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Determinant of Technical Efficiency of Small and Medium Enterprises in Malaysian Manufacturing Firms

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Abstract: Technical efficiency is the ability of an enterprise to produce the maximum output using a set of input or minimizing the use of input in producing a certain level of output. When an enterprise is operating at its most efficient, operating costs can be reduced and profits can be increased. This article attempts to analyses the level of technical efficiency of Small and Medium Enterprises (SMEs) in the Malaysian manufacturing firms and identifies the determinants of their efficiency. The analysis uses the data obtained from the Department of Statistics of Malaysia 2009 Manufacturing Survey, which covers 4661 SMEs. In the analysis, SMEs will be divided into three categories, namely, the micro-Sized Enterprises (CSEs) the Small-Sized Enterprises (SSEs) and the Medium-Sized Enterprises (MSEs). To achieve the objectives of this study, we estimate the frontier production model to obtain technical efficiency scores simultaneously with technical inefficiency determinants model. In this study, we adopt the translog production model in obtaining the technical efficiency scores and the linear technical inefficiency model to determine factors affecting the firms' inefficiency level.

Key words: Technical efficiency, small and medium enterprises, manufacturing firms, frontier production model, enterprise

INTRODUCTION

The efficiency of an enterprise is measured by the ability to produce output with minimum cost or making maximum profit. The issue of Technical Efficiency (TE) was first introduced by Kumbhakar *et al*. (1991) who stipulated that efficiency is the decision-making ability to produce to get the maximum output from a set of inputs (output oriented) or to produce output using the lowest amount of inputs (input oriented). According to Greene (1993), the level of TE of a firm can be characterized by the relationship between the present and potential level of production. TE differs from Allocative Efficiency (AE) which refers to the use of inputs at an optimal rate in order to achieve maximum profit.

Beginning with efforts by Farrell (1957), frontier efficiency analysis has been used to assess the technical and distribution efficiency, scale efficiency, and allocative efficiency. Many different methods have been developed to analyses frontier efficiency. The most clear differences are in the use of boundary specifications (i.e., parametric or non-parametric); approaches in boundary computation (i.e., programming or statistical techniques) and the formula for the standard deviation from the frontier (i.e., inefficiency or a mixture of inefficiency and statistical disorder). Among these methods, the nonparametric approach to the analysis of the efficiency frontier is very attractive due to the minimum data requirements and its flexibility. It does not impose restrictions on the form of the function to calculate the efficiency score for each firm or on the distributional assumptions about the error structure. Furthermore, this method does not impose restrictions on the possible beginning of input substitution. The non-parametric approach allows for explicit TE and does not assume it is a permanent hypothesis. Finally, the non-parametric approach is very simple since it requires only a standard linear algorithm. The principal weakness of the approach is that it is not stochastic, an issue similar to other frontier efficiency analysis methods.

Most previous studies drew attention to characteristics of firms such as size, age of firm, ownership and international linkages such as exporting, direct foreign investment, foreign technology licenses and transfer and outsourcing. Only a few studies examined impacting factors such as low-or-high priority sectors, regional differences, workforce capability such as labor quality, education and training of employees and technology capabilities such as expenditures on Research and Development (R&D) and ICT. The relationship

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between firm size and technical efficiency has been and still remains a debatable issue. From empirical and theoretical viewpoints, the relationship between firm size and efficiency is not clear cut. Some researchers advocate promotion and support of small firms on the basis of both economic and welfare arguments. It is argued, for instance, that an expansion of the small firm segment leads to more efficient resource allocation, less unequal income distribution and less underemployment because small firms tend to use more labor-intensive technologies.

The issue of efficiency is often associated with the quality of labor or human capital which is often identified as the main input in production of output and helping the process of economic growth. An increase in human capital investment through education and training will produce a more knowledgeable labor force. Human capital will improve labor quality and productivity and ultimately improve the efficiency of manufacturing firms. Rahmah (2012) explains that firms with a high number of educated workers are able to maintain and control technologies and adapt to new technologies. Labor with high quality is more able to make further investments in human capital, creating knowledge workers who are able to learn quicker and are more innovative (Bishop, 1990; Chapman and Tan, 1990). In fact, a decline in the proportion of skilled labour in a firm will reduce productivity (Yokohama, 1991). Further, the positive relationship between the length of the education of employees and productivity has been repeatedly proven (Black and Lynch, 1996; Rahmah and Idris, 2009). The rationale is that education improves skills in people, while enabling them to be more innovative and think critically.

The present study examines the extent and determinants of TE for SMEs in Malaysia. This involves two models. Firstly, the Stochastic Frontier Analysis (SFA) through estimating a translog production model to obtain the TE score and secondly, regression model to identify determinants of technical inefficiency. Both models are run simultaneously using FRONTIER 4.1 developed by Coelli *et al.* (1998). The remaining of the paper is divided into five sections. The second section discusses the theoretical framework and empirical literature review. The third section describes the model specification and data. The fourth part discusses the research findings, which is followed by a presentation of the conclusions and policy implications in the fifth section.

Literature review: Many empirical studies have estimated stochastic frontiers production models, predicted firm-level efficiencies and identified determinants of efficiency or inefficiency of firms or industry. Two most commonly adopted approaches by the researchers are the Data Envelopment Analysis (DEA) and the Stochastic Frontier Analysis (SFA). Most studies incorporate many variables when examining determinants of technical efficiency or technical inefficiency to include among others; size, ownership, years of establishment, location, human capital, technology, openness, Foreign Direct Investment (FDI) and government incentives.

A study by Sheehan (1997) in Northern Ireland using manufacturing firms over the period 1973-85 found that foreign ownership was an important factor in determining average efficiency levels. Aw and Batra (1998) and Batra and Tan (2003) estimated the technical efficiency of manufacturing firms and its determinants using micro data from Taiwan. In this study they used more interesting variables than ownership like expenditures on R and D, on-the-job training and openness. They found that efficiency was positively correlated with the firm's investments in training and R&D and its informal contacts with foreign purchasers through export sales. Harris (1999) studied productive efficiency in five United Kingdom manufacturing industries and his finding supported Sheehan' results on the positive effect of ownership on technical efficiency. Mini and Rodriguez (2000) used other variables when examine determinants of efficiency in the Philippines' textile industry to include the size, export and government support. They found that technical efficiency increased with size and both exports and government interventions were positively associated with efficiency, although the link between government support and technical efficiency was somewhat weaker. However, Lundvall and Battese (2000) found that the relationship between firm size and technical efficiency was mixed.

Subsequent studies in the determinants of efficiency stress on capital intensity and labour quality. For example, a study by Mahadevan (2000) for the manufacturing industries in Singapore from 1975-94 found that capital intensity and labor quality were important factors in determining the efficiency levels. Capital intensity is closely associated with technology as shown by Deraniyagala (2001) who examined the effects of technology accumulation on firm-level technical efficiency in the Sri Lankan clothing and agricultural machinery industries and found that adaptive technical change to have a significant and positive effect on efficiency in both industries. Further, variables relating to technological skills and training also emerged as significant determinants of firm-level efficiency. Alvarez and Crespi (2003) supported the importance of capital and innovation as driven factors for efficiency in Chile. Besides these factors, they found that efficiency was positively associated with the experience of workers, but in contrast, other variables such as outward orientation, owner education and participation in some public programs did not affect the efficiency of the firms.

However, Batra and Tan (2003) found that a common set of factors appear to distinguish more-efficient firms from less-efficient firms in all six countries; Malaysia, Indonesia, Mexico, Colombia, Taiwan (China) and Guatemala were education and training of workers, investments in new technology, automation, and quality control. Workers training also emphasized by Ng and Li (2003) when investigate underlying reasons why low efficiency was constantly found in enterprises in China. They focused their attention on the effect of training provision on enterprise efficiency and found a positive relationship between training provision and technical efficiency in enterprises. In the studies by Yao and Zhang (2001) and Wu (2002) to examine the link between the efficiency of firms in China and macro variables indicated that government incentives, location, reward systems, capital, foreign direct investment and expenditure on research and development are key factors in efficiency. Both studies also find that nearly all of the factors included in the estimation process of the TE model are significant. These factors include the percentage of training expenditure; the percentage of research and development; the percentage of professional workers; the level of education of entrepreneurs; the number of employees who attend training and firm size. In another study by Zhang *et al*. (2003) includes ownership and R&D as determinants of efficiency of Chinese firms and found that ownership was an importance factor. Sangho identified and estimated sources of technical inefficiency of Korean manufacturing firms and found that firm size had a positive and significant effect in every sector. The effects of the other factors such as dependency on external funds, R and D expenditure and exports were less systematic and varied across sectors. In supporting this study, Agell (2004) argued that employees of smaller firms may be more motivated by competitive-based incentive schemes rather than financial ones, thus possibly making small firms more efficient. A study by Mokhtarul (2004) for Australian textile and clothing firms confirmed that technical efficiency varied significantly according to firms' age, size, capital intensity, proportion of non-production to total workers and type of legal status.

Zulridah and Rahmah (2007) use the DEA method to analyze the TE of 138 small and medium-sized firms in Malaysia and found that the level of mechanization employed and firm size have significant positive impacts, suggesting that larger firms with a more sophisticated level of mechanization have higher TE. In another study using Malaysian data by Mahadevan and Ibrahim (2007) found that ICT, firm size, skilled labor and exports were positive and significant but the capital labor ratio, firm age, and foreign ownership were insignificant. The effect of training was ambiguous as results were inconsistent and the effect of R and D was less significant. Khalifah and Talib (2008) studied efficiency of foreign and local establishments in Malaysia's automotive sector for the period 2000-2004 and found that the small size of plants and the lower share of white-collar workers were significant in explaining plant inefficiency. Foreign multinationals were significantly more efficient than locally owned plants. Unexpectedly, a higher capital-labor ratio was positively related to plant inefficiency and this might be due to excess capacity in the automobile sector as a result of a small domestic market.

In another study of Malay manufacturing enterprises in Rahmah and Norlinda (2008) indicated that the owner years of schooling and firm size are two important determinants of TE. This is due to more educated owners having better planning and management for their organization and larger firms will benefit from economic of scale. A positive relationship between size and efficiency also supported by Diaz and Sanchez (2008) study. They study technical inefficiency and its determinants for SMEs in Spain using the manufacturing sector data of 1995- 2001 using panel data and SF production. They find that SMEs have greater tendency to be inefficient compared to the large sized firms. On the other hand, Badunenko *et al*. (2008) investigated the determinants of technical efficiency of German manufacturing firms for the period 1992-2002 and linked technical efficiency to firm characteristics e.g., organization, location, outsourcing and R and D. Most surprisingly and in contrast to many previous studies, they found that firm size and R&D did not exert any positive influences on differences of technical efficiency across firms. Sinani *et al*. (2008) investigated the determinants and dynamics of firm efficiency in Estonian firms for the period 1993-1999. Their findings provided support for hypotheses that a firm's ownership structure and its characteristics such as firm size, labor quality, soft budget constraints and time of privatization were important for technical efficiency

Yang and Chen (2009) compared the technical efficiency of SMEs with that of large firms and studied the factors influencing technical efficiency for Taiwan's electronics industry. They found that the average technical efficiency for large firms was higher than that of SMEs, without considering the size effect and lower when considering the endogenous choice on firm size. They also found that being a subcontractor had a statistically significant positive influence on SME's technical efficiencies, but the effect decreased with firm size. Kim and Shafii (2009) also showed that foreign ownership, imports and employee quality underpinned technical efficiency. Le and Harvie (2010) evaluated and firm-level technical efficiency and identified the determinants of technical efficiency of domestic non-state manufacturing Small and Medium Enterprises (SMEs) in Vietnam. Factors such as firm age, size, location, ownership, cooperation with a foreign partner, subcontracting, product innovation, competition and government assistance were significantly related to technical efficiency, albeit with varying degrees and directions. Aggrey *et al*. (2010) investigated the relationship between firm size and technical efficiency in East African manufacturing firms. Contrary to their expectation, the results showed a negative association between firm size and technical efficiency in both Ugandan and Tanzanian manufacturing firms. The existence of a positive association between size squared and technical efficiency and a negative association between firm size and technical efficiency in Ugandan and Tanzanian manufacturing firms suggests an inverted U-relationship between firm size and technical efficiency.

There are more evidences of relationship between firms' characteristics and efficiency. For example, Linz and Rakhovsky (2011) found that non-state ownership more likely to improve efficiency, but the ownership effect varied by industry and over time. Adom *et al*. (2012) study the determinants of efficiency in the 120 manufacturing firms in Nigeria in 2011. Using Cobb-Douglass SF model, their study shows that the main determinants of technical efficiency are total expenditure on unskilled workers development, cost of intermediate inputs and net productive asset. Apart from these, variables like status of registration and year of establishment positively affect firms' technical efficiency, whereas firm size has negative impact. A study by Amornkitvikai *et al*. (2014) employed a stochastic frontier analysis (SFA) and found that variables firm size; firm age, foreign ownership, location and government assistance were firm-specific factors that significantly affected the technical inefficiency of production in the manufacturing and exporting SMEs in Thailand. In another study of Thailand manufacturing firms by Charoenrat *et al.* (2013) using a SFA indicated that the that firm size, firm age, skilled labor, ownership characteristics and location were firm-specific factors that significantly affected the technical inefficiency of production. McIntyre and Martin (2013) studied the efficiency of Eastern Europe countries firms and the determinants of inefficiency and found that, on average, Romanian firms were 10% less efficient than firms in Poland, Hungary and Czech Republic. Evidence suggested that the measurable industrial drivers of technical efficiency tend to be consistent across countries, suggesting that the relative inefficiency of Romanian enterprise is due to institutional factors.

Theoretical framework: Farrell (1957) was the first to measure the productive efficiency in terms of frontiers and argues that economic efficiency should be divided into (a) TE, which measures the ability of a firm to maximize output using a given amount of inputs and (b) Allocative Efficiency (AE) which measures the ability of firms to use inputs at optimal proportions at a given price to produce certain level of output. The measurement of production frontier and efficiency can be classified into two groups; non- parametric model, known as the DEA developed by Farrell (1957) and parametric model known as SFA developed by Aigner *et al*. (1977).

Farrell (1957) defines TE as the production of output in relation to certain fixed inputs. Farrell (1957), the pioneer of efficiency measurement, characterized several instances of how production can be inefficient. Normally, the stochastic production frontier model is used to estimate the TE. The estimated model is often based upon the Cobb-Douglas or translog production function. The present study uses a translog production function to analyse the production frontier. The translog stochastic production frontier model is as follows:

$$l_n y_i = \ln a_0 + \sum_{i=1}^{n} a_i \ln X_i + 1/2 \sum_{i=1}^{n} \beta_{ij} l_n X_j + v_i - u_i \quad (1)$$

Where:

- Y = Output
- α = Efficiency parameter
- X_j = Inputs
- v_i = A random variable that is assumed to be independent and normally distributed $N(0, \sigma_V^2)$
- u_i = A non-negative random variable which refers to the impact of inefficiency in the production of the firms. The variable is assumed to be independently distributed with truncation, $N(0, \sigma_u^2)$
- i = Firm i

The efficiency of firms in the production of output can be achieved when a firm is able to produce output at the frontier level where the firm is at its best performance. Firms operating below the boundary are considered inefficient. The way to enhance efficiency is to improve the existing technology or enhance employee skills through education and training so that the existing technology can be used more efficiently. Existing studies that use SFA include Farrell (1957), Aigner and Chu (1968), Aigner *et al.* (1977), Kumbhakar *et al.* (1991), Greene (1993), Coelli *et al.* (1998) and Battese and Coelli (1995). The variance parameter for the model is written as follows:

$$\sigma^2\sigma^2_v + \sigma^2_u; \lambda = \sigma^2_u / \sigma^2_v \text{and} \gamma = \sigma^2_u / \sigma^2 \quad (2)$$

where, γ parameter having a value between zero and one (Battese and Coelli, 1995; Coelli *et al.*, 1998) and the λ parameter could be any non-negative value. The value of TE for each firm is derived from the following formula:

$$TE = \frac{y_i}{\exp(x,\beta)} = \frac{\exp(x,\beta - ui)}{\exp(x\beta)} = \exp(-u_i) \quad (3)$$

The index of TE is between zero and one or $0<TE_i<1$. The manufacturer i achieves maximum output if $TE_i = 1$. The method of Maximum Likelihood (ML) estimation procedure is used for the frontier production model (Eq. 1). To determine the appropriateness of the frontier model, the value γ is observed. If the value is large and significant, than the frontier production model is better than the ordinary production model for analyzing firm's production process.

The first part of this section explains the model specifications utilized in the present study which consist of a SFA production model and two technical inefficiency (TIE) models. The two TIE models are differentiated by the manner in which human capital are measured. The second part explains the source of data utilized in the study.

MATERIALS AND METHODS

Model specification: The SFA production model which is based upon the translog production function is expressed as follows:

$$l_n VA\beta_0 + \beta_1 \ln LAB_i \beta_2 \ln CAP_i + 0.5\beta_3 (\ln LAB)^2_i + 0.5\beta_4 (\ln CAP)^2_i + \beta_5 \ln LAB_i \ln CAP_i + v_i - u_i \quad (4)$$

Where:

VA	=	Value added
LAB	=	Quantity of labor
CAP	=	Value of fixed asset
I	=	Firm ith
v and u	=	Error terms

The determinants of TIE are selected based upon the Productivity Report 2011/2012 (MPC, 2012).The factors include the human capital development, technological capacity, demand structure, business regulation, innovation and creativity. In accordance with the availability of the data, the determining factors are expressed in the models below. The estimation of the model uses the ML procedure:

$$TIE_i = \beta_{02} + \beta_{12} \ln RDE_i \beta_{22} \ln ICTE_i + \beta_{32} (\ln TRNE)_i + \beta_{42} WTEC_i + \beta_{52} WGEN_i + v_i - u_i \quad (5)$$

$$TIE_i = \beta_{01} + \beta_{11} \ln RDE_i \beta_{21} \ln ICTE_i + \beta_{31} (\ln TRNE)_i + \beta_{41} WUSEC_i + \beta_{51} WLSEC_i + v_i - u_i \quad (6)$$

Where:

TIE	=	The technical inefficiency
RDE	=	The ratio of research and development expenditures to total expenditures of enterprises
ICTE	=	The ratio of information and communication technology
(ICT)	=	Telecommunication expenditure to total expenditure
TRNE	=	The ratio of workers training expenses to total expenditure
WTEC	=	The ratio of technicians and associate professionals workers to total employment
WGEN	=	The ratio of general workers to total employment
WUSEC	=	The ratio of workers with upper secondary level of education to total employment
WLSEC	=	The ratio of workers with lower secondary level of education to total employment. Firms are divided into three categories of size, namely, micro-Sized Firms (CSFs), Small-Sized firms (SSFs) and Medium-Sized Firms (MSFs)

Source of data: The data used for the analysis in the present study is obtained from the Industrial Manufacturing Survey of 2009 conducted by the Department of Statistics Malaysia (DOSM). The total firms used in the study consists of 30.0 percent of the total samples in the manufacturing survey of 2009. DOSM arranges the data according to firm size, from the smaller to the larger size based upon the definition by SMECORP (www.smecorp.gov.my) and randomly selects 30% of the sample. DOSM does not provide all available data to researchers due to the regulation stated that a researcher can only be provided access to a maximum of 30.0% of the available data. The data contains 4,937 firms in

71 sub-industries of the manufacturing sector in Malaysia. Of the 4,937 firms, only 4,661 firms are utilized in the analysis of which all required information are available.

RESULTS AND DISCUSSION

Descriptive statistics: Table 1 presents the descriptive statistics of the independent variables for the inefficiency model. The mean for research and development (R and D) expenditure per year is RM2,358.28, for ICT expenditure is RM6,400.69 and for training expenditure is RM749.97. The small mean of expenditures showed by these three expenditure categories is due to low or no expenses allocated for these purposes for some firms. The CSFs and SSFs, for example, rarely allocate their expenses to train their workers, conduct proper R and D or expand their ICT usage. The mean ratio of workers with upper secondary and lower secondary education are 0.3782 and 0.5766 respectively. The mean ratio of the technical workers is very low at only 0. 0383 but the ratio for the general workers is quite high at 0.7228.

Level of efficiency by size: Table 2 shows the level of technical efficiency by firm size. The mean of the technical efficiency for the whole sample is 0.6547. The MSFs and SSFs demonstrate higher technical efficiency compared to the CSFs. The result shows that only one firm in the MSFs reach full level of efficiency. But the majority of the firms are at the efficiency level of between 0.70-0.79. The number of the firms at the efficiency level below 0.50 is quite large, especially for the CSFs. Table 3 presents the TE scores by the manufacturing sub industries. It is shown that the electrical and electronics industry is the most efficient with the TE score of higher than 0.7326. This is followed by the transport equipment; the plastics and rubber based products and metal products with the TE of higher 0.7.The lowest TE is observed in the textile and wearing apparel industry with the mean of less than 0.6. The results do demonstrate that the heavy industries are relatively more efficient than the light industries.

Production frontier and technical inefficiency: Table 4-6 and 6% the estimation results for the production frontier models and technical inefficiency determinants for the CSFs, SSFs and MSFs. Table 4 and 5 show that the values of gamma are quite large and they are significant at 1% level of significance. This implies that the deviations from the production frontier are due to technical inefficiency. Therefore, the frontier production model is better than the conventional production model in explaining the firm's production process. But this value is very small and not significant for the MSFs model which implies that the deviation is due to noise. For the CSFs, most of the incorporated variables are statistically significant in determining the output level of the firms. The quantity of labor is positively significant in both models but the capital is not significant in the first model but both variables are significant in model 2. The significant determinants of technical inefficiency for the CSFs are expenditures on R and D, ICT and training, in which the increase in these expenditures will reduce the technical inefficiency in CSEs. The quality of labor which are measured by their job categories and level of education are also significant determinants of inefficiency for CSFs except the ratio of workers with education level of lower secondary level.

Table 1: Descriptive statistics for determinants of technical efficiency

Variables	No. of firms	Mean	SD
RDE	4661	2358.28	56849.12
TRNE	4661	749.950	7654.910
ICTE	4661	6400.69	93311.13
WUSPM	4661	0.37820	0.349000
WLSPM	4661	0.57660	0.370600
WTEC	4661	0.03830	0.116100
WGEN	4661	0.72240	0.395800

Computed from data provided by the Department of Statistics, 2009.

Table 2: Technical efficiency by firm size

Technical efficiency	Micro	Small	Medium	Total (%)
1.00	0	0	1	1 (0.02)
0.90-0.99	1	13	19	33 (0.71)
0.80-0.89	246	724	84	1,054(22.61)
0.70-0.79	827	594	68	1,489(31.95)
0.60-0.69	649	131	18	798 (17.12)
0.50-0.59	398	32	7	437 (9.38)
<0.50	809	30	10	849 (18.21)
Total	2,930	1,524	207	4,661
Mean	0.5842	0.7742	0.7741	0.6547

Computed from data provided by the Department of Statistics, 2009 using SFA

Table 3: Technical efficiency by sub industry

Sub industry	Mean
Food (101-108)	0.6561
Beverage and Tobacco (110-120)	0.6240
Textile and Wearing Apparel (131-152)	0.5637
Wood Based Products (161-182, 310)	0.6756
Chemical Products (201-210)	0.6881
Plastic and Rubber Based Products (221-222)	0.7089
Non-Metal Mineral Products (231-239)	0.6555
Metal Products (241-259)	0.7027
Electrical Electronics (231-239)	0.7326
Transport Equipment (291-309, 331-332)	0.7140
Others (321-329)	0.6272
Mean	0.6547

Sub industries are categorized based on Malaysian Standard Industrial Classification; (MSIC) 2008, Department of Statistics.

Table 4: Estimation results for production frontier model and determinants of technical inefficiency for micro-sized firms

	Model 1		Model 2	
Variables	Coefficient	t-ratio	Coefficient	t-ratio
Intercept	10.295	198.11***	10.10	245.88***
lnLAB	0.730	11.77***	0.995	18.01***
lnCAP	-0.086	-0.075	-8.581	-7.41***
0.5 $(\text{lnLAB})^2$	0.029	0.468	-0.105	-1.71*
0.5 $(\text{lnCAP})^2$	0.024	11.20***	0.024	11.11***
lnLAB X lnCAP	-0.003	-4.06***	-0.003	-3.88***
Determinants of technical ineffici encyt				
Intercep	0.611	2.52**	-0.848	-1.35
lnRDE	-0.878	-3.59***	-0.963	-3.15***
lnICTE	-3.084	-9.01***	-0.484	-8.42***
lnTRNE	-0.248	-1.79*	-0.411	-2.59***
WTEC	-7.671	-5.82***	-	-
WGEN	-2.84	-8.18***	-	-
WUSEC	-	-	-1.354	-2.21**
WLSEC	-	-	0.045	0.08
sigma-squared	2.875	-8.18***	3.722	8.63***
gamma	0.938	128.39***	0.950	139.43***

Log Likelihood = -3170.47; -3260.95; LR test of the one-sided error; 880.76; 699.79;*Significant at 10%, ** 5%, *** 1%

Table 5: Estimation results for production frontier model and determinants of technical inefficiency for small-sized Firms

	Model 1		Model 2	
Variables	Coefficient	t-ratio	Coefficient	t-ratio
Intercept	10.459	50.0***	10.395	46.44***
lnLAB	1.285	8.13***	1.366	8.25***
lnCAP	-0.166	8.66***	-0.165	-8.51***
0.5 $(\text{lnLAB})^2$	-0.265	-3.78***	-0.288	-4.03***
0.5 $(\text{lnCAP})^2$	0.025	8.71***	0.025	8.46***
lnLAB X lnCAP	0.001	3.37***	0.001	3.07***
Determinants of technical inefficiency				
Intercept	-6.147	-5.93***	-0.531	-0.94
lnRDE	-0.374	-15.95***	-0.383	-3.29***
lnICTE	-0.419	-0.001	-0.158	-5.07***
lnTRNE	0.203	3.59	0.050	1.95*
WTEC	2.843	2.55***	-	-
WGEN	2.381	4.09***	-	-
WUSEC	-	-	0.132	0.21
WLSEC	-	-	0.650	1.14
sigma-squared	2.792	6.50***	0.941	8.87***
gamma	0.924	76.56***	0.782	25.89***

Log Likelihood-1273.14; -1285.49; LR test of the one-sided erro; 164.57; 139.88; Note: * significant at 10%, ** at 5%, *** 1%.

The results of the estimation for the production model in the SSFs is shown in Table 5. The results are almost similar to the results for CSFs. All independent variables for the production frontier model are significant and give correct signs as predicted by the theory. The technical inefficiency level of the SSFs is mainly determined by their expenditures on R and D and ICT, which are negative and highly significant. However, the ratio of technical and general workers will increase technical inefficiency. On the other hand, the ratio of the workers with level of education does not significantly affect SSFs technical inefficiency.

Table 6: Estimation Results for Production Frontier Model and Determinants of Technical Inefficiency for Medium-sized Firms

	Model 1		Model 2	
Variables	Coefficient	t-ratio	Coefficient	t-ratio
Intercept	14.576	14.78***	14.153	1.61
lnLAB	0.986	1.05	1.564	0.45
lnCAP	-0.467	-2.68***	-0.409	-2.64***
0.5 $(\text{lnLAB})^2$	-0.160	-0.366	-0.357	-0.487
0.5 $(\text{lnCAP})^2$	0.05	1.58	-0.038	1.22
lnLAB X lnCAP	-0.0001	-0.06	0.0005	0.215
Determinants of technical inefficiency				
Intercept	-0.517	-0.67	0.072	0.07
lnRDE	0.006	0.25	0.008	0.54
lnICTE	0.112	1.85*	0.030	0.91
lnTRNE	-0.057	-3.48***	-0.050	-3.33***
WTEC	-1.267	-1.52	-	-
WGEN	0.248	0.29	-	-
WUSEC	-	-	0.658	0.66
WLSEC	-	-	0.884	1.04
Sigma-squared	0.746	9.55***	0.764	10.14***
Gamma	0.012	0.20	0.000	0.00

Log Likelihood -265.67; -265.80; LR test of the one-sided error = 15.64; 15.38

The results for the MSFs in Table 6 show the significant level of the capital input in determining the firms output. But only the expenditures on ICT and training have significant negative effects on the technical inefficiency of the MSFs. Other incorporated variables are not significant. Therefore, there are different determinants of the technical inefficiency for the different firm size. This shows different emphasis has to be formulated in a strategic policy. For the CSFs and SSFs the significant determinant of their technical inefficiency is ICT expenditure but for the MSFs the training expenditure is particularly important in reducing their technical inefficiency level. With regards to the labor quality, the results show that most coefficients for the ratio of workers by level of education are not statistically significant. However, the ratios of workers by job categories do give significant negative impacts on the inefficiency level especially for the CSFs. This implies that CSFs still require less educated workers in accordance with their low technological level. In contrast, for the SSFs, increase in the ratios of workers at the technical and general level will increase their inefficiency level. This reflects that higher level of technology adopted by the SSFs requires more educated workers such as the professional workers.

CONCLUSION

The study examines the TE scores for three categories of firms, CSFs, SSFs and MSFs and identifies the determinants of technical inefficiency for these firms. The results show that the overall TE is at the moderate level with the SSFs and MSFs have a higher efficiency levels compared to CSFs. This shows that the size of the firms is important to obtain higher technical efficiency level. One of the reasons for higher TE for the larger-sized firms is that the economics of scale that will reduce the production cost. The heavy manufacturing sub industries are proven to have higher TE scores than the light industries. Most of the incorporated variables significantly determine the output level of the firms and the signs are in accordance with production theory. The expenditures on R and D, ICT and training seem to be important for reducing inefficiency for the CSFs and SSFs. For the MSFs, the expenditures on ICT and training are important in reducing their inefficiency level. Labor quality which is measured by the ratios of workers at different job categories is also important in reducing the technical inefficiency level of the firms especially in the CSFs. However, for the SSFs, the increase in this ratios of technical and general workers will decrease inefficiency, When labor quality is measured by the ratio of workers at different level of education, the study does not show any significant results, except for the workers with upper secondary education for the CSFs, who contribute negatively to the technical inefficiency.

RECOMMENDATIONS

The results of this study bear several policy implications. The TE levels are still moderate for the three firm size and the number of firms that operating at the optimum levels are very small. Therefore, in order to increase the efficiency level and increase the number of firms with maximum score, inefficiency determinants must be known. Based on the negative contribution of the expenditures on R and D, ICT and training to the technical inefficiency, firms are encourage to increase these types of expenditures in order to be more efficient. The CSFs can still continue hiring low quality workers as they contribute negatively to their inefficiency level. However, with a better technological adoption in the SSFs, higher quality of workers are needed. These firms cannot increase the number of technical and general workers because the result indicates positive consequences to their inefficiency levels.

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