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Keywords
efficiency, technical, thai, performance, manufacturing, medium, enterprises, small, sized

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Technical Efficiency Performance of Thai Manufacturing Small and Medium Sized Enterprises

Teerawat Charoenrat [a] Charles Harvie [b]

Abstract

This paper employs a stochastic frontier production function and technical inefficiency effects model to measure and explain the technical efficiency of Thai manufacturing small and medium sized enterprises (SMEs). Cross-sectional firm-level data from the industrial census conducted in 2007 is used. A simple average technical efficiency levels in all categories of manufacturing SMEs analysed in 2007 is found to be low, indicating a high degree of technical inefficiency in the production process. Despite reform measures aimed at improving firm performance, Thai manufacturing SMEs have remained predominantly labour intensive. The technical inefficiency effects model reveals that firm size, firm age, skilled labour, firm location, ownership type, foreign investment and exporting are key factors contributing to SME technical efficiency. The paper concludes that government policy have been largely ineffective and should place more attention on creating an enabling environment to foster SME growth, enhance technology and encourage the development of an environment, infrastructure and facilities conducive to enhancing the business operation of SMEs in order to enhance their technical efficiency.

Keywords: Technical Efficiency; Technical Inefficiency Effects Model; Stochastic Frontier Analysis (SFA); Manufacturing Small and Medium Sized Enterprises (SMEs)

JEL classification: C31, G01, L6

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1. Introduction

Small and medium sized enterprises (SMEs) play a significant role in the economic and social development of many developing economies (Newby, 2006; Harvie, 2007, 2008b; Doern, 2009; Le and Harvie, 2010), and this is no less so than for the case of Thailand. Thai SMEs represent 99 percent of business establishments in the country, employ more than seven million workers, equivalent to 73 percent of total employment, and contributed around 39 percent of total GDP at current prices in 2009 (Office of Small and Medium Enterprises Promotion, 2009). Average annual real output growth of SMEs was 3.91 percent over the period 1999-2009 (Office of Small and Medium Enterprises Promotion, 2009). They are particularly dense in Bangkok and its vicinity, accounting for around 30 percent of total SMEs. Consequently, their development and ability to sustain competitiveness in an increasingly integrated regional and global economy is critical for the sustained social and economic development of the country (Brimble et al., 2002; Mephokee, 2003; Sahakijpicharn, 2007; Office of Small and Medium Enterprises Promotion, 2009). In this context it is a mute point to analyse the contemporary performance of the SME sector in Thailand. Subsequent reforms aimed to put the economy on a sustainable path to growth and development, focusing on improving the regulatory and supervisory environment of the financial system, improving corporate sector governance and transparency, improving firm competitiveness and performance, embracing foreign ownership and involvement in the corporate and financial sectors, and developing firm capacity to take advantage of market opportunities arising from regional and global economic integration.

However, there is a little evidence on Thailand's manufacturing SMEs particularly in terms of their technical efficiency, and the key factors affecting SME inefficiency. The primary motivation of this study is to identify why Thai manufacturing SMEs are under-performing in terms of their output and the technical efficiency, and investigate firm-specific factors that are influencing the relatively poor performance of manufacturing SMEs. This paper is the first empirical study to use Stochastic Frontier Analysis (SFA) to measure and analyse the technical efficiency performance of Thai manufacturing SMEs. In addition, firm-specific factors affecting technical efficiency are identified. Such an empirical analysis has not been conducted before for Thai manufacturing SMEs, and this study aims to rectify this gap by: 1) empirically estimating the level of technical efficiency of Thai manufacturing SMEs in 2007 in five categories: by aggregate manufacturing SMEs, by size of manufacturing SMEs (small and medium), by non-exporting market intensity and by export intensity 2) empirically estimating firm-specific factors and explanatory variables influencing the technical inefficiency of Thai manufacturing SMEs in 2007 for each of the above five categories. Potential firm-specific factors contributing to the technical inefficiency of Thai manufacturing SMEs

based upon the literature are: firm size, firm age, skilled labour, firm location (municipal and non-municipal areas), region (i.e., Bangkok, central and vicinity, Northern and North-eastern provinces), type of ownership (i.e., individual proprietor, juristic partnership, limited liability, government and state, and co-operative), foreign ownership or investment, export intensity and government assistance (via the Board of Investment (BOI)); 3) and identifying policies to improve the technical efficiency of Thai manufacturing SMEs. The analysis is conducted using firm-level data obtained from the 2007[1] industrial census[2], conducted by the National Statistical Office (NSO) of Thailand, containing 73,931 observations (the National Statistical Office of Thailand, 2010b).

The structure of the paper is as follows. Section 2 provides a brief review of the contribution of manufacturing SMEs to the economy. Section 3 describes the methodology and data utilised in this study. Section 4 presents the results from four hypothesis tests. Section 5 presents the empirical results from SFA and the technical inefficiency effects model. An interpretation of the empirical results and implications for policy are presented in Section 6. Finally, policy implications and conclusions are presented in Section 7.

2. An overview of Thai Manufacturing SMEs

2.1 Definition of manufacturing SMEs

The most common means of defining an SME are number of employees or the level of fixed assets (Office of Small and Medium Enterprises Promotion, 2002; Sahakijpicharn, 2007). The Ministry of Industry (MOI) of Thailand Regulation of 11 September 2002 adopted employment or fixed assets, excluding land, as criteria in defining SMEs (Brimble et al., 2002; Office of Small and Medium Enterprises Promotion, 2003). Hence, an enterprise employing less than or equal to 50 workers, or fixed assets, excluding land, not exceeding THB 50 million (approximately US$1.65 million) in the manufacturing sector is considered a small enterprise. An enterprise employing between 51-200 workers or fixed assets, excluding land, between THB 51-200 million (approximately US$1.68 - 6.6 million) is defined as a medium-sized enterprise (Mephokee, 2003; Office of Small and Medium Enterprises Promotion, 2003).

The average number of Thai manufacturing SMEs during the period 1994[3] to 2009 was approximately 460,002 or 27.1 percent of total SMEs. They employed, on average, around 2,630,800

[1] Substantive data is more readily available for manufacturing SMEs in Thailand. Particularly firm level industrial census data is produced every 10 years.

[2] The 2007 industrial census firm-level data covered the operations of firms from 1st January 2006 to 31st December 2006 (the National Statistical Office of Thailand, 2010b).

[3] The first year in which statistics on SMEs were compiled in Thailand.

workers over the period 1994 to 2009, equivalent to about 27.1 percent of total employment in the private sector during this period. Average manufacturing SME output was THB 748,749 million, or 28.68 percent of total SME output, during the period in 1994 – 2009, with an average annual real output growth rate of 6.89 percent during this same period (Office of Small and Medium Enterprises, various). The Office of Small and Medium Enterprises Promotion do not compile statistics on the exports of SMEs by sector. It only identifies the export value of SMEs classified by size of enterprises. Thus, the average value of exports by SMEs was approximately THB 1,311,493 million, or 33.02 percent of total exports over the period 2000 to 2009.

3. Methodology and data

3.1 Methodology

The focus of this study is upon measuring the technical efficiency of Thai manufacturing SMEs[4], which requires determining maximum output from given inputs and identifying the relevant production function or frontier of a sample of firms (Vu, 2003; Coelli et al., 2005). The two most common approaches of estimating the maximum level of output are data envelopment analysis (DEA) and stochastic frontier analysis (SFA). Data Envelopment Analysis (DEA) is a non-parametric approach that makes no assumptions concerning the form of the production function. Instead, the best practice production function is created empirically from observed input and output. DEA does not identify the difference between technical inefficiency and random errors (Admassie and Matambalya, 2002; Vu, 2003; Coelli et al., 2005; Arunsawadiwong, 2007; Zahid and Mokhtar, 2007). On the other hand SFA is a parametric approach where the form of the production function is assumed to be known or is estimated statistically. SFA also allows other parameters of the production technology to be explored (Coelli, 1996a; Coelli et al., 2005). The advantages of this approach are that hypotheses can be tested with statistical rigour, and that relationships between inputs and outputs follow known functional forms. SFA can be used to simultaneously estimate firm technical efficiency and a technical inefficiency effects model (Admassie and Matambalya, 2002; Coelli et al., 2005; Arunsawadiwong, 2007; Zahid and Mokhtar, 2007). The empirical analysis conducted in this study is that of SFA. SFA employs the method of maximum likelihood to calculate a wide variety of stochastic frontier models, based on Cobb-Douglas and Transcendental-logarithm (Translog) production functions, using cross-sectional firm level data (Coelli, 1996a; Coelli et al., 2005).

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[4] Technical efficiency is defined as a firm's ability to produce the maximum level of output from a given combination of inputs.

Cobb-Douglas and Translog production functions are the most common functional forms used for SFA (Coelli et al., 2005). Both of these are tested in this study for adequate functional form (Kim, 2003; Vu, 2003; Tran et al., 2008; Amornkitvikai and Harvie, 2010, 2011). A two factor Cobb-Douglas production function utilising cross-sectional data can be written as follows (Coelli, 1996a):

$$lnY_i = \beta_0 + \beta_1 ln(K_i) + \beta_2 ln(L_i) + (V_i - U_i) \qquad \text{,i=1,…,N,} \qquad (1)$$

The Transcendental-logarithm (Translog) production function using cross-sectional data can be expressed as follows (Coelli, 1996a):

$$lnY_i = \beta_0 + \beta_1 ln(K_i) + \beta_2 ln(L_i) + \beta_3 ln(K_i)^2 + \beta_4 ln(L_i)^2 + \beta_5 ln(K_i) ln(L_i) + (V_i - U_i) \qquad (2)$$

Where:

Y_i = Value added[5] of firm *i*

K_i = The net value of fixed assets[6] of firm *i*

L_i = The total number of employees of firm *i*

V_i = A random variable which is assumed to be an independently and identically distributed normal variable with zero mean and variance, $\left(v_i : \ iidN\left(0, \sigma_v^2\right)\right)$, and is assumed to be independently distributed of U_i (Vu, 2003; Coelli et al., 2005; Tran et al., 2008).

U_i = A non-negative random variable that accounts for technical inefficiency in the production function, and is assumed to be independently and identically distributed as a truncation at zero of a normal distribution, $\left(u_i : \ iidN^+\left(0, \sigma_u^2\right)\right)$ (Vu, 2003; Coelli et al., 2005; Tran et al., 2008).

To examine the determinants of technical inefficiency, U_i is assumed to be a function of explanatory variables. This can be defined as the technical efficiency effects model as follows:

$$\begin{aligned} U_i = {} & \delta_0 + \delta_1 Size_i + \delta_2 Age_i + \delta_3 Skill_i + \delta_4 Location_i + \delta_5 Bangkok_i + \delta_6 Central_i + \delta_7 Northern_i \\ & + \delta_8 North-eastern_i + \delta_9 Individual_i + \delta_{10} Juristic_i + \delta_{11} Limited_i + \delta_{12} State_i \\ & + \delta_{13} Co-operative_i + \delta_{14} Foreign_i + \delta_{15} Export_i + \delta_{16} Government-assis\tan ce_i + \omega_i \end{aligned} \qquad (3)$$

Where:

$Size_i$ = 1 for small enterprises employing up to 50 workers;

= 0 for medium enterprises employing between 51-200 workers;

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[5] The value added (*Y*) of firms was deflated by the Producer Price Index (PPI) of manufactured product in 2007, with 2000 as the base year obtained from the Bureau of Trade and Economic Indices, Ministry of Commerce of Thailand (Bureau of Trade and Economic indices of Thailand, 2010).

[6] The capital (*K*) of firms was deflated by the Producer Price Index (PPI) of capital equipment in 2007, with 2000 as the base year, obtained from the Bureau of Trade and Economic Indices, Ministry of Commerce of Thailand (Bureau of Trade and Economic indices of Thailand, 2010).

Age_i = age of firm i, represented by operating years;

$Skill_i$ = skilled labour of firm i, represented by the ratio of skilled workers to total workers;

$Location_i$ = 1 if firm i is located in a municipal area; = 0 otherwise;

$Bangkok_i$ = 1 if firm i is located in Bangkok; = 0 otherwise;

$Central_i$ = 1 if firm i is located in the central region; = 0 otherwise;

$Northern_i$ = 1 if firm i is located in the Northern region; = 0 otherwise;

$North-eastern_i$ = 1 if firm i is located in the North-eastern region; = 0 otherwise;

$Individual_i$ = 1 if firm i is an individual proprietor; = 0 otherwise;

$Juristic\ partnership_i$ = 1 if firm i is a juristic partnership; = 0 otherwise;

$Limited_i$ = 1 if firm i is a limited liability company; = 0 otherwise;

$State_i$ = 1 if firm i is a state-owned enterprise; = 0 otherwise;

$Cooperative_i$ = 1 if firm i is a cooperative, = 0 otherwise;

$Foreign_i$ = 1 if firm i has foreign investment[7]; = 0, otherwise;

$Export_i$ = 1 if firm i exports more than 50 per cent of its total sales revenue, = 0 otherwise;

$Government\ assistance_i$ = 1 if firm i obtains privileges from the BOI; = 0 otherwise;

δ_i = a vector of unknown parameters to be estimated; and

ω_i = A random error defined as the truncation of the normal distribution $N(0,\sigma_\omega^2)$, the position of the truncation is $-(\delta_0 + z_i\delta)$ (Coelli et al., 2005; Tran et al., 2008).

The validity of the technical inefficiency term and stochastic frontier production function can be tested by calculating the value of the gamma parameter (γ) (Battese and Corra, 1977; Coelli et al., 2005; Arunsawadiwong, 2007). The parameter γ must contain a value between 0 and 1 and depends upon two variance parameters of the stochastic frontier function. This can be defined as (Battese and Corra, 1977; Coelli et al., 2005; Arunsawadiwong, 2007; Tran et al., 2008):

$$\gamma = \sigma_u^2 + \sigma^2 \text{ and } \sigma^2 = \sigma_v^2 / \sigma_u^2 \quad (4)$$

Where: σ_v^2 = A statistical noise variance and σ_u^2 = A technical inefficiency effects variance

If the value of γ is close to zero deviations from the stochastic frontier function are ascribed to random error, whereas a value of γ close to unity indicates that deviations are due to technical inefficiency (Coelli et al., 2005; Arunsawadiwong, 2007; Tran et al., 2008).

[7] According to the Thai Foreign Business Act 1999 foreign shareholders are allowed to own up to 49 percent of a firm's total shares.

3.2 Data Classification

Cross sectional firm-level data from the industrial census conducted in 2007 by the National Statistical Office (NSO) of Thailand is used in this study[8]. Establishments under the scope of these censuses are those engaged primarily in manufacturing industry (category D International Standard Industrial Classification of All Economic Activities; ISIC: Rev.3). However, this study focuses only upon manufacturing SMEs. The total number of manufacturing SMEs in the 2007 industrial census 56,441, and this is classified into the following three categories: aggregate manufacturing SMEs, small and medium sized manufacturing SMEs, and non-exporting and exporting manufacturing SMEs. Data[9] extracted for manufacturing SMEs from the 2007 census was based on that required to estimate Cobb-Douglas and Translog production functions, and to examine a technical inefficiency effects model. Key variables extracted include output value added (Y) , labour input (L), capital input (K). Y is measured as the value of gross output minus intermediate consumption. L is measured as the number of workers in the establishment, including owner or partner, unpaid workers, skilled labour and unskilled labour. The total number of workers is used as the proxy for labour. K is measured as the net value of fixed assets after deducting accumulated depreciation at the end of the year. The net value of fixed assets for each firm in the 2007 industrial census is utilized as a proxy for capital. The net value of fixed assets is a combination of land, buildings, construction, machinery and equipment, vehicles, office appliances and software. Table 1 presents the number and percentage of the 2007 industrial censuses classified by three categories.

Table 1: Number and Percentage of Thai Manufacturing SMEs by Categories

Year	The 2007 Industrial Census	
Categories	**Observations**	**Percentage (%)**
Aggregate Manufacturing SMEs	56,441	100
Size of Manufacturing		
Small Enterprises	49,835	88.30
Medium Enterprises	6,606	11.70
Total	**56,441**	**100**
Export Intensity		
Domestic SMEs	52,721	93.41
Exporting SMEs	3,720	6.59
Total	**56,441**	**100**

[8] These industrial censuses are conducted every 10 years in Thailand.

[9] Summary statistics for key variables utilised in this study by aggregate manufacturing SME, size of manufacturing SME (small or medium) and by non-exporting and exporting manufacturing SMEs from the 2007 industrial census are available from the authors on request.

4. Hypotheses Tests

Estimation of a stochastic frontier production function and technical inefficiency effects model can be used to test for the validation of three null hypotheses: 1) absence of technical inefficiency effects; 2) absence of stochastic inefficiency effects; and 3) insignificance of joint inefficiency variables. Formal hypothesis tests associated with the stochastic frontier and technical inefficiency effects model are represented in Tables 2, 3 and 4 respectively. Three hypotheses tests are conducted by utilising the generalized likelihood-ratio test, which can be expressed as follows (see Kim, 2003; Coelli et al., 2005; Arunsawadiwong, 2007; Tran et al., 2008; Amornkitvikai and Harvie, 2010, 2011):

$$\lambda = -2\{log[L(H_0)] - log[L(H_1)]\} \quad (4)$$

Where:

$log[L(H_0)]$ and $log[L(H_1)]$ are the values of a log-likelihood function for the stochastic frontier model under the null hypothesis (H_0) and the alternative hypothesis (H_1).

Coelli (1996a) emphasised that the LR test statistic contains an asymptotic chi-square distribution with parameters equal to the number of restricted parameters imposed under the null hypothesis (H_0), except hypotheses (1) and (2) which contain a mixture of a chi-square distribution (Kodde and Palm, 1986). Hypotheses (1) and (2) involve the restriction that γ is equal to zero which defines a value on the boundary of the parameter space (Coelli, 1996a, p6).

Table 2 exhibits results for hypothesis tests for aggregate manufacturing SMEs in 2007. From Table 2 the first null hypothesis (H_0), which specifies that technical inefficiency effects are absent from the model, is strongly rejected at the 1 percent level of significance. This implies that the technical inefficiency effects model exists for aggregate manufacturing SMEs in 2007, as defined by equations (1) and (2). The second null hypothesis (H_0) is that the inefficiency effects are not stochastic and is strongly rejected at the 1 percent level, implying that the estimated parameters can be defined in the technical inefficiency effects model for aggregate manufacturing SMEs in 2007, respectively, as specified by equation (1). The last null hypothesis (H_0) specifies that all estimated parameters of the explanatory variables in the inefficiency effects model are equal to zero. The null hypothesis is strongly rejected at the 1 percent level for aggregate manufacturing SMEs in 2007. This also indicates that the efficiency effects are not a linear function in the model, as defined by equations (1) and (2), respectively.

Table 2: Statistics for Hypothesis Tests of the Stochastic Frontier Model and Technical Inefficiency Effects Model by Aggregate Manufacturing SMEs

	Aggregate Manufacturing SMEs
	No technical inefficiency Effects
(1) Null Hypothesis	$(H_0 : \gamma = \delta_0 = \delta_1 = \mathrm{L} \ = \delta_{16} = 0)$
LR Statistics	19956.16
Critical Value	**34.17***
Decision	Reject H_0
(2) Null Hypothesis	**Non stochastic Inefficiency** $(H_0 : \gamma = 0)$
LR Statistics	2387.42
Critical Value	**5.41***
Decision	Reject H_0
(3) Null Hypothesis	**No joint Inefficiency Variables** $(H_0 : \delta_1 = \delta_2 = \mathrm{L} \ = \delta_{16} = 0)$
LR Statistics	16353.43
Critical Value	**32.00**
Decision	Reject H_0

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

In Table 3 the first null hypothesis (H_0) specifying that technical inefficiency effects are absent from the model, is strongly rejected at the 1 percent level. This implies that the traditional response model is not an adequate representation of the data for size of manufacturing SMEs in 2007, as specified by equations (1) and (2). The second null hypothesis (H_0), that inefficiency effects are not stochastic, is strongly rejected at the 1 percent level, meaning that the technical inefficiency effects model is applicable for size of manufacturing SMEs in 2007, as given by equation (1). The last null hypothesis (H_0) specifies that all estimated parameters of the explanatory variables in the inefficiency effects model are equal to zero. The null hypothesis is strongly rejected at the 1 percent level for size of manufacturing SMEs, as defined by equations (1) and (2).

Table 3: Statistics for Hypothesis Tests of the Stochastic Frontier Model and Technical Inefficiency Effects Model by Size of Manufacturing SMEs

	Small Enterprises	Medium Enterprises
(1) Null Hypothesis	**No technical inefficiency Effects** $(H_0 : \gamma = \delta_0 = \delta_1 = \mathrm{L} \ = \delta_{15} = 0)$	
LR Statistics	18120.21	2073.68
Critical Value	**32.77***	
Decision	Reject H_0	Reject H_0
(2) Null Hypothesis	**Non stochastic Inefficiency** $(H_0 : \gamma = 0)$	
LR Statistics	2132.77	328.23
Critical Value	**5.41***	
Decision	Reject H_0	Reject H_0
(3) Null Hypothesis	**No joint Inefficiency Variables** $(H_0 : \delta_1 = \delta_2 = \mathrm{L} \ = \delta_{15} = 0)$	
LR Statistics	15011.08	1416.28
Critical Value	**30.58**	
Decision	Reject H_0	Reject H_0

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

Table 4 presents results for hypothesis tests for non-exporting and exporting SMEs in2007. In Table 4 the first null hypothesis (H_0), which specifies that technical inefficiency effects are absent from the model, is strongly rejected at the 1 percent level. This specifies that the technical inefficiency effects model exists for non-exporting and exporting SMEs in both periods, given by equations (1) and (2). The second null hypothesis (H_0), that the inefficiency effects are not stochastic, is strongly rejected at the 1 percent level, indicating that the technical inefficiency effects model is applicable for non-exporting and exporting SMEs in 2007, as defined by equation (1). The last null hypothesis (H_0) specifies that all estimated parameters of the explanatory variables in the inefficiency effects model are equal to zero. The null hypothesis is strongly rejected at the 1 percent level for non-exporting and exporting SMEs in 2007, as specified by equations (1) and (2).

Table 4: Statistics for Hypothesis Tests of the Stochastic Frontier Model and Technical Inefficiency Effects Model by Non-exporting and Exporting SMEs

	Non-exporting SMEs	Exporting SMEs
(1) Null Hypothesis	**No technical inefficiency Effects** $(H_0 : \gamma = \delta_0 = \delta_1 = \mathrm{L} \ = \delta_{16} = 0)$	**No technical inefficiency Effects** $(H_0 : \gamma = \delta_0 = \delta_1 = \mathrm{L} \ = \delta_{15} = 0)$
LR Statistics	19375.02	245.14
Critical Value	**34.17***	**32.77***
Decision	Reject H_0	Reject H_0
(2) Null Hypothesis	**Non stochastic Inefficiency** $(H_0 : \gamma = 0)$	**Non stochastic Inefficiency** $(H_0 : \gamma = 0)$
LR Statistics	2357.54	13.67
Critical Value	**5.41***	**5.41***
Decision	Reject H_0	Reject H_0
(3) Null Hypothesis	**No joint Inefficiency Variables** $(H_0 : \delta_1 = \delta_2 = \mathrm{L} \ = \delta_{16} = 0)$	**No joint Inefficiency Variables** $(H_0 : \delta_1 = \delta_2 = \mathrm{L} \ = \delta_{15} = 0)$
LR Statistics	15893.11	210.03
Critical Value	**32.00**	**30.58**
Decision	Reject H_0	Reject H_0

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

5. Empirical Results from SFA and the Technical Inefficiency Effects Model

Maximum likelihood estimates for parameters of the stochastic frontier and technical inefficiency effects model, as specified by equations (1) and (2) respectively, were estimated simultaneously using the computer programme Frontier[10] Version 4.1 developed by Coelli (1996a). The estimated results for equations (1) and (2) are provided in Tables 5 and 6. A summary of the simple average technical efficiency of manufacturing SMEs in 2007 is shown in Table 8.

5.1 *Results from SFA - Input Elasticities and Gamma Parameters*

Table 5 presents the results of maximum likelihood estimation for aggregate manufacturing SMEs and by size of manufacturing SME (small and medium) in 2007. In 2007 the Cobb-Douglas production function reveals increasing returns to scale for aggregate manufacturing SMEs, as the

[10] LIMDEP is an alternative program to estimate a stochastic production frontier and technical inefficiency. However, LIMDEP is unable to accommodate a wider range of assumptions regarding the error distribution term compared to SFA (Frontier 4.1). It is also unable to estimate the technical inefficiency effects model in a one step process compared to Frontier 4.1. This may create bias as the distribution of the technical inefficiency estimates is pre-determined through the distributional assumptions used in its empirical analysis (Herrero and Pascoe, 2002; Amornkitvikai and Harvie, 2011)

combined value of the estimated input coefficients is 1.21. The estimate of the variance parameter gamma (γ) is 0.651 (see Table 5) meaning that all deviations are caused by technical inefficiency (Coelli et al., 2005). Aggregate manufacturing SMEs have positive signs for capital (β_1) and labour (β_2), 0.233 and 0.973 respectively, and they are also highly significant at the 1 percent level. Table 5 also shows the results of maximum likelihood estimation by size of SME (small and medium) in 2007. Small SMEs have positive signs for both capital (β_1) and labour (β_2), which are 0.219 and 1.042 respectively and they are also highly significant at the 1 percent level. Small SMEs are found to have increasing returns to scale, because the combined values of the estimated input coefficient (1.26) is greater than unity. The estimated gamma parameter of small SMEs is 0.65, indicating that all deviations from the model are ascribed to technical inefficiency. For medium sized SMEs the coefficients of capital (β_1) and labour (β_2) have positive signs, 0.307 and 0.653 respectively, and they are statistically significant at the 1 percent level. Medium sized SMEs have tended to have constant returns to scale in 2007 as the summed value of the estimated input coefficients (0.96) is close to unity. The estimate of the variance parameter of gamma is 0.770 implying that all deviations are mainly due to technical inefficiency in the production function. However, there is a different elasticity by size of SME (small and medium). The contribution of labour in the production function is higher than capital irrespective of the size of the SME, showing that small and medium sized enterprises were labour intensive in 2007.

Table 5: Maximum Likelihood Estimates for Parameters of the Stochastic Frontier Model and Technical Inefficiency Effects Model by Aggregate Manufacturing SMEs and Size of SMEs

Variables	Aggregate Manufacturing SMEs	Small Enterprises	Medium Enterprises
Number of Observations	**56441**	**49835**	**6606**
	Coefficients	Coefficients	Coefficients
Stochastic Frontier Model			
Constant	5.457***	5.407***	5.956***
	(0.032)	(0.039)	(0.144)
Capital	0.233***	0.219***	0.307***
	(0.002)	(0.003)	(0.007)
Labour	0.973***	1.042***	0.653***
	(0.006)	(0.007)	(0.028)
Technical Inefficiency Effects Model			
Constant	3.031***	2.586***	1.719***
	(0.064)	(0.045)	(0.214)
Firm Size (dummy)	-0.492***	N/A	N/A
	(0.055)		
Firm Age (years)	-0.002**	-0.002*	-0.023***
	(0.001)	(0.001)	(0.004)
Skilled Labour (ratio)	-0.850***	-0.854***	0.411***
	(0.027)	(0.026)	(0.111)
Municipality (dummy)	-0.347***	-0.385***	0.090
	(0.023)	(0.025)	(0.103)
Bangkok Area (dummy)	-2.186***	-2.343***	-2.055***
	(0.157)	(0.193)	(0.518)
Central & Vicinity Regions	-0.024	0.009	-0.425**
(dummy)	(0.036)	(0.037)	(0.207)
Northern Region (dummy)	0.645***	0.641***	2.330***
	(0.035)	(0.035)	(0.212)
North-eastern Region (dummy)	0.358***	0.389***	-0.129
	(0.035)	(0.033)	(0.195)
Individual Proprietor (dummy)	-1.104***	-1.245***	-1.584***
	(0.028)	(0.034)	(0.196)
Juristic Partnership (dummy)	-2.860***	-2.960***	-3.429***
	(0.086)	(0.101)	(0.300)
Limited & Public Limited	-4.064***	-4.469***	-4.545***
company (dummy)	(0.119)	(0.191)	(0.356)
Government & State Enterprises	0.599***	0.009	1.383***
(dummy)	(0.148)	(0.198)	(0.242)
Cooperatives (dummy)	-1.716***	-1.901***	-0.727*
	(0.149)	(0.163)	(0.443)
Foreign Investment (dummy)	-0.575***	-0.258	-0.951***
	(0.225)	(0.396)	(0.217)
Exports (dummy)	-0.414**	-0.621**	-0.194
	(0.177)	(0.264)	(0.333)
Government Assistance (BOI)	-0.230	-0.353	-1.270***
(dummy)	(0.204)	(0.327)	(0.369)
Variance Parameters			
Sigma-squared	1.787***	1.782***	2.664***
	(0.029)	(0.031)	(0.237)
Gamma	0.651***	0.652***	0.770***
	(0.006)	(0.007)	(0.022)
Log-likelihood Function	-83151.65	-73972.99	-8800.36
Mean Technical Efficiency	0.44	0.42	0.65
Returns to scale	1.21	1.26	0.96

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

Table 6 shows the results for non-exporting and exporting SMEs in 2007. The Cobb-Douglas production function indicates that non-exporting market oriented and export oriented SMEs have positive signs for both capital input (β_1) and labour input (β_2), and they are also strongly significant at the 1 percent level. Non-exporting market oriented SMEs are found to have increasing returns to scale, because the combined values of the estimated input coefficient obtained from the stochastic frontier models is higher than unity, which is 1.22, whereas export oriented SMEs are found to have decreasing returns to scale because the sum of the estimated input coefficients (0.84) is less than unity. However, these elasticities are different for non-exporting and exporting manufacturing SMEs. The elasticities of labour (β_2) in the stochastic production function are much higher than capital (β_1). From Table 6 the elasticities of labour input (β_2) in the production functions for non-exporting and exporting SMEs are equal to 0.984 and 0.589 respectively. The capital (β_1) elasticities in the production function for non-exporting and exporting SMEs are 0.231and 0.260 respectively. The high labour elasticity value indicates that non-exporting and exporting SMEs are labour intensive. The low value of capital elasticity in the production function reveals that capital has a low input share in non-exporting and exporting SME output in 2007. Furthermore, the estimated gamma parameter (γ) of non-exporting SMEs is 0.660, indicating that all deviations from the model are attributable to technical inefficiency. The estimate of the variance parameter of gamma (γ) in exporting SMEs is 0.239, implying that all deviations from the production function were attributable to noise in 2007.

Table 6: Maximum Likelihood Estimates for Parameters of the Stochastic Frontier Model and Technical Inefficiency Effects Model by Non-exporting and Exporting SMEs

Variables	Non-exporting SMEs	Exporting SMEs
Number of Observations	**54676**	**1765**
	Coefficients	Coefficients
Stochastic Frontier Model		
Constant	5.425***	6.925***
	(0.033)	(0.271)
Capital	0.231***	0.260***
	(0.002)	(0.017)
Labour	0.984***	0.589***
	(0.006)	(0.049)
Technical Inefficiency Effects Model		
Constant	3.006***	-0.096
	(0.067)	(0.970)
Firm Size (dummy)	-0.483***	0.271
	(0.057)	(0.182)
Firm Age (years)	-0.002**	0.005
	(0.001)	(0.007)
Skilled Labour (ratio)	-0.867***	0.316
	(0.027)	(0.209)
Municipality (dummy)	-0.361***	-0.040
	(0.027)	(0.121)
Bangkok Area (dummy)	-2.290***	1.352
	(0.163)	(0.793)
Central & Vicinity Regions (dummy)	-0.024	1.829
	(0.037)	(1.079)
Northern Region (dummy)	0.658***	2.299**
	(0.035)	(1.126)
North-eastern Region (dummy)	0.362***	2.360**
	(0.035)	(1.198)
Individual Proprietor (dummy)	-1.141***	-0.541
	(0.029)	(0.335)
Juristic Partnership (dummy)	-2.953***	-1.267***
	(0.092)	(0.352)
Limited & Public limited company (dummy)	-4.213***	-1.556***
	(0.131)	(0.329)
Government & State Enterprises (dummy)	0.631***	-5.384
	(0.149)	(4.480)
Cooperatives (dummy)	-1.751***	0.533
	(0.149)	(0.995)
Foreign Investment (dummy)	-0.380*	-0.289
	(0.211)	(0.191)
Exports (dummy)	-0.525*	N/A
	(0.270)	
Government Assistance (BOI) (dummy)	-0.473	-0.096
	(0.296)	(0.970)
Variance Parameters		
Sigma-squared	1.815***	0.946***
	(0.029)	(0.198)
Gamma	0.660***	0.239
	(0.006)	(0.232)
Log-likelihood Function	-80691.46	-2346.28
Mean Technical Efficiency	0.44	0.63
Returns to scale	1.22	0.84

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

5.2 *Results from the Technical Inefficiency Effects Model*

The model defined by equations (1) and (2) is estimated simultaneously to obtain results for a technical inefficiency effects model[11]. The estimated results for equations (1) and (2) are also contained in Tables 4 and 5. All negative coefficient signs of the technical inefficiency effects model represent technical efficiency. Hence all negative signs must be converted to positive for their relationship to technical efficiency. Furthermore, Table 6 presents firm-specific factors impacting upon the efficiency of SMEs and other sectors in various studies based upon the literature review.

5.3 *Firm-Specific Factors*

Many empirical studies have found that firm size is an important firm-specific factor contributing to a firm's technical efficiency (Lundvall and Battese, 2000; Admassie and Matambalya, 2002; Kim, 2003; Yang, 2006; Tran et al., 2008; Park et al., 2009; Amornkitvikai and Harvie, 2010, 2011). The estimates of the coefficients for firm size have negative signs for aggregate manufacturing SMEs and non-exporting SMEs, implying that small SMEs are more technically efficient than medium sized SMEs in these categories. The coefficient for aggregate manufacturing SMEs and non-exporting SMEs are highly significant at the 1 percent level. However, there is a positive coefficient for exporting SMEs in 2007, but it is not statistically significant (see Table 6). A number of empirical studies have highlighted that firm size has a negative association with technical efficiency (Biggs, 2002; Alvarez and Crespi, 2003; Yang and Chen, 2009; Le, 2010). The benefits of being a small firm are as follows (Biggs, 2002; Yang and Chen, 2009; Le, 2010): 1) they have the flexibility to adjust and diversify their activities in order to become more efficient; 2) small firms add dynamism to business activities which can improve economic performance ; 3) small firms are likely to have a cost advantage relative to medium and large firms.

A number of empirical studies suggest that the age of a firm has a positive and significant association with its technical efficiency based on the principle of learning by doing and accumulated knowledge (Admassie and Matambalya, 2002; Batra and Tan, 2003; Phan, 2004; Tran et al., 2008; Park et al., 2009; Amornkitvikai and Harvie, 2010). Estimates of the coefficients for firm age are found to be negative for aggregate manufacturing, small, medium sized and non-exporting SMEs. The coefficient for medium sized SMEs is highly significant at the 1 percent level. The coefficients for aggregate manufacturing and non-exporting SMEs are significant at the 5 percent level, while the coefficient for small SMEs is statistically significant at the 10 percent level. However, the estimated coefficient of exporting SMEs in 2007 is positive but not statistically significant (see Table 6).

[11] This was done using the Frontier 4.1 econometric package.

Hence, in general, firm age has a positive impact on SME technical efficiency but the magnitude is very small.

Skilled labour is another firm-specific factor identified as affecting a firm's technical efficiency (Admassie and Matambalya, 2002; Zahid and Mokhtar, 2007; Amornkitvikai and Harvie, 2010). The estimated coefficients for skilled labour, represented by the ratio of skilled labour to total workers, are negative and highly significant at the 1 percent level in three categories - aggregate manufacturing, small and non-exporting SMEs. This implies that skilled labour has a positive association with technical efficiency for SMEs in these categories. In addition, the coefficient for exporting SMEs is negative, but not statistically significant, while the coefficient for skilled labour has a positive sign for medium sized SMEs but is also not statistically significant. Several empirical studies reveal that a municipal location has a positive relationship to firm technical efficiency (Krasachat, 2000; Li and Hu, 2002; Yang, 2006; Park et al., 2009; Le and Harvie, 2010). Results concerning the dummy variable for municipality show a negative sign for aggregate manufacturing, small and non-exporting SMEs. The coefficients for aggregate manufacturing, small and non-exporting SMEs are highly significant at the 1 percent level. These results suggest that a municipal area location has a positive relationship with the technical efficiency of SMEs in these categories. However, the estimated coefficients for medium sized and exporting SMEs in 2007 are positive but not statistically significant.

The Bangkok area contains the highest density of SMEs in Thailand, accounting for around 30 percent of total SMEs on average over the period 1994 to 2009. Bangkok is also recognised as the major economic centre of the nation (Office of Small and Medium Enterprises Promotion, 2001-2009). Estimates of the coefficients for the Bangkok area have negative signs in four categories, including aggregate manufacturing, small, medium sized and non-exporting SMEs and they are highly significant at the 1 percent level. This indicates that location in the Bangkok area has a positive impact on technical efficiency. However, there is a positive coefficient for export oriented SMEs in 2007 but it is not statistically significant. The central and vicinity regions contain many of Thailand's large businesses (Office of Small and Medium Enterprises Promotion, 2008). Estimates of the coefficients for central and vicinity regions are found to be negative for aggregate manufacturing, medium sized and non-exporting SMEs. However, only the coefficient for medium sized SMEs is significant. Furthermore, there are positive coefficients for small and exporting SMEs in 2007, but they are not statistically significant (see Table 6).

The Northern region had 311,681 SMEs equivalent to 17 percent of all SMEs on average during 1994 to 2008 (Office of Small and Medium Enterprises Promotion, (2001-2008)). Estimates of the coefficients for the Northern region exhibit positive signs in all categories, and they are highly

significant at the 1 percent level, while the coefficient for exporting SMEs is significant at the 5 percent level. These positive coefficients indicate that location in the Northern region was negatively related to SME technical efficiency across all categories in 2007. According to the Office of Small and Medium Enterprises Promotion (2001-2008), the second highest number of SMEs in the nation can be found in the North-eastern area, having 514,498 SMEs equivalent to 27.41 percent of all SMEs on average during 1994 to 2008. Estimates of the coefficients for location in the North-eastern region have positive signs for aggregate manufacturing, small, non-exporting and export oriented SMEs and they are significant at the 1 percent level, while the coefficient for medium sized SMEs is negative but not statistically significant. Therefore, it can be concluded that the positive coefficients in 2007 specify that location in the Northern and North-eastern regions are negatively related with SME technical efficiency, suggesting major locational problems for manufacturing SMEs in these regions.

Estimates of the coefficients for individual proprietor ownership have negative signs for all categories, and they are highly significant at the 1 percent level, except for export oriented SMEs where it is not statistically significant. This implies that individual proprietor ownership has a positive relationship with the technical efficiency of SMEs. The benefits of being an individual or sole proprietorship are in the following (Ward and Dolan, 1998; Buranajarukorn, 2006; Cooper and Dunkelberg, 2006; Fernández and Nieto, 2006; Ha, 2006): 1) It is complete control within the parameters of the law and decision-making power over a business; 2) It is easy and inexpensive form of starting business; 3) Sale or transfer can operate at the discretion of an individual or sole proprietor; 4) The owner has an absolute authority over its business decision. The estimated coefficients for juristic partnership ownership in 2007 have negative signs for all SME categories, and they are highly significant at the 1 percent level. This implies a positive relationship between juristic partnership and SME technical efficiency. As compared to an individual or sole proprietorship, a juristic partnership has the advantage of allowing the owner to draw on resources and expertise of co-partners. It can be easily formed by an oral agreement between two or more people. With a juristic partnership, partners share risk and management and jointly solve barriers to doing business (Cooper and Dunkelberg, 2006; Fernández and Nieto, 2006; Ha, 2006).

Estimates of the coefficients for limited and public limited companies in 2007 have negative signs for all categories. The negative coefficients of these categories are strongly significant at the 1 percent level. This can be interpreted to mean that limited and public limited companies in 2007 are positively related with SME technical efficiency in all categories. A number of studies have highlighted the advantages of limited and public limited companies (Cooper and Dunkelberg, 2006; Fernández and Nieto, 2006; Ha, 2006). Estimates of the coefficients for government and state

ownership have positive signs for aggregate manufacturing, small, medium sized and non-exporting SMEs, with the exception of exporting SMEs. The coefficients for aggregate manufacturing SMEs, medium and non-exporting SMEs are strongly significant at the 1 percent level, whereas the coefficients of small and exporting SMEs are insignificant. These results suggest a negative relationship between government and state ownership and SME technical efficiency in 2007.

For cooperative ownership estimated coefficients are negative in 2007 for all categories, comprising aggregate manufacturing, small, medium sized, non-exporting and exporting SMEs, with the exception of exporting SMEs. The coefficients for aggregate manufacturing, small and non-exporting SMEs are strongly significant at the 1 percent level, while the coefficient for medium sized SMEs is significant at the 10 percent level. However, the positive coefficient for exporting SMEs is insignificant. It can be concluded, therefore, that cooperative ownership in 2007 had a statistically positive correlation with SME technical efficiency. Several empirical studies have found that foreign ownership or investment in a firm has a positive relationship with its technical efficiency (Fukuyama et al., 1999; Goldar et al., 2003; Bottasso and Sembenelli, 2004). The coefficients for aggregate manufacturing and medium sized SMEs are strongly significant at the 1 percent level, while the coefficient for non-exporting SMEs is significant at the 10 percent level. In addition, the estimated coefficients for small and exporting SMEs in 2007 are not statistically significant[12]. Therefore, it can be concluded that there is a statistically positive association between foreign investment and SME technical efficiency in 2007.

Estimates of the coefficients for the dummy variable for export intensity have negative signs for all SME categories in 2007. The coefficients for aggregate manufacturing and small SMEs are significant at the 5 percent level, and the coefficient for non-exporting SMEs is significant at the 10 percent level of significance, whereas the coefficient for medium sized SMEs is insignificant. Many empirical studies suggest a positive relationship between export intensity and technical efficiency (the learning by exporting hypothesis) (Rankin, 2001; Bigsten et al., 2002; Granér and Isaksson, 2002; Kim, 2003; Granér and Isaksson, 2009; Amornkitvikai and Harvie, 2010). Therefore, it can be concluded that exporting in 2007 has generally had a statistically significant and positive relationship with SME technical efficiency. A number of empirical studies have found that government assistance has a positive and significant impact upon a firm's technical efficiency (Vu, 2003; Tran et al., 2008; Le and Harvie, 2010). Estimates of the coefficients for government assistance have negative signs for all SME categories. However, only the coefficient for medium sized SMEs is statistically significant

[12] This could be due to the fact that most foreign investment in SMEs targets non-exporting market oriented firms.

at the 1 percent level. This indicates that government assistance via the Broad of Investment (BOI) had a positive association with the technical efficiency of medium sized SMEs in 2007.

Table 7: Firm-specific Factors impacting upon the technical efficiency of SMEs and other sectors

Authors/Years	Countries	Sectors	Firm Location	Firm Age	Firm Size	Skilled labour	ICT	Financial support	Government Support
Yang (2006)	Korea	SMEs	✓	x	✓	x	x	x	✓
Batra and Tan (2003)	Six countries	Manufacturing	x	✓	✓	✓	✓	✓	✓
Lundvall and Battese (2000)	Kenya	Manufacturing	x	✓	✓	x	x	x	x
Arunsawadiwong (2007)	Thailand	Manufacturing	x	x	x	x	x	x	x
Wiboonchutikula (2002)	Thailand	SMEs	x	x	✓	x	x	x	x
Tran et al. (2007)	Vietnam	Manufacturing SMEs	✓	✓	✓	✓	x	✓	✓
Admassie and Matambalay (2002)	Tanzania	SMEs	x	✓	✓	✓	x	✓	✓
Zahid and Mokhtar (2007)	Malaysia	Manufacturing SMEs	x	x	x	x	x	x	x
Vu (2003)	Vietnam	Manufacturing SMEs	✓	x	x	✓	x	x	x
Park et al. (2009)	Korea	Manufacturing Industry	x	✓	✓	x	x	x	X
Le (2010)	Vietnam	Manufacturing SMEs	✓	✓	✓	x	x	✓	✓
Amornkitvikai, and Harvie (2010)	Thailand	Manufacturing Firms	✓	✓	✓	✓	x	✓	✓

A Simple Average Technical Efficiency of Thai manufacturing SMEs

Table 8 summarises the simple mean technical efficiency of Thai manufacturing SMEs in 2007. As shown in the table, the simple mean technical efficiency ranges from 65 percent in medium enterprises to 42 percent in small enterprises. Medium enterprises had the highest percentage or simple mean technical efficiency in 2007, at 65 percent. The second highest percentage of simple mean technical efficiency is medium enterprises, at 63 percent. Non-exporting SMEs ranked third at 44 percent simple mean technical efficiency. The fourth ranked technical efficiency is small enterprises, with 42 percent simple mean technical efficiency. The simple average technical efficiency of aggregate manufacturing SMEs is 44 percent. Finally, the simple average technical efficiency of all categories of manufacturing SMEs in 2007 is 50 percent, signifying a high degree of technical inefficiency in the operation of these enterprises.

Table 8: A Simple Average Technical Efficiency of Thai manufacturing SMEs in 2007

Categories	A Simple Average Technical Efficiency
Aggregate manufacturing SMEs	0.44
Small Enterprises	0.42
Medium Enterprises	0.65
Non-exporting SMEs	0.44
Exporting SMEs	0.63
Overall Simple Average Technical Efficiency	**0.50**

6. Interpretation and Policy Implications

Thai manufacturing SMEs in all categories experienced a high degree of technical inefficiency in their production process in 2007. The biggest concern relates to non-exporting market oriented small SMEs which predominate in the economy. It will be essential for SME policy makers to focus upon this component of the SME sector if a major improvement in technical efficiency is to be achieved. SMEs have been predominantly dependent upon labour input in the production process in 2007, particularly so for small firms. In aggregate, SMEs have become relatively more dependent on labour input for their output. Many small firms remain heavily involved in labour intensive, low skill and low valuing adding activities. Small firms are the most heavily labour input dependent SME category in 2007.The output of medium sized SMEs also remains dependent on labour input. However, they are the least dependent SME category on labour input in the production process. Non-exporting market oriented SMEs are the second most heavily labour input dependent SME category. Export oriented SMEs are also dependent heavily on labour input. Faced with the need to enhance their efficiency and competitiveness in international markets, export oriented SMEs appear to be moving towards relatively greater reliance on capital input and technology in their production. Their total number in the overall SME manufacturing cohort remains small. Thus, a critical policy issue will be how best to facilitate and encourage the uptake of capital and technology in SME production with the objective of enhancing technical efficiency.

In aggregate, SMEs have experienced increasing returns to scale in 2007, and a similar development is found for small SMEs. Medium sized SMEs have experienced constant returns to scale. Non-exporting market intensive SMEs experienced increasing returns to scale in 2007. Export intensive SMEs experienced decreasing returns to scale in this period. Hence, although input is increasing output either proportionately or less than proportionately, the way in which the inputs are being combined has improved. This could be a reflection of improved technology usage in these sectors or more appropriate factor intensities in production.

Factors contributing to technical efficiency or inefficiency also provide enlightening results. Results for the relationship between firm size and technical efficiency indicate that small sized SMEs are more efficient than medium sized SMEs for aggregate SME manufacturing firms and non-exporting market oriented SMEs. However, small sized SMEs are more efficient than medium sized SMEs. Small sized SMEs can benefit from greater flexibility in adjusting and diversifying their activities, which can improve their business performance (Biggs, 2002; Yang and Chen, 2009; Le, 2010). The importance of firm age and learning by doing for technical efficiency is mixed. For aggregate manufacturing SMEs it is statistically significant and positively related to technical efficiency, but its impact is small. It is only statistically significant for small SMEs and is statistically significant for medium sized SMEs. However the impact of firm age on technical efficiency is quite small. Firm age is only statistically significant for non-exporting market oriented firms but with a small impact. The latter could be a reflection of the fact that with rapidly changing technology in some sectors and the growth of high tech firms the age of a firm is not necessarily an advantage in export markets The results for firm age overall on technical efficiency suggests that older firms can have an advantage over younger firms, due to, for example, superior management experience and knowledge, learning-by-doing, higher technology and equipment (Pasanen, 2006; Amornkitvikai and Harvie, 2010; Le and Harvie, 2010), however its importance appears to be quite limited.

A higher skilled labour ratio is positively and significantly related to technical efficiency for all categories of SMEs with the exception of medium sized SMEs, where is it negatively related to technical efficiency, and export intensive firms where it is insignificant. The negative impact of the skilled labour ratio on technical efficiency is a puzzle for medium sized SMEs. This may be due to a mismatch of labour skills and the capital or technology being used by this category of SME, which have experienced increased dependence on capital in the production process. These results indicate that policy measures, in general, should focus on improving the knowledge and skills of human resources in manufacturing SMEs (Office of Small and Medium Enterprises Promotion, 2007).

Location can be an important factor contributing to technical efficiency. Location in a municipality, and in particular Bangkok, is positively and significantly related to technical efficiency for aggregate manufacturing SMEs, small SMEs and non-exporting market oriented SMEs in 2007. For medium sized SMEs only location in Bangkok is significantly and positively related to technical efficiency in 2007. A municipal or Bangkok location for exporting SMEs does not appear to be significantly related to technical efficiency, and in the case of Bangkok the relationship is not of the expected sign. Bangkok appears to provide a good location for non-exporting market oriented SMEs but not for export oriented SMEs.

Results for location in the Central or Vicinity regions are variable. Location in these regions is not statistically significant for aggregate manufacturing SMEs, small and non-exporting SMEs, while it is only found to be significant for medium sized SMEs. Location in these regions offered no benefits for the technical efficiency of export oriented SMEs. A notable problem relates to the technical efficiency of SMEs located in the Northern and North eastern regions. Location in the Northern region for aggregate, small, medium, non-exporting and export oriented SMEs resulted in a negative relationship with technical efficiency. Location in the North eastern region is generally significantly and negatively related to the technical efficiency of SME in all categories. Thai manufacturing SMEs in these regions appear to be having major problems with regard to technical inefficiency, particularly export intensive SMEs. This needs to be addressed as a matter of priority to identify the specific problems afflicting these regions. From a regional equity perspective it can be recommended that the government give more emphasise to the promotion of SMEs in the regions and localities by: supporting SME networks, promoting local communities and products, encouraging technology upgrading including that of information and communications technology, enhancing the skills and capabilities of the local workforce and entrepreneurs and improving local infrastructure (Office of Small and Medium Enterprises Promotion, 2007). Export oriented SMEs appear to have major problems with technical inefficiency in both these regions, and their particular difficulties need to be identified and addressed.

Ownership characteristics - individual proprietor, juristic partnership and public limited company have a significant and highly positive relationship with the technical efficiency of virtually all categories of manufacturing SMEs. Individual proprietor ownership has remained positively and significantly related to technical efficiency for all categories of SMEs, with the exception of exporting intensive SMEs. The juristic partnership form of ownership has remained consistently positive and significantly related to technical efficiency across all categories of SMEs. This is the most important form of ownership for all categories of SMEs, in terms of its contribution to technical efficiency as measured by the estimated coefficient values. Government and state ownership of SMEs had a significant and negative relationship with technical efficiency for a majority of the SME categories. This may be due to the fact that with the process of reform the privatisation of viable enterprises occurred, leaving only the most technically inefficient SMEs in government or state ownership.

Cooperative ownership had a significant and positive effect upon the technical efficiency of all categories of Thai manufacturing SMEs, except for exporting SMEs where the relationship is not statistically significant. This result suggests that government policy can usefully support the development of SME cooperatives in all categories of manufacturing SMEs, and should be

encouraged in non municipal localities and in the Northern and North-eastern provinces. Foreign investment in local SMEs is found to have a significant and positive relationship with the technical efficiency of all categories of Thai manufacturing SMEs, with the exception of small SMEs and export intensive SMEs. The government should, however, continue to relax foreign ownership controls and encourage foreign investment in Thai SMEs in an attempt to promote technological upgrading, managerial skills and knowledge, good corporate governance and good networking with foreign markets (Okuda and Rungsomboon, 2006; Kimura and Kiyota, 2007; Amornkitvikai and Harvie, 2011). The extent of export involvement appears to be significant for the technical efficiency of SMEs across all categories in 2007. These results also suggest that policy should focus on creating higher value added activity in manufacturing SMEs, enhance quality standards and the capability of SMEs to meet market demands, increase differentiation and the competitiveness of SMEs particularly in industrial products (Office of Small and Medium Enterprises Promotion, 2007). Finally, government assistance via the Office of the Board of Investment (BOI) is found to have had a significant and positive effect on the technical efficiency of medium sized SMEs in 2007.

7. **Conclusions**

The Thai economy is at a critical stage in its economic development. As a middle income economy it can no longer base its future economic growth and development on unskilled low cost labour. Its firms must become more innovative and efficient if they are to compete in an increasingly competitive regional and global economy. In recognition of this need the Thai Office of Small and Medium Enterprises Promotion formulated the first SME promotion plan from 2002 to 2006 aimed at enhancing the efficiency and capacity of SMEs (Mephokee, 2003; Office of Small and Medium Enterprises Promotion, 2003, 2006, 2007; Punyasavatsut, 2007). The results from this study suggest, however, that the objectives of the plan have not been achieved. With the exception of medium sized and export intensive SMEs, which represent a relatively small proportion of overall SMEs. Manufacturing SMEs do not appear to have benefited much from reforms and the promotion plan despite their importance to the economy. They remain heavily dependent on labour input in their production, most notably small non-exporting market intensive SMEs which make up the vast majority of the local SME cohort. Medium sized and export intensive SMEs offer most hope in terms of technical efficiency, but these are quite small in overall SME manufacturing numbers. Capital input has remained of lesser importance but will be critical if SMEs are to become: more efficient, able to move into higher value adding areas of activity, and more innovative in their activities (Dhanani and Scholtès, 2002; Chirasirimongkol and Chutimaskul, 2005; Office of Small and

Medium Enterprises Promotion, 2007; Punyasavatsut, 2007; Thai Industrial Standards Institute, 2009).

The empirical results of the technical inefficiency effects model signify that small sized enterprises are found be more technically efficient than medium sized enterprises. Firm age does not offset the disadvantages of being small by presenting major benefits in the form of increased technical efficiency. SMEs face difficulty in competing for skilled labour which can make a significant contribution to technical efficiency. Location can also contribute to poor technical efficiency unless they are located in the more congested and expensive Bangkok area. A more proactive regional development policy will be required to tackle factors contributing to regional growth and development disparities, particularly in the context of SME technical efficiency. The limited and public limited form of ownership produces the biggest benefit for technical efficiency, but accessing stock markets is costly and beyond the reach of many small SMEs which make up the majority of SMEs. Foreign investment can bring with it advantages in terms of new technology, managerial skills and market opportunities, but this tends to be out-with the realms of possibility for the vast majority of SMEs. Engaging in export activity can also produce beneficial outcomes for manufacturing SMEs, but this is restricted to a relatively small number of firms and these tend to be of medium size. The costs of participating in export activity can be prohibitively high and risky for many small SMEs whose owners lack the necessary knowledge and experience.

Government assistance programs have not had a statistically significant impact on the technical efficiency performance of small and primarily non-exporting market oriented manufacturing SMEs. Thai government agencies seem ill prepared to play an effective role in assisting the development of manufacturing SMEs. They need to strengthen technical assistance and practical policy in order to improve the technical efficiency level of all categories of Thai manufacturing SMEs. Specific policy emphasis should be placed on: providing greater market access, greater access to credit facilities, promoting the utilisation of information technology and communication (ICT), providing financial assistance to avoid management risks and financial problems, providing knowledge and information on market opportunities, improving the quality and competency of SME employees and entrepreneurs, and providing greater regional development equity through extensive regional infrastructure development (Brimble et al., 2002; Huang, 2003; Mephokee, 2003; Arunsawadiwong, 2007; Office of Small and Medium Enterprises Promotion, 2007, 2008). Furthermore, the government should place more focus upon the encouragement of public and private partnerships at the local level to improve the business environment for SMEs with continual monitoring and assessment of existing policy measures and enhancing the effectiveness of their delivery, expand the coverage and the impact of government programs by utilising the private

sector to distribute services, and focus on scarce public resources in an attempt to facilitate market transactions and invest in public goods with major positive externalities (Hallberg, 2000; Asasen et al., 2003; Harvie and Lee, 2005b; Hussain et al., 2009).

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