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Determinants of Technical Efficiency in Indonesian Manufacturing: The Case of Motor-Vehicle Firms

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Abstract

This current study analyses the technical efficiency of Indonesian motor vehicle manufacturing firms (ISIC 34100) and its selected important determinants. The technical efficiency scores are calculated using Data Envelopment Analysis (DEA) and the estimation on the determinants employs the panel data method. The output variable is the total value of output for each firm, whereas the input variables are material, workers, capital, and energy. The selected determinants affecting technical efficiency are export, import, capital-labour ratio, and foreign ownership. It is found that the average technical efficiency score under VRS is 0.81 during the period 2007-2013, with the lowest score is 0.53 in 2010 and the highest score is 0.89 in 2012. The findings from the estimation of important determinants show that export, capital-labour ratio, and foreign ownership provide a positive significant effect on the technical efficiency respectively. In contrast, import has a positive insignificant effect on the technical efficiency.

Keywords: Technical Efficiency; Export; Import; Capital Labor Ratio; Foreign Ownership.
JEL Classification: D24, D29, F23

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1. Introduction

The numbers of motor-vehicles in Indonesia has increased by an average of 14% per year over the past decade (Indonesian Central Board of Statistics, 2020). The growing number of motor-vehicles is due to the fact that the motor-vehicles are still considered as one of the cheapest, the most convenient and the fastest medium of transportation in Indonesia (Irawan, Begiawan, Joewono, & Simanjuntak, 2020). The lack of a well-developed, safe and secure mass transportation system, such as the subway, in Indonesia has encouraged people to choose motor-vehicles as the main medium of transportation (Pratikto, 2020).

The significant increase in the demand of motor vehicles triggers an increase in production output. Based on the survey data from Indonesian Central Board of Statistics, motor vehicle production in Indonesia has increased by 12% per year during the period of 2007-2015, in response to increased in public demand for motor-vehicles (Indonesian Central Board of Statistics, 2019). The interesting point from this survey is that the increase in inputs used in production is greater than the increase in output produced (Indonesian Central Board of Statistics, 2020). This fact intuitively indicates a decreasing return to scale (DRS) in the production of motor vehicle companies in Indonesia. This fact is interesting to study further in relation to the efficiency of motor vehicle manufacturing companies. A question arises “does the production of motor vehicles in Indonesia experience technical inefficiency?”

The earlier literature on technical efficiency focuses on efficiency scores of firms with two commonly used approaches, namely the parametric Stochastic Production Frontier (SPF) approach and the non-parametric Data Envelopment Analysis (DEA) approach. The SPF approach has the advantage of accommodating large numbers of data and allows parametric estimation with disturbance variables (Tsionas, 2020). Meanwhile, the DEA approach allows the estimation of efficiency with more than one output variables and accommodates small numbers of data due to the using of linear programming method (Lin & Chen, 2020). This present study uses DEA with the consideration that the data of motor-vehicle manufacturing companies is very little compared to the total manufacturing companies. With a focus on four-wheeled motor vehicle manufacturing companies, the total companies after the construction of a balanced panel is 11 companies. According to Jradi & Ruggiero (2019), DEA provides a more efficient results compared to SPF for the small numbers of data.

The more recent literature analyzes technical efficiency in relation to the key determinants (for example, (Arellano & Reyes, 2019; Puertas-Medina, Marti-Selva, & Calafat-Marzal, 2020; Wu, 2020). The key determinants of a company that affect technical efficiency can come from the within the company itself and can come from the outside the company. The capital-labor ratio is one of the determinants in a company that can significantly influence technical efficiency (Fahmy-Abdullah, Sieng, & Isa, 2019; Gupta, Gupta, & Dhamija, 2019). Foreign ownership is another factor in companies that is crucial in influencing technical efficiency (Fukuyama, Matausek, & Tzerremes, 2020; Lemi & Wright, 2020). Meanwhile, exports and imports are two important external factors in affecting the company’s technical efficiency, which represent global influences on local companies (Ai, Wu, & Li, 2020; Lemi & Wright, 2020; Mazorodze, 2019; Setiawan, 2019). These four key determinants are examined in this present study.

The chief contribution of this current research is two-fold. Firstly, it covers both the internal-controllable and the external-uncontrollable determinants of technical efficiency, showing the inward- and outward looking decision of the observed firms. Secondly, it focuses on a very specific industry, namely four-wheel motor-vehicle manufacturing, which reduces a heterogeneity issue arise in previous studies. This two-side novelty extends the existing literature in the empirical findings.

2. Research Methods

2.1 Research Approach and Techniques

This research is an explorative research with a quantitative method. The relationship between the variables is estimated in order to measure the influence of one variable to another. This study estimates the technical efficiency scores of each firm in each year of observation. It also analyzes the relationship of some pivotal variables against the technical efficiency variable. The estimation of the technical efficiency scores follows the non-parametric Data Envelopment Analysis (DEA) method, whereas the analysis of the impact of pivotal variables on technical efficiency scores is conducted under the panel data analysis method. Both methods are presented below sequentially after the discussion about the sources of data and the construction of the dataset for analysis.

2.2 Data and Sources

The data used in this current study is the annual survey of the large and medium enterprises conducted by the Indonesian Central Board of Statistics (*Badan Pusat Statistik* - BPS) for the period 2007-2013. The survey is purely on the large and medium manufacturing firms in Indonesia with 20 or more labours. The survey data is in the database form and in the coding system. Each firm is assigned with a specific identification code (PSID), so that it is possible to set a balanced panel data. Together with the database, the annual questionnaires are supplemented in the softcopy database. The survey covers rich information about each firms, such as specific identification code (PSID), industrial classification (ISIC), year of starting production, location of firm, ownership, gross output, number of labor in production and non-production, value of fixed capital and investment, material, energy consumption, share of production exported, and value of material imported.

The construction of balanced panel data for the analysis in this study follows the five-step procedure. The first step is to choose the relevant firms; those are four-wheel motor-vehicle firms which taken out from the total manufacturing firms in the database. In this step, the four-wheel motor-vehicle firms are selected based on the International Standard of Industrial Classification (ISIC), those are the firms with ISIC 34100. The second step is cleaning for noise and typographical error, such as cutting out firms with zero or a negative value of output or inputs (material, labour, or energy), dropping out firms with missing values of the related variables, and correcting key-punch errors. In the third step, the missing capital values are back-casted using the procedure in Suyanto, Salim, & Bloch (2014). The fourth step is matching firms from year to year of observation based on the PSID code. The last step is to deflate the monetary values of output and material using a wholesale price index provided by BPS and to deflate the monetary values of energy using energy price index provided by the Indonesian ministry of energy and mineral resources.

After the construction of the balanced panel data, the total numbers of firm in the dataset are 11 firms for seven years. Therefore, the total observations are 77. These observations are used in both the estimation of technical efficiency scores and the analysis for the key determinants affecting technical efficiency.

2.3 Variables and the Operational Definitions

The variables used in this current study are divided into two groups. The first group is the variables for estimating technical efficiency score and the second group is the variables for analyzing the key determinants of technical efficiency. The first group variables for estimating technical efficiency score are output (Y), material (M), labour (L), capital (K), and energy (E). The second group variables are technical efficiency score (TE), capital-labour ratio (KL), foreign ownership (FO), exported output (X) and imported material (I). The output variable (Y) is measured using the total monetary value of output deflated under the wholesale price index with the base year 2010. The material (M) is calculated from the total monetary value of material used in the production deflated under the wholesale price index with the base year 2010. Labour (L) is the fulltime equivalent numbers of workers in production. The energy (L) is measured from the total monetary value of fuels and electricity used in the production deflated under the energy price index with the base year 2010. The technical efficiency score (TE) is the scores of efficiency for each firm at each year of production calculated from the first group of estimation. The capital-labour ratio (KL) is the ratio of the monetary value of capital per one labour, whereas the ownership (FO) is measured from the percentage of foreign ownership in the firm. Export (X) is calculated from the percentage of output exported, and import (M) is the percentage of material imported. Table 1 summarizes the operational definitions of each variables.

Table 1. ***Operational Definitions of Varibles***

Variable	Symbol	Definition
Variables for estimating technical efficiency score		
Output	Y	Total monetary value of output (in rupiah) deflated under the wholesale price index with base year 2010.
Material	M	Total monetary value of material (in rupiah) deflated under the wholesale price index with base year 2010.
Labour	L	Equivalent numbers of fulltime labour (in person) in production
Capital	K	Total monetary value of capital (in rupiah) deflated under the wholesale price index with base year 2010.
Energy	E	Total monetary value of energy (in rupiah) that calculated from the sum of monetary value of fuels and monetary value of electricity, deflated using the energy index with base year 2010.
Variables for Analyzing Key Determinant of Technical Efficiency		
Technical efficiency score	TE	The score of time-varying technical efficiency of firms calculated from the linear programming DEA
Capital-labour ratio	KL	The ratio of capital for each unit of labour, calculated from the monetary value of capital divided by the number of labour.
Foreign ownership	FO	The percentage of foreign ownership in each firm
Export	X	The percentage of output exported
Import	I	The percentage of material imported

Source: The definitions consistently follow the survey of large and medium enterprises conducted by Indonesian Central Board of Statistics.

2.4 Methods of Analysis

Two methods of analysis are applied in this current study. The first method is *data envelopment Analysis* (DEA) for estimating the technical efficiency score, whereas the second method is the panel data regression for analyzing the key determinants of technical efficiency. The first method is to answer the research question on whether the observed firms experience technical inefficiency. The second method is to address the research question on what are the key determinants of technical efficiency in the four-wheel motor-vehicle manufacturing firms. These two methods are briefly discussed as followed.

a. *Data Envelopment Analysis* (DEA)

Data Envelopment Analysis (DEA) is a non parametric frontier method that uses linear programming to calculate the best practice and the dispersion toward the frontier (Lin and Chen, 2020). This method calculates the ratio of inputs and outputs in each unit compared to the best practice. The purpose of this method is to determine the level of technical efficiency carried out by the Decision Making Unit (DMU) relative to similar observed companies (Adom & Adams, 2020). The efficiency score of each company has a value between 0 to 1, with a value of 0 means the company is in a condition of perfect inefficiency and a value of 1 means that the company is in perfect efficient condition (Coelli, Rao, O'Donnell, & Battese, 2005; Kumbhakar & Lovell, 2000).

In general, the mathematical expression in calculating technical efficiency is as follows:

$$ET_i = \frac{0Q}{0P(M)\ 0P(L)\ 0P(K)\ 0P(E)} \quad (1)$$

for ET is the technical efficiency score, which is a positive number between 0 and 1; Q is the total output of production, P is inputs or factors of production, M is material, L is labour, K is capital, E is energy.

Based on the mathematical expression in equation (1), the linear programming model of the output-oriented DEA is formulated as follows:

$$Max_{\varphi\lambda}\ \boldsymbol{\varphi},$$
subject to
$$\begin{aligned} &-\varphi y_i + Y\lambda \geq 0, \\ &x_i - X\lambda \geq 0, \\ &N1'\lambda = 1 \\ &\lambda \geq 0 \end{aligned} \quad (2)$$

where is a scalar and is a vector of constants, Y represents all output data for *N* firms, X represents all input data for *N* firms, *xi* are individual inputs and yi are the output for firm, represents the efficiency score for each firm that takes a value between 0 and 1.

b. *Panel Data Regression*

After obtained the technical efficiency score from the DEA model in equation (2), it is possible to analyze the key determinants affecting technical efficiency. The panel data regression model is employed to analyze the impact of key determinants on technical efficiency. Using the selected determinants as described in Table 1, namely exports, imports, capital-labor ratios, and foreign ownership, the panel data model for this study is written as follows:

$$TE_{it} = \alpha_0 + \alpha_1 KL_{it} + \alpha_2 FO_{it} + \alpha_3 X_{it} + \alpha_4 IM_{it} + \varepsilon_{it} \quad (3)$$

where TE_{it} is the technical efficiency score of firm *i* at time *t*, KL_{it} represents the capital-labor ratio of firm *i* at time *t*, FO_{it} is the percentage of foreign ownership of firm *i* at time *t*, X_{it} represents the percentage of exported output of firm *i* at time *t*, IM_{it} is a measure for the percentage of imported material of firm *i* at time *t*, are parameters to be estimated, ε_i represents *error term*.

3. Result and Discussion

3.1 Results of Technical Efficiency Score

Using DEA as shown in the previous section, panel data was iterated using DEAP 2.1 software, following the Coelli's (1996) procedure. The DEA method in this study uses an output-oriented orientation, which is to estimate the maximum output from certain input combinations, as described in Coelli, Rao, O'Donnell, & Battese (2005). The measurements of technical efficiency score is under Constant Return to Scale (CRS) and Variable Return to Scale (VRS), interchangeably. According to Wardana, Yamamoto, & Kano (2018), CRS measures the level of efficiency of a company production when the output increases proportionally with the increase in all inputs, while VRS present of the company's success in turning inputs into outputs when the increase in output is larger than the increase in all inputs.

Table 2 shows the average technical efficiency of CRS and VRS in Indonesian four-wheel motor-vehicle companies. It can be seen from the table that the average score of technical efficiency during the 2007-2013 period was 0.677 for CRS and 0.81 for VRS. When the data is grouped based on the year (the upper part of Table 1), it was seen that the highest technical efficiency under CRS measurement is occurred in 2008 with the score of 0.768.The lowest technical efficiency is in 2010 withthe score of 0.36. Under the VRS measurement, the highest technical efficiency occurred in 2012 with the score of 0.899 and the lowest is in 2010 with score of 0.53.

When the dataset is differentiated for each observed company (the bottom part of Table 2), the results show that the company with survey code PSID 10137 are the best-practice companyunder the CRS measurement. In contrast, there are four best-practice companies under VRS measurement, namely companies with PSID codes 10137, 45295, 31090, and 10132. Meanwhile, the company with the lowest technical efficiency score is the company with the PSID code 17860, with a value of 0.417 for the CRS measurement and 0.51 for the VRS measurement. From the finding of technical efficiency scores, it can be shown that a high dispersion occurs between companies. The dispersion of the lowest score company to the best practice is 58.3% under the CRS measurement and 49% under the VRS measurement.

Table 2. ***Annual Average Score and Firm Average Score of Technical Efficiency***

Year	PSID Code	CRS	VRS
2007	-	0.695	0.826
2008	-	0.768	0.868
2009	-	0.732	0.847
2010	-	0.36	0.53
2011	-	0.717	0.896
2012	-	0.714	0.899
2013	-	0.758	0.809
-	10137	1	1
-	17781	0.767	0.838
-	17783	0.479	0.606
-	45295	0.359	1
-	31090	0.737	1
-	17917	0.455	0.569
-	10131	0.798	0.801
-	10129	0.554	0.663
-	60443	0.918	0.925
-	17860	0.417	0.510
-	10132	0.969	1
Overall Average		**0.677**	**0.810**

Source: Estimation results on the balanced panel dataset using the DEAP 2.1 software

3.2 Results of the Key Determinants on Technical Efficiency

After obtaining technical efficiency scores for each observed company during 2007-2013, the estimationon the key determinants of technical efficiency can be conducted. The technical efficiency score is used as the dependent variable, while exports, imports, capital-labor ratios and foreign ownership are used as independent variables in the panel regression analysis. Common Effects, Fixed Effects, and Random Effects are used in the estimation. Chow Test, Hausman Test, and Breusch-Pagan Lagrangian Multiplier Test are carried out to determine the appropriate model. This study uses STATA14 software to estimate the panel regression. The estimation results of the three models are presented in Table 3.

From the findings of Chow test as shown in Table 3, the Fixed Effect model is a more suitable model than the Common Effect model,as the F-test probability value was smaller than alpha 0.05. Furthermore, the result of Hausman Test suggests that the more suitable model is the Random Effect model if compare d to the Fixed Effect model, because the chi-squared probability value was greater than 0.05. In addition, the finding of the Breusch-Pagan Lagrangian Multipler Test shows the Random Effect model is a more suitable than the Common Effect model, as the chi-bar-squared probability value is less than 0.05. From the results of the three tests, it can be concluded that the most suitable model for the panel dataset in this present study is the Random Effect model. Thus, the interpretation of the estimates is based on the results of the Random Effect model (the last column in Table 3). There is a positive impact of Capital-Labour Ratio (KL) on the technical efficiency (TE), as indicated from the positive and significant coefficient of KL in Table 3. The increase in one unit of capital-labour ratio leads to the increase of TE score for 0.019791. These results are in line with the results of research conducted by Rath (2018) and Setiawan (2019), but different from Fahmy-Abdullah, Sieng, & Isa (2019) and Ayelign & Singh (2019). The similarity of results with Rath (2018) and with Setiawan (2019) is more due to the nature of the observed industry as capital-intensive industries such as the industrial industries observed in this study. Meanwhile, differences in findings with Fahmy-Abdullah, Sieng, & Isa (2019) and Ayulign & Singh (2019) are more on differences in the nature of the industry under study and the differences in research methods.

The Foreign Ownership (FO) variable was also found to have a positive effect on technical efficiency (TE) score with a significance level of 1%. This magnitude of effect is reflected from the coefficient 0.0221. These findings support the results of research conducted by Sur & Nandy (2018) who say that there is a positive relationship between Foreign Ownership and Technical Efficiency. This finding is also in line with Fukuyama, Matausek, & Tzerremes (2020) for banking companies in Turkey and Lemi & Wright (2020) for manufacturing companies in Ethiopia and Kenya.

Table 3. ***Regression Results of Common Effect, Fixed Effect, and Random Effect (independent variable: Technical Efficiency Scores)***

Variable	***Common Effect***	***Fixed Effect***	***Random Effect***
Constants	1.118*** (0.000)	0.977*** (0.000)	1.045*** (0.000)
CapitalLabor Ratio (KL)	0,020 (0.237)	0.069* (0.056)	0,063* (0,064)
Foreign Ownership (FO)	0.020** (0.043)	0.023*** (0.010)	0.022*** (0.009)
Export (X)	0.040*** (0.000)	0.303** (0.026)	0.035*** (0.002)
Import (IM)	0.013 (0.281)	0.026 (0.537)	0.013 (0.489)
R^2	0.270	0.233	0.264
Chow *Test*	*Fixed Effect*		F-test: 3.310 (0.002)
Hausman *Test*	Chi-Square: 0.750 (0.946)	*Random Effect*	
LM *Test*	*Random Effect*		Chi-Bar^2: 11,8 (0.000)
Companies	11	11	11
Observation	77	77	77

Source: The panel estimation results on the balanced panel set of the Indonesian Large and Medium Manufacturing Survey Database conducted by Indonesian Central Board of Statistics.

Note: * indicates a level of significance at α=10%, ** indicates a level of significance at α=5%, *** indicated a level of significance at α=1%. The numbers in the parentheses represent the probability of t-statistics.

Moreover, the export (X) variable has a positive significant effect on technical efficiency (TE) at level of α = 1%. The coefficient value of 0.0348 shows that when exports increase by 1%, the technical efficiency score will increase by 0.03. This finding supports the findings of Mazorodze (2019), which shows a positive relationship between exports and technical efficiency for South African companies. The results of this study are also in line with findings by Setiawan (2019) and Lemi & Wright (2020). Meanwhile, the import variable does not have a significant effect on technical efficiency because the significance level exceeds 10%. Imported raw materials have a positive but not significant effect on technical efficiency. Differences in findings related to imports in this study and findings by Ai, Wu, & Li (2020) tends to be caused by differences in the types of companies studied and the methods used.

4. Conclusions

This study analyzes technical efficiency scores for Indonesian four-wheel motor-vehicle firms. This study also estimates the key determinants that affect technical efficiency. The results of the technical efficiency scores show that the average score of technical efficiency during 2007-2013 is 0.677 for the CRS measurement and 0.81 for the VRS measurement. The highest technical efficiency occurred in 2012 with a score of 0.899 and the lowest TE occurred in 2010 with a score of 0.53 under the VRS measurement. The low technical efficiency in 2010 tends to be caused by the global crisis in Europe which has an impact on the reduction in imported spare-parts and the rising prices of raw materials for production. The high efficiency score in 2012 was mostly because of the beginning of recovery in the global economy and the increasing trend in the Indonesian economy. Based on the efficiency scores of each company, there were four best-practice companies during the study period, those with the PSID code 10137, 45295, and 31090, while the company with the lowest technical efficiency score was the company with the PSID code 17860, with a value of 0.51 under the VRS measurement. Considerable heterogeneity occurs between the best-practice companies and the lowest efficiency companies, dispersion of 49%.

The key determinants that significantly affect Technical Efficiency are Exports, Capital Labor Ratio, and Foreign Ownership. These three variables have a positive effect on Technical Efficiency. In contrast, imports have a positive but insignificant effect on Technical Efficiency. Companies that export their products have higher technical efficiency compare to those do not export. Likewise, companies with high capital-labor ratios tend to have higher technical efficiency than companies with small capital-labor ratios. The existence of foreign ownershiptriggers an increase in company's technical efficiency. Meanwhile, the use of imported raw materials does not significantly increase the technical efficiency of the four-wheel motor-vehicle companies in Indonesia.

The simplifications of regulation enacted under the law number PER-1/BC/2019 by the Director General of Customs and the excise regarding the export of motor vehicles in a complete condition (completely built up) is expected to significantly increase exports.As a result, exports of motor vehicles increase, and in turn increase technical efficiency. This policy is one of the positive policies issued by the Indonesian government in the spirit to improve firms' technical efficiency and value added of the products. The Online Single Submission (OSS) currently run by the Indonesian Investment Coordinating Board (BKPM) to facilitate foreign investment to Indonesia is expected to have a significant positive effect on foreign investment, so that companies can improve their technical efficiency.

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