date technologies, consumer and environmental accountability and strong networks in conducting business operations. More importantly, the competitiveness of Thai industry, particularly SMEs, has traditionally relied on low-cost labour and natural resource (raw materials) advantages rather than technological capability or qualified human capital. Thai business segments, nevertheless, are now under the "*Nut-Cracker Effect*" (OSMEP, 2007). This effect implies that Thailand is now stuck between countries with greater price competitiveness, such as China, Vietnam and Indonesia, and countries which can differentiate their outputs by concentrating in higher value-added products and services, such as Japan, South Korea and Taiwan. In addition, more skilled labour and higher productivity can be observed in these countries. To address these problems, a few studies, for example Charoenrat and Harvie (2012), have empirically shown that Thai SMEs rely on labour intensive processes in production.

This paper focuses on the export segment of Thai SMEs to estimate their stochastic production efficient frontier which can be used to confirm their over-reliance on labour intensive processes, one of the causes of the "*Nut-Cracker Effect*", as well as evaluate their technical efficiency performance. This paper specifically investigates the factors which significantly influence the technical inefficiency of Thai manufacturing and exporting SMEs,

and evaluates their technical efficiency performance for 89 exporting countries which can be grouped into 7 sub-exporting SME groups, such as (i) SMEs exporting to ASEAN, (ii) SMEs exporting to East Asia, (iii) SMEs exporting to South Asia, (iv) SMEs exporting to OCEANIA, (v) SMEs exporting to Europe, (vi) SMEs exporting to North & South Africa, and (vii) SMEs exporting to the Middle East & Africa.

The structure of this paper is organized as follows: Section II provides an overview of Thai small and medium sized enterprises (SMEs). Section III provides a review of the stochastic frontier production and technical inefficiency effects model as well as of empirical studies which investigate key factors impacting on firm technical inefficiency. Sector IV describes the data source. Section V presents the model specifications for this study. Section VI presents the hypothesis test. Section VII provides the empirical result of this study. Some conclusions and recommendations are also provided in the final section.

II. AN OVERVIEW OF THAI SMES

SMEs are crucial drivers of the Thai economy, contributing significantly to social and economic development (Brimble *et al*., 2002). They represent 99.6 percent of business establishments in the country, employ more than 10.51 million workers, and accounted for 77.86 percent of total employment in 2010 (OSMEP, 2010). SMEs also accounted for 38.9 percent of GDP in 2006, falling to 37.1 percent of GDP by 2010 (OSMEP, 2010). The contribution of SMEs to Thai GDP, however, is lower than large enterprises' contribution to the country's GDP. Large enterprises accounted for 0.4 percent of business establishments in the country in 2010, but accounted for 45.9 percent of GDP in 2006, rising to 46.1 percent of GDP in 2010.

Nevertheless, SMEs still play significant roles and functions in assisting large enterprises, particularly in the context of regional production networks as they help link all important units of industry together, and filling gaps in industrial clusters which may not be completed by large enterprises alone (Mephokee, 2003; Regnier, 2000). They also supply goods, services, information, and knowledge for large enterprises, and play a pivotal role in the production process of export goods (Tapaneeyangkul, 2001). The manufacturing sector is the most crucial industrial sector in the country, constituting 35.0 percent of Thai GDP in 2006 rising to 35.6 percent of Thai GDP in 2010 (OSMEP, 2010). Similarly, Thai manufacturing SMEs have played a leading role in the economy, accounting for 30.3 percent of Thai SME GDP in 2006 and 32.3 percent of Thai SME GDP in 2010. With regard to the numbers of Thai SMEs the highest numbers of Thai SMEs are Thai manufacturing SMEs, accounting for 17.90 percent of total SMEs in 2010. They also contribute significantly to the country's employment, accounting for 25.23 percent of total employment or 32.40 percent of total SME employment in 2010 (OSMEP, 2010). Focusing on Thailand's exports the growth rate of exports in Thailand has expanded from 11.16 percent in 2008 to 18.78 percent in 2010. The country's export growth rate, however, turned negative in 2009 (-11.17 percent) due to the global economic slowdown.

With regard to the proportion of exports to overall GDP the Thai economy relies greatly on exports, accounting for 61.45 percent of the country's GDP in 2007 and 61.13 percent of GDP in 2010. In terms of contribution to exports, however, Thai SMEs have become less important compared with large enterprises whose exports accounted for 31.39 percent of GDP in 2007 and 32.73 percent in 2010. Thai SME exports, however, only accounted for 30.06 percent of GDP in 2007 and 28.40 percent of GDP in 2010 even though the number of SMEs accounted for 99.60 of all enterprises in Thailand at the end of 2010. This implies that large enterprises play a leading role in the country's international trade even

though they only accounted for 0.4 percent of the country's business establishments in 2010. The Office of SMEs Promotion (2011) also stated that the country's exports primarily rely on large enterprises, and therefore both the public and private sectors should pay attention to promoting greater international trade participation by SMEs. Punyasavatsut (2007) also acknowledged that Thai manufacturing SMEs were not ready to face the rigours of "*international competition*" in competitive global markets arising from the country's increased opening and economic integration, and more intense competition from lower labour cost countries.

More importantly, Thai business segments, particularly Thai SMEs, are now under the "*Nut-Cracker Effect*" which implies that Thailand is now trapped between countries with lower price competitiveness (e.g., China, Vietnam and Indonesia) and countries with higher value added production and services (e.g., Japan, South Korea and Taiwan). Therefore, examining possible significant factors which influence technical inefficiency of Thai manufacturing SMEs as well as measuring their technical efficiency is crucial to be able to compete with foreign firms and also alleviate the "*Nut-Cracker Effect*" on the country. A review of the stochastic production frontier and technical efficiency as well as a review of empirical studies focusing upon factors which affect a firm's technical efficiency is provided in the next section before conducting the empirical analysis of this study.

III. LITERATURE REVIEW

The Stochastic Frontier Production and Inefficiency Effects Model

This paper employs the concept of technical efficiency to measure a firm's performance. Technical efficiency is defined as the capacity and ability of a firm to produce

at the maximum possible output from a given bundle of inputs and a given technology. Its measurement of a firm's performance also differs from allocative efficiency which refers to the ability and willingness of a firm to equate its marginal revenue with its marginal cost (Kalirajan and Shand, 1999). More importantly, the concept of efficiency differs from productivity. The term "*productivity*" refers to "*total factor productivity*", which is defined as the ratio of total outputs over total inputs (Coelli *et al*., 2005). A technically efficient firm operates on the production frontier, but a technically inefficient firm's operation is located beneath the production frontier. 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 up to a point where a firm obtains the maximum productivity or technically optimal scale (Coelli *et al*., 2005).

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. The first error component, v_i , allows random variation of the frontier across firms. It indicates the effects of the omission of relevant variables from the vector x_i, random shocks outside the firm's control, measurement errors, and approximation errors associated with the use of this functional form (see Førsund *et al*. (1980, p.13); Coelli *et al*. (2005, pp. 242-243)). The second error component, u_i , captures the effects of inefficiency relative to the stochastic frontier. 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, p. 243).

$$lny_i = \beta_0 + \beta_1 lnx_i + v_i - u_i \qquad (1)$$

A number of studies (e.g., Pitt and Lee (1981)) have estimated stochastic frontiers and predicted technical efficiency using two-stage estimation. More specifically, stochastic frontiers and firm-level inefficiencies are estimated and predicted, respectively, by employing estimated functions, and are then regressed upon firm-specific variables (e.g., managerial experience, ownership characteristics). This is to identify some of the reasons why predicted inefficiencies between firms in an industry are different. However, the inefficiency effects obtained from the second-stage regression are biased due to the omission of relevant variables in the first-stage of the frontier estimation, which was addressed by Reifschneider and Stevenson (1991). They proposed stochastic frontier models in which the inefficiency effects (U_i) are expressed as an explicit function of a vector of firm-specific variables and a random error.

The one-stage process suggested by Battese and Coelli (1995) who proposed the model which is equivalent to the Kumbhakar, Ghosh and McGukin (1991) specification, with the exception that allocative efficiency is imposed. Battese and Coelli (1995) present a model in an attempt to capture technical inefficiency using "*panel data*", where inefficiency effects are stochastic and the model also allows for the estimation of both technical change in the stochastic frontier and time-varying technical inefficiencies. Their model is expressed as follows:

$$Y_{it} = X_{it}\beta + (V_{it} - U_{it}) \qquad \text{,i =1,...,N, t=1,...,T, (2)}$$

where

Y_{it} is the production (or the logarithm of the production) of the i-th firm in the t-time period;

X_{it} is a k×1 vector of (transformations of the) input quantities of the i-th firm in the t-th time period;

β is a vector of unknown parameters;

V_{it} are random variables which are assumed to be identically and independently distributed (iid) $N(0, \sigma_v^2)$, and independent of the U_{it}

U_{it} are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N(m_{it}, \sigma_u^2)$ distribution; where the inefficiency effects, u_{it}, in the stochastic frontier production can be specified as follows:

$$u_{it} = z_{it}\delta + w_{it} \qquad (3)$$

where z_{it} is a p×1 vector of variables which may influence the inefficiency of a firm; and

δ is an 1×p vector of parameters to be estimated; and

w_{it} is defined by the truncation of the normal distribution with zero mean and variance, σ^2, such that the point of truncation is $z_{it}\delta$ (e.g., $w_{it} \geq -z_{it}\delta$).

The parameterisation from Battese and Corra (1977) is used for this model, replacing σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/\sigma^2$. In this model, the technical efficiencies of production can be 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:

$$TE_{it}{}^{1} = \exp(-u_{it}) = \exp(-Z_{it}\delta - w_{it}) \qquad (4)$$

As a result their model can be applied 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.

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

Furthermore, FRONTIER can accommodate a wider range of assumptions regarding the error distribution term than LIMDEP (Herrero and Pascoe, 2002).

Firm Specific Factors

This section provides a review of the literature regarding the factors that affect a firm's technical efficiency, such as firm size, firm age, foreign investment, government support, firm location, and exports.

Firm Size

Focusing on the effect of firm size on technical efficiency, empirical results are still ambiguous depending on countries and sectors analysed. Alvarez and Crespi (2003) found for 1,091 Chilean manufacturing small firms that larger firms are more efficient than small ones, since small firms are likely to have the following difficulties: (i) difficulty in accessing external loans for their investments, (ii) they lack efficient resources (e.g., human capital), (iii) they lack economies of scale, and (iv) they lack formal contracts with customers and suppliers. Similarly, Harvie (2002) also mentioned that there are five main difficulties obstructing SME development, such as (i) access to markets, (ii) access to technology, (iii) access to human resources, (iv) access to financing, and (v) access to information. An empirical study of Vietnamese SMEs, by Le and Harvie (2010) found that larger Vietnamese manufacturing SMEs tend to be technically inefficient compared to small ones. They explain that small firms are more efficient due to flexibility in diversifying and adjusting their businesses and activities in a rapidly changing transition economy.

Firm Age

With respect to empirical studies the effect of firm age on technical efficiency is still inconclusive, depending on countries and sectors. Burki and Terrell (1998) used the two-stage Data Envelopment Analysis (DEA) to investigate factors that affect the efficiency of

153 Pakistani small manufacturing firms. They found that firm age has a significant and positive effect upon efficiency. However, Tran *et al*. (2008) used firm-level data in Vietnam in 1996 and 2001, and found that firm age has an insignificant and negative effect on technical efficiency, indicating no evidence of a "learning by doing" experience. However, they suggested that the negative result does not mean that a "learning by doing" experience is not important in Vietnam, but young firms are likely to benefit more from advanced technology rather than from a "learning by doing" process. Similarly, Le and Harvie (2010) used large surveys of domestic non-state manufacturing SMEs in 2002, 2005 and 2007 to examine the technical efficiency performance in Vietnam, and found that older manufacturing SMEs are likely to be technically inefficient[2].

Firm Investment (Ownership)

Foreign investment (via the form of 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 number of empirical studies have also found a positive association between foreign investment (foreign ownership) and technical efficiency (Fukuyama *et al*., 1999; Goldar *et al*., 2003; Bottasso and Sembenelli, 2004). However, Pham *et al*. (2010) used the Vietnam Enterprise Survey (VES) in 2003 to examine the determinants of efficiency, and found foreign-invested enterprises (FIEs) to be less technically efficient than local-level state owned enterprises. They argued that the reason for this unexpected result is that FIEs on average are younger than those in other sectors. Hence, learning by doing is weaker.

Government Assistance

The effect of government assistance on a firm's technical efficiency has been examined in a number of empirical studies. Government assistance can be, for example, in the form of financial support (e.g., credit assistance, income tax exemption or reduction, and exemption from import duty on essential raw materials) and non-financial support (e.g., managerial and technical assistance, and training support). Empirical results are still inconclusive depending on countries and sectors. For instance, Tran *et al*. (2008) found that the effect of direct government support (e.g., government credit assistance and government technical support) on firm performance varied across years and industries in Vietnam. They found a positive effect of "government credit assistance" on technical efficiency for the machinery and transport equipment sector and also miscellaneous industries sector in 1996. Their empirical results also revealed that "government technical support" has a significant and positive effect on the technical efficiency for the machinery and transport sector in 1996, and for (i) food processing and (ii) miscellaneous manufacturing sectors in 2001. In addition, Le and Harvie (2010) found that government assistance in the form of land, premises, and credit are found to have a significant and negative effect on the technical efficiency of Vietnamese manufacturing SMEs for surveys conducted in 2002, 2005, and 2007, with significant and positive evidence only found for government credit assistance for newly established SMEs in the 2002 survey.

Firm Location

Location is also another important factor, since firms in different locations are likely to have varying technical efficiency. Empirical results are found to be inconclusive. For instance, Le and Harvie (2010) found that manufacturing SMEs located in urban centres in Vietnam had lower technical efficiency compared with SMEs located in rural areas in a survey conducted in 2005, due to higher costs for land, labour and space constraints, but such

significant evidence is not found for surveys conducted in 2002 and 2007. However, Tran *et al*. (2008) found that firms located in metropolitan areas are more technically efficient than their counterparts located in less developed areas in all Vietnamese manufacturing sectors, except in the miscellaneous industries sector. Their result implies that SMEs in metropolitan areas have higher technical and managerial training, educational level, and market opportunities than their non metropolitan counterparts (Tran *et al*., 2008).

Exports

A number of empirical studies have also investigated the effect of export participation on a firm's technical efficiency (the learning-by-exporting hypothesis). Kim (2003) found that exports positively affect technical efficiency for the food and paper industries, but such a finding is not found in the textile, chemical, and fabrication industries for Korean manufacturing industries. Dilling-Hansen *et al*. (2003) found no effect of exports on firm technical efficiency for 2,370 Danish firms. Granér and Isaksson (2007) found that exports significantly increased the technical efficiency of Kenyan manufacturing firms. However, Alvarez and Crespi (2003) found that an outward orientation (firms that sell mainly to foreign markets) has no significant impact on a firm's efficiency for Chilean manufacturing small firms. Le and Harvie (2010) also found no significant evidence supporting a learning-by-exporting hypothesis for Vietnamese manufacturing SMEs.

IV. DATA

The 2007 Thai Industrial Census is used to conduct the empirical analysis for this study, which consists of 73,931 firms across all regions in Thailand. This Industrial Census is conducted by the National Statistical Office (NSO) every 10 years, which is the most updated Industrial Census. Thailand's SMEs can be defined using two measures: (i) by the number of employees or (ii) by the level of fixed assets. Focusing on the Thai manufacturing sector, an enterprise which either employs less than 50 workers or has fixed assets with a value not

exceeding 50 million baht is considered as a small enterprise. In addition, an enterprise which either employs between 51 and 200 workers or has fixed assets with a value between 51 and 200 million baht is defined as a medium sized enterprise. With respect to this criteria, enterprises which have 200 or less workers are selected as SMEs for this study. As a result, 70,355 enterprises are defined as SMEs, accounting for 95.16 percent of total manufacturing enterprises in the Industrial Census[3].

This paper, however, only focuses on exporting SMEs since it aims to examine the effects of firm-specific variables on the technical inefficiency of Thai manufacturing and exporting SMEs, and also compare technical efficiency among SMEs exporting to different destinations. As a result, 3,894 exporting SMEs are selected from 70,355 manufacturing SMEs, accounting for 5.53 percent of total manufacturing SMEs. The selection of output and input variables in this study, however, caused 93 exporting SMEs to be excluded from the sample due to a negative value for "value added" output, and unusual observed values for labour and capital inputs (e.g., fixed assets are recorded as 1 baht, or there are no workers in the firm). In addition, 635 exporting SMEs are excluded from the sample, since these firms are recorded repeatedly in the data set.

As a result of this 3,168 exporting SMEs are used to conduct the empirical analysis for this study, which are divided into 7 groups as follows: (i) SMEs exporting to ASEAN, (ii) SMEs exporting to East Asia, (iii) SMEs exporting to South Asia, (iv) SMEs exporting to Europe, (v) SMEs exporting to OCEANIA, (vi) SMEs exporting to North and South America, and (vii) SMEs exporting to the Middle East and Africa.

[3] The Thai industrial census is not a census in the strict sense. It is based upon a selected sample of 73,931 firms. The census does not incorporate all SMEs.

V. MODEL SPECIFICATIONS

Applying the model of Battese and Coelli (1995) stochastic production frontier functions in both Cobb-Douglas and translog functional forms, which are the most common functional forms, are tested for adequate functional form.

The Cobb-Douglas functional form can be written as:

$$Ln(Y_i) = \beta_0 + \beta_1 \ln(L_i) + \beta_2 \ln(K_i) + V_i - U_i \quad (5)$$

The Translog functional form can be written as:

$$Ln(Y_i) = \beta_0 + \beta_1 \ln(L_i) + \beta_2 \ln(K_i) + \frac{1}{2}\beta_3 \ln(L_i^2) + \frac{1}{2}\beta_4 \ln(K_i^2) + \beta_5 \ln(L_i) * \ln(K_i) + V_i - U_i \quad (6)$$

Where:

Y_i = Value added of the i^{th} firm[4]

L_i = Number of employees of the i^{th} firm

K_i = Net fixed assets of the i^{th} firm

V_i = Random error ($V_i \sim iid\ N(0, \sigma_V^2)$)

U_i = Non-negative random variable (or technical inefficiency) ($U_i \sim N(Z_i\delta, \sigma_u^2)$)

The Inefficiency Effects Model can be written as follows:

$$U_i = \sigma_0 + \sigma_1 S\&M_i + \sigma_2 Age_i + \sigma_3 Size_i + \sigma_4 Foreign_i + \sigma_5 Govt_i + \sigma_6 Municipality_i + \sigma_7 EXP_i + W_i \quad (7)$$

Where:

$S\&M_i$ = Dummy for small and medium enterprises;

$S\&M_i$ = 1 if firm *i* is a medium enterprise

= 0, otherwise

Age_i = Age of firm *i*, represented by the logarithm form of number of operating years

[4] See the Appendix for basic data descriptive statistics

$Size_i$ = Size of firm *i*, represented by the logarithm form of total number of employees

$Foreign_i$ = Dummy for foreign investment (ownership);

$Foreign_i$ = 1 if firm *i* has foreign investment (ownership).

= 0, otherwise

$Govt_i$ = Dummy for government support;

$GOVT_{it}$ = 1 if firm *i* receives Board of Investment (BOI) support.

= 0, otherwise

$Municipality_i$ = Dummy for firm location;

$Municipality_i$ = 1 if firm *i* is located in Bangkok

= 0, otherwise

EXP_i = Dummy for exporting intensity;

EXP_i = 1 if firm *i* exports more than 50 percent of its total sales revenue.

= 0, otherwise

W_i = Random error ($W_i \sim N(0, \sigma_W^2)$)

Basic descriptive statistics for all the variables mentioned above are provided in Appendix.

VI. HYPOTHESIS TESTS

Four null hypothesis tests are required to be conducted as follows: (i) the validation of the Cobb-Douglas production function, (ii) the absence of inefficiency effects, (iii) the absence of stochastic inefficiency effects, (iv) the insignificance of joint inefficiency variables (see Table 1). A likelihood-ratio test (LR test) is used to test these hypotheses, which can be conducted as follows:

$$\lambda = -2\{\log[L(H_0)] - \log[L(H_1)]\} \quad (8)$$

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_1), 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.

Table 1: Statistics for Hypothesis Tests of the Stochastic Frontier Model and Inefficiency Effects Model

	Aggregate Exporting SMEs	SMEs Exporting to ASEAN	SMEs Exporting to East Asia	SMEs Exporting to South Asia	SMEs Exporting to Oceania	SMEs Exporting to Europe	SMEs Exporting to North & South America	SMEs Exporting to Middle East & Africa
Null Hypothesis	**(1) No Cobb-Douglas (H_0:$\beta_2 = \beta_4 = \beta_5 = 0$)**							
LR Statistics	301.60	97.21	100.71	4.97	4.84	37.48	41.27	3.43
Critical Value	11.34*	11.34*	11.34*	11.34*	11.34*	11.34*	11.34*	11.34*
Decision	Reject	Reject	Reject	Do not Reject	Do not Reject	Reject	Reject	Do not Reject
Null Hypothesis	**(2) No technical inefficiency Effects (H_0:$\gamma = \delta_0 = \cdots = \beta_7 = 0$)**							
LR Statistics	179.73	93.02	30.96	54.38	18.90	103.00	49.59	26.39
Critical Value	20.97*	20.97*	20.97*	20.97*	16.27**	20.97*	20.97*	20.97*
Decision	Reject	Reject	Reject	Reject	Reject	Reject	Reject	Reject
Null Hypothesis	**(3) Non stochastic Inefficiency (H_0: $\gamma = 0$)**							
LR Statistics	124.09	16.37	6.21	16.04	1.47	11.04	14.23	4.25
Critical Value	5.41*	5.41*	5.41*	5.41*	5.41*	5.41*	5.41*	2.71**
Decision	Reject	Reject	Reject	Reject	Do not Reject	Reject	Reject	Reject
Null Hypothesis	**(4) No joint Inefficiency Variables (H_0:$\delta_1 = \delta_2 = \cdots = \delta_7 = 0$)**							
LR Statistics	71.54	59.63	7.54	29.99	-	82.82	22.63	19.11
Critical Value	14.07*	14.07*	14.07*	14.07*	-	14.07*	14.07*	14.07*
Decision	Reject	Reject	Do not Reject	Reject	-	Reject	Reject	Reject

Note: All critical values of the test statistic indicated by * and ** are presented at the 1% and 5% level of significance, obtained from a chi-square distribution, except those found in Hypotheses (2) and (3), which contain a mixture of a chi-square distributions, obtained from Table 1 of Kodde and Palm (1986).

From Table 1 the null hypothesis (i) is to test whether the Cobb-Douglas production function is adequate for Thai manufacturing and exporting SMEs[5]. Following Equations (5)

[5] The main reason to test for the best functional form between the Translog and Cobb-Douglas productions is because the production technology of each exporting SME group might be different, and therefore this hypothesis needs to be tested to obtain the appropriate production technology for each exporting SME group as this helps increase an accuracy in predicting their technical efficiency for this study.

and (6) the null hypothesis $(H_0 : \beta_3 = \beta_4 = \beta_5 = 0)$ is strongly rejected at the 1 percent level of significance, which indicates that the Cobb-Douglas production function is not an adequate specification for the case of Thai manufacturing and exporting SMEs in aggregate including SME groups exporting to ASEAN, East Asia, Europe, and North & South America, 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). The Translog production function, however, is an adequate specification for the groups of SMEs exporting to South Asia, Oceania, and Middle East & Africa. Hypotheses (ii) and (iii) involve the restriction that γ is equal to zero, which defines a point on the boundary of the parameter space (Coelli, 1996, p. 6).

The null hypothesis (ii) which specifies that the inefficiency effects are absent from the model $(\gamma = \delta_0 = \delta_1 \ldots = \delta_7 = 0)$ is strongly rejected at the 1 percent level of significance, which implies that the model of inefficiency effects exists for the case of Thai manufacturing and exporting SMEs in aggregate including all exporting SME groups.The null hypothesis (iii) that the inefficiency effects are not "stochastic" $(\gamma = 0)$ is strongly rejected for the case of Thai manufacturing and exporting SMEs and almost all exporting SME groups, except those exporting to OCEANIA. The rejection of this hypothesis indicates that the model of inefficiency effects is not reduced to a traditional mean response function. 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 is applicable, and therefore the estimated parameters can be identified in the model of inefficiency effects. The last null hypothesis that specifies inefficiency effects are not a linear function of all explanatory variables or all parameters of the explanatory variables are equal to zero $(H_0 : \delta_1 = \delta_2 = \cdots = \delta_7 = 0)$ is found for the case of Thai manufacturing and exporting SMEs including almost exporting SME groups, except the SME group exporting to East Asia.

Table 2: Maximum Likelihood Estimates for Parameters of the Stochastic Frontier Model and Inefficiency Effects Model

	Aggregate Exporting SMES	SMEs Exporting to ASEAN	SMEs Exporting to East Asia	SMEs Exporting to South Asia	SMEs Exporting to OCEANIA	SMEs Exporting to Europe	SMEs Exporting to N&S America	SMEs Exporting to Middle East & Africa
Stochastic Frontier Model								
Constant	15.2549*	16.3316*	11.5911*	9.4511*	7.6829*	20.7441*	20.1475*	10.2028*
	(0.6810)	(1.1847)	(1.2404)	(0.5627)	(0.8239)	(2.1968)	(2.1310)	(0.5167)
Ln (Labour)	1.6044*	1.4203*	2.2184*	0.4332*	0.9777*	0.9474	2.3576*	0.4476*
	(0.2034)	(0.2971)	(0.3206)	(0.1099)	(0.1367)	(0.6889)	(0.4842)	(0.1628)
Ln (Capital)	-0.6056*	-0.6753*	-0.3007**	0.3604*	0.3726*	-1.0821*	-1.3707*	0.3196*
	(0.0531)	(0.1182)	(0.1169)	(0.0441)	(0.0552)	(0.2575)	(0.2475)	(0.0501)
Ln (Labour)^2	-0.1479*	-0.3250*	-0.1078			0.4150*	-0.1296	
	(0.0452)	(0.0890)	(0.0958)			(0.1636)	(0.0886)	
Ln (Capital)^2	0.0636*	0.0550*	0.0541*			0.1206*	0.1199*	
	(0.0035)	(0.0059)	(0.0058)			(0.0195)	(0.0180)	
1/2ln(Labour)*ln(Capital)	-0.0277*	0.0253	-0.0699*			-0.1412*	-0.0754*	
	(0.0106)	(0.0194)	(0.0210)			(0.0343)	(0.0310)	
Inefficiency Effects Model								
Constant	4.3195*	6.0834*	-1.2632	3.3240		5.1640*	5.8039*	0.5276
	(0.4641)	(1.0879)	(1.9759)	(1.2433)		(1.1054)	(1.4691)	(0.9861)
Small & Medium Size (Dummy)	-1.1951*	-0.0642	2.4934*	-0.4168		-1.1044***	0.7557***	1.4946
	(0.2992)	(0.3273)	(0.7185)	(0.8565)		(0.6007)	(0.4417)	(0.9556)
Firm Age (Logarithm)	-0.3970*	-0.9729*	0.2077	-1.0802		0.3078**	-1.2525**	0.0723***
	(0.0930)	(0.3023)	(0.2206)	(0.7068)		(0.1439)	(0.4943)	(0.0418)
Firm Size (Logarithm)	-1.4840*	-1.1462*	-3.0318*	-0.4856		-1.2460*	-1.4441*	-0.4238***
	(0.2592)	(0.2847)	(0.6902)	(0.4742)		(0.3113)	(0.5442)	(0.2166)
Foreign Ownership (Dummy)	-3.6381*	-4.3591**	-0.4183	-3.7061*		-2.0492**	-1.7334**	-2.5208**
	(0.7342)	(1.7173)	(0.2850)	(1.4890)		(0.7885)	(0.8375)	(1.2339)
Government Support (Dummy)	-1.6312*	-1.9908*	2.5674*	0.2679		-0.2084	-2.7771**	-0.5390***
	(0.3374)	(0.5770)	(0.9199)	(0.7840)		(0.2397)	(1.1521)	(0.3145)
Municipality (Dummy)	-3.2003*	-1.5520*	-3.8944*	-1.2621		-1.2272*	-5.4884**	1.6249**
	(0.7363)	(0.5646)	(1.4458)	(0.8145)		(0.2815)	(2.6497)	(0.7853)
Export Intensity (Dummy)	0.0716	1.5383*	0.1623	2.4111*		-0.0399	-1.3939**	-4.4007
	(0.0869)	(0.5999)	(0.2512)	(0.8307)		(0.2031)	(0.6752)	(2.7740)
Sigma-squared	3.7776*	2.4908*	5.5077*	0.9484*	1.3552*	1.1421*	4.5943*	1.5297*
	(0.6670)	(0.4655)	(1.3025)	(0.2058)	(0.5203)	(0.1939)	(1.6527)	(0.4107)
Gamma	0.8515*	0.7744*	0.8811*	0.7760*	0.7402*	0.5804	0.9019*	0.7618*
	(0.0275)	(0.0436)	(0.0284)	(0.0602)	(0.2511)	(0.0945)	(0.0367)	(0.0972)

Note: Standard errors are in brackets; *, ** and *** indicate that the coefficients are statistically significant at 1% ,5%, and 10%, respectively.

VII. RESULTS

The Stochastic Frontier Model

Maximum likelihood estimates for parameters of the stochastic frontier model and inefficiency effects model, as specified by equations (5), (6), and (7), were estimated simultaneously with the econometric package Frontier 4.1. Focusing on the Cobb - Douglas production function the estimates of both labour (β_1) and capital (β_2) inputs are found to be significantly positive for the groups of SMEs exporting to South Asia, Oceania, and Middle East & Africa. The estimates for parameters of labour (β_1) and capital (β_2) inputs for Cobb-Douglas production function readily indicates the output elasticities of labour and capital inputs.

The output elasticity of labour is obviously higher than the output elasticity of capital as shown in Tables 2 and 3, indicating that Thai SMEs exporting to South Asia, Oceania, and Middle East & Africa rely more on labour intensive or low value-adding activities to increase their output. Focusing on the Translog production function the estimates of the labour (β_1) and capital (β_2) inputs are found to be significantly positive and negative, respectively, for Thai manufacturing and exporting manufacturing enterprises in aggregate, including the groups of SMEs exporting to ASEAN, East Asia, Europe, and North & South America. Theoretically, the expected sign of the capital coefficient should be positive[6].

Unlike the Cobb-Douglas production function, a negative sign of 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;

[6] This is a problem which is typical for the Translog functional form.

Tran *et al*., 2008). For the Translog production function the output elasticities of labour and capital inputs indicated in Table 3, therefore, are meaningful in analyzing what kind of inputs are used to increase output.

Table 3: Output Elasticities of Capital and Labour Inputs and Returns to Scale of Thai Manufacturing and Exporting SMEs

	WORLD*	ASEAN*	EAST* ASIA	SOUTH ASIA**	OCEANIA**	EUROPE*	N&S AMERICA*	MIDDLE EAST & AFRICA**
$\partial ln(Y_i)/\partial ln(K_i)$	0.3445	0.3606	0.3327	0.3604	0.3726	0.2895	0.26205	0.3196
$\partial ln(Y_i)/\partial ln(L_i)$	0.5392	0.5420	0.5873	0.4332	0.8239	0.3592	0.25913	0.4476
Returns to Scale	0.8837	0.9027	0.9200	0.7935	1.1965	0.6487	0.52118	0.7672

Note: * For the Translog production function as shown in Equation 6 returns to scale is calculated as the sum of the elasticity of output with respect to capital input ($\partial ln(Y_i)/\partial ln(K_i) = \beta_2+\beta_4 ln(K_i)+\beta_5 ln(L_i)$) and the elasticity of output with respect to labour input ($\partial ln(Y_i)/\partial ln(L_i) = \beta_1+\beta_3 ln(Li)+\beta_5 ln(K_i)$). **With respect to the Cobb-Douglas production function as shown in Equation 5 returns to scale is calculated the sum of the elasticity of output with respect to capital input ($\partial ln(Y_i)/\partial ln(K_i) = \beta_2$) and the elasticity of output with respect to labour input ($\partial ln(Y_i)/\partial ln(L_i) = \beta_1$) .

Focusing on the Translog production function SMEs exporting to South Asia, Oceania, and Middle East & Africa rely more on labour to increase their output. This suggests that the over-reliance on labour could lead to a low cost labour trap, which causes difficulty for Thai exporting and manufacturing firms to move up the value chain and enhance their competitiveness as suggested in Le and Havie (2010). The sum of the output elasticities of labour and capital inputs, given by 0.8837[7], indicates the existence of decreasing returns to scale for the production of Thai manufacturing and exporting SMEs in aggregate, including SMEs exporting to ASEAN (0.9027), East Asia (0.9200), South Asia (0.7935), Europe (0.6487), North & South America (0.5212), and Middle East & Africa (0.7672) (see Kim (1992)). The production of Thai manufacturing SMEs exporting to Oceania, however, is found to have increasing returns to scale (1.1965).

[7] According to Equation (5), returns to scale is calculated as the sum of the elasticity of output with respect to capital input ($\partial ln(Y_i)/\partial ln(K_i) = \beta_2+\beta_4\ ln(K_i)+\beta_5 ln(L_i)$) and the elasticity of output with respect to labour input ($\partial ln(Y_i)/\partial ln(L_i) = \beta_1+\beta_3 ln(L_i)+\beta_5 ln(K_i)$).

Table 4: Technical Efficiency of Thai Manufacturing and Exporting SMEs Classified by Each Exporting Country and Region

	Average Technical Efficiency (TE)	Number of SMES	Minimum TE	Maximum TE	Standard Deviation TE
I. SMEs Exporting to ASEAN					
1. Brunei Darussalam	0.7277	2	0.7875	0.6680	0.0845
2. Cambodia	0.6544	68	0.8556	0.0490	0.1656
3. Indonesia	0.7229	77	0.8620	0.3448	0.1206
4. Lao People's Democratic Republic	0.6081	48	0.8469	0.0281	0.2065
5. Malaysia	0.7208	252	0.8828	0.0894	0.1097
6. Myanmar	0.7231	58	0.8837	0.0506	0.1546
7. Philippines	0.6928	47	0.8588	0.4001	0.1184
8. Singapore	0.7010	185	0.8901	0.0339	0.1625
9. Viet Nam	0.7209	120	0.8754	0.4312	0.0969
SMEs Exporting to ASEAN (1-9)	0.7038	857	0.8901	0.0281	0.1398
II.SMEs Exporting to East Asia					
1. China	0.6824	197	0.8638	0.2197	0.1219
2. Democratic People's Republic of Korea	0.7128	16	0.8131	0.5124	0.0980
3. Hong Kong Special Administrative Region of China	0.7207	69	0.8689	0.4235	0.0933
4. Japan	0.7267	486	0.9083	0.0256	0.1304
5. Macao Special Administrative Region of China	0.6538	2	0.7962	0.5114	0.2013
6. Republic of Korea	0.6415	31	0.8473	0.2769	0.1475
7. Taiwan	0.6825	107	0.8735	0.0582	0.1436
SMEs Exporting to East Asia (1-7)	0.7081	908	0.9083	0.0256	0.1299
III.SMEs Exporting to South Asia					
1. Bangladesh	0.7572	15	0.8447	0.6446	0.0567
2. India	0.6931	57	0.8033	0.1283	0.1418
3. Maldives	0.6614	7	0.7514	0.5994	0.0651
4. Nepal	0.7789	1	0.7789	0.7789	
5. Pakistan	0.6037	18	0.7728	0.0969	0.1509
6. Sri Lanka	0.6593	12	0.8173	0.4106	0.1277
7. Tajikistan	0.7343	1	0.7343	0.7343	
SMEs Exporting to South Asia (1-7)	0.6828	111	0.8447	0.0969	0.1344
IV. SMEs Exporting to Europe					
1. Andorra	0.2482	1	0.2482	0.2482	
2. Austria	0.7372	11	0.8078	0.6091	0.0714
3. Belgium	0.6974	12	0.7993	0.4726	0.1075
4. Bosnia and Herzegovina	0.8167	2	0.8287	0.8046	0.0170
5. Bulgaria	0.5194	3	0.7182	0.1797	0.2956
6. Croatia	0.1722	2	0.2442	0.1002	0.1018
7. Cyprus	0.8102	1	0.8102	0.8102	
8. Czech Republic	0.7551	1	0.7551	0.7551	
9. Denmark	0.6708	7	0.8511	0.5099	0.1068
10. Estonia	0.7644	1	0.7644	0.7644	
11. Finland	0.6736	6	0.8205	0.2777	0.2090
12. France	0.6349	84	0.8516	0.0782	0.1761
13. Germany	0.6920	107	0.8667	0.0167	0.1501

14. Greece	0.6826	11	0.7688	0.3510	0.1258
15. Hungary	0.6694	2	0.7667	0.5722	0.1375
16. Iceland	0.3267	1	0.3267	0.3267	
17. Ireland	0.7643	2	0.8138	0.7147	0.0700
18. Italy	0.6337	47	0.8439	0.0908	0.1833
19. Netherlands	0.7312	21	0.8571	0.3200	0.1225
20. Netherlands Antilles	0.7936	2	0.8490	0.7382	0.0783
21. New Caledonia	0.4225	1	0.4225	0.4225	
22. Norway	0.7205	6	0.7835	0.6526	0.0572
23. Poland	0.7465	4	0.7841	0.6895	0.0402
24. Portugal	0.6383	2	0.6704	0.6062	0.0454
25. Romania	0.6981	2	0.7021	0.6941	0.0057
26. Russian Federation	0.6514	12	0.8134	0.2920	0.1416
27. Spain	0.7184	30	0.8593	0.4111	0.1056
28. Sweden	0.7150	16	0.8476	0.4341	0.1069
29. Switzerland	0.6787	24	0.8510	0.0898	0.1989
30. Turkey	0.7186	6	0.8441	0.5775	0.1098
31. Ukraine	0.7156	3	0.7614	0.6634	0.0493
32. United Kingdom Britain and Northern Ireland	0.6840	97	0.8784	0.2408	0.1344

	Average Technical Efficiency (TE)	Number of SMES	Minimum TE	Maximum TE	Standard Deviation TE
SMEs Exporting to Europe (1-32)	0.6764	527	0.8784	0.0167	0.1552
V. SMEs Exporting to OCEANIA					
1. Australia	0.6953	69	0.8707	0.1063	0.1634
2. New Zealand	0.7154	10	0.8142	0.4635	0.1116
SMEs Exporting to OCEANIA	0.6979	79	0.8707	0.1063	0.1573
VI. SMEs Exporting to North & South America					
1. Brazil	0.5294	3	0.6845	0.4500	0.1343
2. Canada	0.6402	26	0.8805	0.1603	0.1638
3. Chile	0.6774	1	0.6774	0.6774	
4. Colombia	0.7184	3	0.8204	0.5737	0.1288
5. Guatemala	0.8462	1	0.8462	0.8462	
6. Honduras	0.8525	1	0.8525	0.8525	
7. Mexico	0.7347	8	0.7667	0.6595	0.0356
8. Panama	0.7846	5	0.8529	0.7224	0.0543
9. Paraguay	0.6283	1	0.6283	0.6283	
10. United States of America	0.7030	471	0.8785	0.0201	0.1280
11. United States Virgin Islands	0.6844	3	0.7583	0.6474	0.0640
12. Venezuela	0.7182	1	0.7182	0.7182	
SMEs Exporting to North & South America (1-12)	0.7005	524	0.8805	0.0201	0.1294
VII. SMEs Exporting to Middle East & Africa					
1. Afghanistan	0.5328	1	0.5328	0.5328	
2. Congo	0.6674	1	0.6674	0.6674	

3. Egypt	0.6134	12	0.8001	0.2967	0.1599
4. Ghana	0.7596	2	0.7863	0.7329	0.0378
5. Iran (Islamic Republic of)	0.6525	7	0.8185	0.3842	0.1475
6. Israel	0.6515	13	0.8402	0.0362	0.2558
7. Jordan	0.7193	3	0.7427	0.6725	0.0405
8. Kuwait	0.7228	4	0.7518	0.6880	0.0263
9. Lebanon	0.5731	2	0.6289	0.5173	0.0789
10. Libyan Arab Jamahiriya	0.5915	1	0.5915	0.5915	
11. Mauritius	0.8203	1	0.8203	0.8203	
12. Nigeria	0.6601	11	0.7851	0.3894	0.1307
13. Occupied Palestinian Territory	0.6003	1	0.6003	0.6003	
14. Qatar	0.7843	3	0.7970	0.7779	0.0110
15. Saudi Arabia	0.6889	23	0.8381	0.3434	0.1178
16. South Africa	0.7304	9	0.8183	0.5763	0.0718
17. Syrian Arab Republic	0.8208	1	0.8208	0.8208	
18. United Arab Emirates	0.6595	61	0.8380	0.0872	0.1484
19. Yemen	0.6712	5	0.8477	0.2662	0.2322
20. Zimbabwe	0.4431	1	0.4431	0.4431	
SMEs Exporting to Middle East and Africa (1-20)	0.6679	162	0.8477	0.0362	0.1491
VIII. SMEs Exporting to All Regions	0.6972	3168	0.9083	0.0167	0.1393

As shown in Table 4, Thai manufacturing and exporting SMEs operated at a moderate level of technical efficiency, since aggregate manufacturing and exporting SMEs have mean technical efficiency of 0.6972 (69.72 percent). With respect to each group of manufacturing and exporting SMEs, SMEs exporting to East Asia have a level of technical efficiency of 0.7081, followed by SMEs exporting to ASEAN (0.7038), North & South America (0.7005), OCEANIA (0.6979), South Asia (0.6828), Europe (0.6764), and Middle East & Africa (0.6679). More specifically, the average technical efficiencies of SMEs exporting to South Asia, Europe, and Middle East & Africa are lower than the average technical efficiency of Thai manufacturing and exporting SMEs in aggregate. Focusing on each of the exporting SME groups, SMEs exporting to Japan have the highest number of firms among SMEs exporting to East Asia accounting for 53.52 percent of the total number of SMEs exporting to East Asia. Their average technical efficiency is 0.7267.

Thai manufacturing SMEs exporting to Malaysia also have the highest number of firms in the SME group exporting to ASEAN, accounting for 29.40 percent of total SMEs exporting to ASEAN. Their average technical efficiency is 0.7208 (or 53.49 percent). For the SME group exporting to North & South America the number of Thai SMEs exporting to the United States of America are the highest with an average technical efficiency at 0.7030, accounting for 89.89 percent of total SMEs exporting to North & South America. In addition, Thai manufacturing SMEs exporting to Australia are found to have the highest number of firms in the SME group exporting to OCEANIA, accounting for 87.34 percent of the total number of SMEs exporting to OCEANIA. The average technical efficiency of SMEs exporting to Australia is 0.6953.

Thai manufacturing SMEs exporting to India, Germany, and the United Arab Emirates also have the highest number of firms in the SME group exporting to South Asia, Europe, and Middle East & Africa, respectively. Thai manufacturing SMEs exporting to India account for 51.35 percent of total SMEs exporting to South Asia with an average technical efficiency of 0.8033. Focusing on the SME group exporting to Europe Thai manufacturing SMEs exporting to Germany account for 20.30 percent of total SMEs exporting to Europe, and their average technical efficiency is 0.6920. Finally, those SMEs exporting to the United Arab Emirates account for 37.65 percent of total SMEs exporting to Middle East & Africa, and their average technical efficiency is 0.8380.

Inefficiency Effects Model

The Maximum Likelihood Estimations (MLE), estimated by FRONTIER 4.1, also provides estimates of the variance parameters sigma-squared (σ^2) and gamma (γ). The estimated variance parameter sigma - squared (σ^2) indicates the possibility of a firm to become inefficient. The estimated variance parameter gamma (γ) determines that all variations of the frontier are caused by random error or technical inefficiency. From Table 2

the variance parameter sigma - squared (σ^2) is statistically different from zero at the 0.01 level of significance, ranging from 0.95 to 5.51. This indicates that all Thai manufacturing and exporting SMEs are not technically efficient. In addition, the value of the variance parameter gamma (γ) is statistically different from zero at the 0.01 level of significance for all Thai manufacturing and exporting SMEs, except the SME group exporting to Europe, which ranges from 0.58 to 0.88. This suggests that technical inefficiency explains 58 percent to 88 percent of the total variation from the frontier.

From Table 2 medium sized enterprises are found to perform better than small sized enterprises for Thai manufacturing and exporting SMEs in aggregate as well as for the SME group exporting to Europe. This result is also consistent with another finding that firm size has a significant and positive effect on technical efficiency for the case of Thai manufacturing exporting SMEs in aggregate and the SME group exporting to Europe, which implies that large firms benefit from economies of scale. This evidence is also similar to the finding of Alvarez and Crespi (2003). The ambiguous evidence, however, is found for other exporting SME groups, except those exporting to OCEANIA[8] due to the conflicting results found in these two firm-specific variables (the dummy variable for medium-sized enterprises and the firm-size variable).

Firm age is also found to have a significant and positive effect on technical efficiency for Thai manufacturing and exporting SMEs in aggregate and the SME groups exporting to ASEAN and North & South America, indicating that learning-by-doing is an important factor in enhancing their technical efficiency. This evidence is consistent with the finding of Burki and Terrell (1998). The significant and negative association between firm age and technical

[8] The inefficiency effects model is not applicable for the case of the SME group exporting to OCEANIA (see Table 1).

efficiency, however, is found for the SME groups exporting to Europe and Middle East & Africa, which is similar to the result of Le and Harvie (2010), implying that young firms are likely to benefit more from advanced technology rather than from a "learning by doing" process. An insignificant result is found for other exporting SME groups.

Foreign investment (via the form of ownership) is also found to have a significant and positive association with a firm's technical efficiency for aggregate exporting SMEs as well as the SME groups exporting to ASEAN, South Asia, Europe, North & South America, and Middle East & Africa. This result is also consistent with the finding of Fukuyama *et al*. (1999), Goldar *et al*. (2003), and Bottasso and Sembenelli (2004), implying that foreign investment can bring superior technology, managerial expertise, good corporate governance, and strong foreign - market networks, leading to an improvement of Thai manufacturing and exporting SMEs' technical efficiency. An insignificant result, however, is found for the case of SMEs exporting to East Asia.

SMEs receiving government assistance are found to have higher technical efficiency compared with their counterparts that receive no government assistance for the case of Thai manufacturing and exporting SMEs in aggregate, as well as the SME groups exporting to ASEAN, North & South America, and Middle East & Africa. This result implies that SMEs are likely to benefit from government assistance via the Board of Investment's financial assistance in the form of income tax exemption or reduction, and exemption from import duty on essential raw materials. In addition, this finding is consistent with the findings of Tran *et al*. (2008) and Le and Harvie (2010). A significant and negative result, however, is found for the case of SMEs exporting to East Asia.

In addition, SMEs located in municipality areas are found to have higher technical efficiency compared with their counterparts located in non - municipality areas for the case of

Thai manufacturing and exporting SMEs including the SME group exporting to ASEAN, East Asia, Europe, North & South America, and Middle East & Africa. This result is similar with Tran *et al*. (2008), indicating that metropolitan areas are likely to have higher technical efficiency due to a higher level of technical, managerial training, educational level, and market opportunities than their counterparts in non metropolitan areas. An insignificant result, however, is also for the SME group exporting to South Asia. Finally, SMEs with high export intensity are found to have higher technical efficiency than those SMEs with low export intensity for the case of SMEs exporting to North & South America. This finding is consistent with the evidence found by Granér and Isaksson (2007). For the SME group exporting to ASEAN and South Asia SMEs with low export intensity, however, they are found to have higher technical efficiency than those SMEs with high export intensity.

VIII. CONCLUSIONS AND RECOMMENDATIONS

Thai business segments, particularly SMEs, are now experiencing the "*Nut - Cracker Effect*". This effect indicates that Thailand is not fully competitive and now stuck between countries which benefit from greater price competitiveness, such as China, Vietnam and Indonesia, and countries which can differentiate their outputs by concentrating in higher value-added products and services as well as more skilled labour and higher productivity activities , such as Japan, South Korea and Taiwan (OSMEP, 2007).

The results of the estimated output elasticities of capital and labour inputs suggest that Thai manufacturing and exporting SMEs traditionally rely on labour rather than capital to increase their output, including almost all exporting SME groups, except those exporting to North & South America. This causes difficulty for Thai manufacturing and exporting firms to move up the value chain and improve their competitiveness due to over-reliance on labour, resulting in a low cost labour trap. Furthermore, the production of Thai manufacturing and

exporting firms exhibit decreasing returns to scale (0.8837), including the production of SMEs exporting to ASEAN (0.9027), East Asia (0.9200), South Asia (0.7935), Europe (0.6487), North & South America (0.52118), and Middle East & Africa (0.7672). However, evidence of increasing returns to scale is only found for the production of manufacturing SMEs exporting to OCEANIA. Moreover, Thai manufacturing and exporting SMEs operate at a moderate level of technical efficiency (0.6972). Comparing among exporting SME groups, SMEs exporting to East Asia obtain the highest level of technical efficiency (0.7081), followed by SMEs exporting to ASEAN (0.7038), North & South America (0.7005), OCEANIA (0.6979), South Asia (0.6828), Europe (0.6764), and Middle East & Africa (0.6679).

These results imply that Thai manufacturing and exporting SMEs should focus on improving input efficiencies (e.g., more skilled labour) to enable them to operate on their most efficient production frontier given the current state of technology in increasing output. In particular, the utilization of improved technology would shift the existing production frontier outward. In other words, upgrading technology enables them to move up the value chain, avoid the labour - intensive production, and low value-added trap as suggested by Le and Harvie (2010). The differing levels of technical efficiency across SMEs exporting to each region suggest that specific policies should be addressed for each exporting SME group.

Empirical results from the inefficiency effects model indicate that the variables representing medium sized enterprises and firm size are positively and significantly correlated with the technical efficiency of aggregate manufacturing and exporting SMEs and for the SME group exporting to Europe. Increased firm size and growth, therefore, should be encouraged since larger firms can benefit from economies of scale and scope, reduced production costs, improved efficiency and competitiveness (Phan 2004). More specifically,

policy implications in terms of access to inputs (e.g., finance and skilled labour) needs to be implemented to facilitate firm growth. Firm age is positively and significantly correlated with the technical efficiency of aggregate manufacturing and exporting SMEs and for the SME groups exporting to ASEAN and North & South America. Policy implications which help facilitate new firm start-ups need to be encouraged to increase their technical efficiency performance.

Foreign investment (via the form of ownership) is positively and significantly associated with the technical efficiency of aggregate manufacturing and exporting SMEs and for the SME groups exporting to ASEAN, South Asia, Europe, North & South America, and Middle East & Africa. Government policy should encourage greater foreign investment through tax and non - tax privileges and stabilizing the country's political and economic conditions.

Location in a municipal area is also positively and significantly correlated with the technical efficiency of aggregate manufacturing and exporting SMEs including the SME group exporting to ASEAN, East Asia, Europe, North & South America, and Middle East & Africa. Specific government policy measures need to be implemented to enhance the development of SMEs in the rural area since agglomeration benefits are mostly in the urban area, which is likely to make it difficult to encourage SME development in non municipal or rural areas. Government assistance is also significantly and positively correlated with the technical efficiency of aggregate Thai manufacturing and exporting SMEs and for the SME groups exporting to ASEAN, North & South America, and Middle East & Africa. Therefore, the government’s SME development strategy should still continue to provide financial and non-financial support (via tax and non-tax privileges) from the Board of Investment (BOI).

Finally, SMEs with high export intensity are found to have higher technical efficiency than those SMEs with low export intensity for the case of SMEs exporting to North & South America. This finding is consistent with the evidence found by Granér and Isaksson (2007). For the SME group exporting to ASEAN and South Asia, SMEs with low export intensity, however, are found to have higher technical efficiency than those SMEs with high export intensity.

Appendix: Basic Data Descriptive Statistics

SMEs Exporting to All Regions	Ln(Value Added)	Ln(Capital)	Ln(Labour)	Small & Medium Sized Enterprises	Firm Size	Ln (Firm Size)	Age	Ln(Age)	Municipality	Government Assistance	Export Intensity	Foreign Ownership
Mean	17.0112	16.7146	4.0663	0.5855	79.4703	4.0663	14.4937	2.4508	0.5543	0.8321	0.4214	0.2623
Median	17.0736	16.8093	4.1744	1.0000	65.0000	4.1744	13.0000	2.5649	1.0000	1.0000	0.0000	0.0000
Maximum	22.5798	24.4609	5.2983	1.0000	200.0000	5.2983	88.0000	4.4773	1.0000	1.0000	1.0000	1.0000
Minimum	9.7517	1.0986	0.6931	0.0000	2.0000	0.6931	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.4406	1.8700	0.8723	0.4927	54.9597	0.8723	9.5796	0.7156	0.4971	0.3739	0.4939	0.4400
Observations	3168	3168	3168	3168	3168	3168	3168	3168	3168	3168	3168	3168
SMEs Exporting to ASEAN												
Mean	17.1578	16.9653	4.0262	0.5659	76.4352	4.0262	15.4971	2.5300	0.5543	0.8541	0.1914	0.2544
Median	17.1465	17.1031	4.1271	1.0000	62.0000	4.1271	14.0000	2.6391	1.0000	1.0000	0.0000	0.0000
Maximum	22.5798	23.9346	5.2983	1.0000	200.0000	5.2983	88.0000	4.4773	1.0000	1.0000	1.0000	1.0000
Minimum	9.7517	1.6094	0.6931	0.0000	2.0000	0.6931	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.5309	1.9440	0.8737	0.4959	53.5935	0.8737	9.7932	0.7053	0.4973	0.3532	0.3936	0.4358
Observations	857	857	857	857	857	857	857	857	857	857	857	857
SMEs Exporting to East Asia												
Mean	17.1987	17.0066	4.0950	0.5969	81.0914	4.0950	13.8689	2.4177	0.4769	0.8822	0.4725	0.3645
Median	17.2342	17.2021	4.2485	1.0000	70.0000	4.2485	12.0000	2.4849	0.0000	1.0000	0.0000	0.0000
Maximum	21.2448	24.4609	5.2983	1.0000	200.0000	5.2983	59.0000	4.0775	1.0000	1.0000	1.0000	1.0000
Minimum	11.0877	1.0986	1.0986	0.0000	3.0000	1.0986	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.3961	1.8974	0.8561	0.4908	55.2868	0.8561	9.1753	0.6817	0.4997	0.3226	0.4995	0.4816
Observations	908	908	908	908	908	908	908	908	908	908	908	908
SMEs Exporting to South Asia												
Mean	16.8338	16.7795	3.9635	0.5135	68.3874	3.9635	15.1802	2.5055	0.5315	0.7658	0.1351	0.1892
Median	17.0123	16.9389	3.9703	1.0000	53.0000	3.9703	15.0000	2.7081	1.0000	1.0000	0.0000	0.0000
Maximum	19.0205	19.7309	5.2832	1.0000	197.0000	5.2832	51.0000	3.9318	1.0000	1.0000	1.0000	1.0000
Minimum	11.6952	12.1414	0.6931	0.0000	2.0000	0.6931	3.0000	1.0986	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.1760	1.4925	0.7993	0.5021	46.6765	0.7993	9.7002	0.6921	0.5013	0.4254	0.3434	0.3934
Observations	111	111	111	111	111	111	111	111	111	111	111	111

SMEs Exporting to OCEANIA	Ln(Value Added)	ln(Capital)	ln(Labour)	Small & Medium Sized Enterprises	Firm Size	ln(Firm Size)	Age	ln(Age)	Municipality	Government Assistance	Export Intensity	Foreign Ownership
Mean	17.2489	16.9777	4.1334	0.6076	85.4430	4.1334	14.1772	2.4839	0.5190	0.7468	0.3544	0.2152
Median	17.2057	17.0559	4.3694	1.0000	79.0000	4.3694	13.0000	2.5649	1.0000	1.0000	0.0000	0.0000
Maximum	20.9202	21.4099	5.2933	1.0000	199.0000	5.2933	33.0000	3.4965	1.0000	1.0000	1.0000	1.0000
Minimum	11.7019	12.1777	1.6094	0.0000	5.0000	1.6094	2.0000	0.6931	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.7477	2.1056	0.8843	0.4914	58.6458	0.8843	7.4640	0.6303	0.5028	0.4376	0.4814	0.4136
Observations	79	79	79	79	79	79	79	79	79	79	79	79
SMEs Exporting to Europe												
Mean	16.6489	16.1465	4.0771	0.5901	80.8710	4.0771	13.9829	2.3886	0.6376	0.7932	0.5769	0.1973
Median	16.7891	16.3278	4.1589	1.0000	64.0000	4.1589	12.0000	2.4849	1.0000	1.0000	1.0000	0.0000
Maximum	20.4643	21.3615	5.2983	1.0000	200.0000	5.2983	81.0000	4.3944	1.0000	1.0000	1.0000	1.0000
Minimum	11.0744	9.2965	0.6931	0.0000	2.0000	0.6931	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.4022	1.7835	0.8901	0.4923	56.0959	0.8901	10.4140	0.7465	0.4812	0.4054	0.4945	0.3984
Observations	527	527	527	527	527	527	527	527	527	527	527	527
SMEs Exporting to North & South America												
Mean	16.9704	16.5086	4.1443	0.6412	85.8378	4.1443	14.4428	2.4373	0.5744	0.7939	0.6317	0.2252
Median	17.0881	16.5870	4.3306	1.0000	76.0000	4.3306	14.0000	2.6391	1.0000	1.0000	1.0000	0.0000
Maximum	20.7820	21.7895	5.2983	1.0000	200.0000	5.2983	50.0000	3.9120	1.0000	1.0000	1.0000	1.0000
Minimum	10.4012	10.8198	1.0986	0.0000	3.0000	1.0986	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.3289	1.6830	0.8908	0.4801	56.6826	0.8908	9.1738	0.7560	0.4949	0.4049	0.4828	0.4181
Observations	524	524	524	524	524	524	524	524	524	524	524	524
SMEs Exporting to Middle East & Africa												
Mean	16.5013	16.0931	3.8690	0.4691	65.9691	3.8690	14.1975	2.4105	0.6852	0.7716	0.3951	0.1358
Median	16.5702	16.0838	3.8712	0.0000	48.0000	3.8712	11.0000	2.3979	1.0000	1.0000	0.0000	0.0000
Maximum	20.1500	20.1196	5.2983	1.0000	200.0000	5.2983	46.0000	3.8286	1.0000	1.0000	1.0000	1.0000
Minimum	11.4031	11.4076	1.7918	0.0000	6.0000	1.7918	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev.	1.3189	1.6469	0.8463	0.5006	50.6539	0.8463	9.6490	0.7459	0.4659	0.4211	0.4904	0.3436
Observations	162	162	162	162	162	162	162	162	162	162	162	162

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