Application of Two-Stage Data Envelopment Analysis (DEA) in Identifying the Technical Efficiency and Determinants in the Plastic Manufacturing Industry in Malaysia

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***Abstract*— This aim of this study is to measure the technical efficiency score and identify the factors that affect the technical efficiency in plastic manufacturing firm in Malaysia for the year 2015 using the two stage Data Envelopment Analysis (DEA) method. The first stage involves calculating the efficiency score through the DEA using firm-level data, provided by the Department of Statistics, Malaysia. In the second stage, Tobit Regression Analysis was used to identify the significant factors affecting the efficiency of the plastic industry. The determining factors are the labor-ratio, training expenses, educational level ratios, wage rates, information and communications technology expenses and firm size. The results show that average efficiency score is moderate rate. Information and communication technology (ICT) expenditure, wage rate, research and development expenditure and education level are significant factors of the efficiency factor of a plastic product manufacturing firm. The implication of this decision suggests that firms need to emphasize significant factors to enhance firms' efficiency.**

***Keywords*—** *Data Envelopment Analysis, technical efficiency, plastic manufacturing firms, Tobit Regression Analysis.*

1. Introduction

Efficiency is the effective use of inputs effectively influenced by production techniques, technological innovation, management skills and labor skills and optimum efficiency can be produced and influenced by efficient input factors such as employee quality [1]. Technical efficiency refers to the firm's ability to produce the highest output by using the input set given [1]. According to [2], the particular level of technical efficiency of a firm can be characterized by the relationship between current production and potential expenditure. Studies have found that Denmark and Japan are among the countries with the highest average cost efficiency and technique growth [3].

ASEAN is a market with great opportunities for ready-made plastic products as well as complex plastic parts. Based on its strategic location, Malaysia is one of the few countries capable of producing plastic products efficiently and the government has set targets for the plastic industry to continue to grow in the ASEAN region (TCEB, 2015). The enhancement of the ASEAN Economic Community (AEC) in 2015 and the free trade allocation has benefited Malaysian plastic producers; Malaysia, Thailand and Singapore have supply of plastic products which exceed demand have been ready to enter Indonesia, Vietnam and Philippines markets which have shortages of suppliers and thus make it a potential market for the future (Thailand Convention and Exhibition Bureau TECB, 2015). Plastic products are highly demanded due to their flexibility, lightness, durability, strength and processing facilities [4]. Globally, the packaging industry remains the largest plastic end user (37%), followed by building and construction (21%), automation manufacturing (8%) and electronics manufacturing (6%). Asia has become the largest plastic consumer in the world for several years, accounting for about 36.5% of global consumption (North America is 26% and Western Europe is 23%) [4].

However, based on the report of the Malaysian Plastics Manufacturers Association (MPMA, 2016), the performance of the plastic product manufacturing industry is in a state of inconsistency and has experienced volatile performance. There was a decline in export value in 2008-2009 from RM 9.3 billion to RM 8.3 billion. In addition, the plastic industry also showed a decline in export value from RM 10.15 billion to RM10.05 billion in 2011-2012.In fact, the contribution of the plastic manufacturing industry to the gross output in 2014 was at a low rate of 2.9% or RM 28.9 billion compared to other manufacturing groups. (Department of Statistics Malaysia, 2015). In addition, raw materials which are monopolized by overseas industrial players are one of the factors causing the achievement of the

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plastic products manufacturing industry to be less prominent (MPMA, 2016). Based on the Academy of Science of Malaysia Report (2016), the rapid growth in the plastic product manufacturing industry leads to many environmental problems. Globally, world countries have unanimously agreed that some serious action will be taken against the party disposing of plastic in the wrong way. The goal is to minimize negative effects and reduce demand for plastic.

In Malaysia, studies conducted on the plastic industry in Malaysia are more focused on the impact of the plastic industry on the environment. Most of the studies conducted such as [5] are focus more on the environment. In addition, research conducted by researchers focuses on analyzing Total Factor Productivity (TFP) but studies in identifying the factors of technical efficiency are less likely to be attentive. Studies carried out by [6] also focus more on identifying Total Factor Productivity (TFP). Therefore, the study in identifying the factors determining the technical efficiency of the plastic product manufacturing industry in Malaysia is facing a lack of reference.

Therefore, the objective of this study is to determine the level of technical efficiency, and the second analysis identifies the determinants of technical efficiency among the firms studied. The second section of this article reviews previous studies. The third section discusses the research methodology, data sources, and model specification. The fourth section analyzes the results of the empirical analysis, and the fifth section provides the conclusions and the implications of this study.

2. Literature Review

The concept of technical efficiency was basically introduced by [1]. The technical production process is efficient if and only if the specified use of input quantities and technology produces maximum output quantities. [1] also proposed a method for measuring technical efficiency, i.e. through Data Envelopment Analysis (DEA). A production model developed based on Farrell's work (1957) and widely used among researchers to estimate the technical efficiency is Data Envelopment Analysis. Efficiency is the effective use of inputs influenced by production techniques, technological innovation, management skills and labor skills [7]. Technical efficiency are defined as the use of inputs to maximize output [8].

Research conducted by researchers focuses on several aspects of the plastic industry such as the environmental impact of plastic shopping bags, the risks faced by the plastic industry, adopting new technologies in the plastics industry, the performance of traditional plastic industrial plastics, plastic debris and measures for support and enable policy makers to develop the plastic industry. Very little research has been done in the financial aspects of the plastic industry [9], [10] analyzes issues relating to the risk issues faced by public listing companies in Taiwan traditional industries, including food and plastic industries. The study covers the period 2001 to 2006, and the result is on both the food and plastic industries, if the company has greater operating leverage, it is at greater risk and certain risks. If a company has a higher shareholding ratio than board directors and higher assets, it faces less risk and risk. [11] has provided an overview of Pakistan's economic growth of the growth of the plastic industry in its study. Pakistan's economy achieved a 8.4% growth in GDP growth in 2004-2005, the fastest two decades and the fastest growing third economy in Asia. Driving the economy with remarkable performance, the manufacturing sector in Pakistan accounted for 18.3% of GDP while recording a growth of 12.5%. The Plastics, Printing & Packaging industries have had a tremendous growth over the years in which the printing and graphing industry was the second largest industry in terms of manpower in Pakistan. Pakistani plastics industry expanded at an average annual growth rate of 15% with an estimated total production capacity of 624,200 per year. The industry attracts US $ 260 billion worth of investments, almost half of which are foreign direct investments (FDI), all contributing to an incredible 35% growth in exports. [12] shows that the development of new materials and material transitions play a growing role in the development of industrial production. The main issue of this paper is the industry's ability to adapt to new materials. This study shows that it is difficult for steady firms in Denmark, both in the plastics industry and outside, to make changes in technology. This study also shows that the most open firms for material adaptation are firms based on non-material product ideas. Another finding is that the Danish plastic industry has been characterized by high growth rates despite low R & D numbers. The reason for this is on the one hand the ability of Danish plastic firms to exploit existing knowledge and instead increase the firm's specialization.

There are other studies that investigate the determinants of technical efficiency by positing that the capital-labour ratio can increase the efficiency of the technique [13]; [14]. Through the capital-labor ratio, the amount of capital allocated for each employee in the production process can be identified [15]. [16] states that the ratio of capital-labor is the most important factor in productivity growth. The study conducted by [14] and

[17] prove that the capital-labor ratio can increase efficiency and thus reduce inefficiencies. Besides that, skills to the labor force can improve and encourage the production of more quality goods and services. The skillful labor force can create or innovate the use of technology that can enhance the firm's TE level [15]. In addition, skilled laborers have high demand compared to less skilled workers [18].

[19] studies emphasize that the benefits gained from higher and higher education are higher in developing countries than in developed countries. Other studies also show that the improvement of employee education level can increase the production of firms [20]. In the study of [16] and [21] stress human capital such as education among employees is important in influencing the firm's competence in Malaysia. Firms size also plays an important role in enhancing firm technical efficiency. Based on [22] studies, the TE level increases with the increase in firm size. [23] studies show larger firms size and higher level of military technology have higher TE levels.

A study conducted by [24] found that reductions in wage rates caused a firm to become weak and led to a situation where productivity was lower as a result of low wage rates. In addition, [25] emphasized that the payment of appropriate wage rates could increase the level of self-motivation in carrying out the task of a firm. Some previous studies have shown that ICT spending in developed countries is very important and positive, but not in developing countries. A study conducted by [26] [1] found that excessive capital investment capital or disagreement in human capital and technology relations led to a relationship with efficiency and productivity was negative.

3. Methodology

3.1. Data Envelopment Analysis (DEA) Approach

The DEA method founded by Farrell (1957) is a non parametric linear programming technique aimed at assessing the performance of firms or organizations (ie the Decision Making Unit or DMU in the DEA literature). [27] and [28] have carried out further studies to measure the efficiency level and propose an input-oriented model ie Model Charnes, Cooper and Rhodes (Model CCR). This model assumes that input reduction or output increase is at a constant rate (CRS-based constant return) for each DMU or also known as the CCR-CRS model that provides the technical efficiency score of General Technical Eficiency (GTE) [29].

The CCR model assumes that there is no significant relationship between the size of the operation and the efficiency assuming that the efficiency score obtained is CRS. The CRS assumption is only appropriate when all DMUs operate at an optimum level. However, firms in the plastic product manufacturing industry are likely to experience ascending or decreasing economic scale (SE) (increasing the maximum number of outputs from the minimum use of inputs). Therefore, if the assumption of CRS is performed and at the same time not all DMUs are operating at optimum levels, the calculation of technical efficiency scores will be contaminated with scale efficiency.

[30] has improved the previous CCR model which assumes that all DMUs are CRS. BCC models have been introduced to evaluate the DMU efficiency score with the assumption that the input reduction or output increase is at an irregular rate (Variable Returns by Scale - VRS). The BCC-VRS model delivers the efficiency of Local Pure Technical Efficiency (LPTE) [29] VRS measures technical efficiency score without detecting SE. If there is a difference between the technical efficiency score and the LPTE from a particular DMU, then it indicates the inefficiency of the scale, ie Technical Efficiency = PTE x SE. This situation demonstrates that the ability to use fırına resources provided, while the latter refers to exploiting the economics of scale that operate at the production boundary points indicating CRS.

The BCC-VRS model differs from the CCR-CRS model when the LPTE efficiency score obtained indicates that the factors contributing to the efficiency of a DMU are irregular operating sizes and inefficiencies due to constraints in the DMU. Such inefficiencies cause, for example, firms unable to operate at an optimum scale. The constraints are represented by $\sum_{j=1}^{n} \lambda f = 1$ as an additional constraint in the BCC-VRS model with the assumption of "a combination of cohesion for DMU study focus forming PPS and BCC-VRS score named LPTE" (Cooper et al., 2007: 152) with uneven input and output rates.

If the bending constraint is dropped in the BCC-VRS model, then the CCR-CRS model is used to obtain the TE value with the assumption of CRS. This indicates that LPTE from DMU is always greater or equal to TE value. Based on the assumption of VRS, the resulting SE can be measured as most of the firms operating do not reach the optimum level. This is likely due to the fact that the firms involved have too small operating sizes and cause a fall in ascending returns to scale (IRS) or the firms involved have too large operating volumes and operate in a descending return scale (DRS) within the production function . Thus, these firms can improve their efficiency by changing the scale of the firm's operations.

3.2. Tobit Regression Model

[28] has suggested environmental variables can be included in the DEA analysis. Normally, the term 'environment variable' refers to factors that can influence the efficiency of a firm, but the factor is beyond the control of the manufacturer. Based on BCC-VRS model, the DEA score will fall between the intervals 0 and 1 (0 & 1) which will make the dependent variable to be a limited dependent variable. The Tobit model is well known for its advantages in controlling the inequality size distribution channel. The DEA efficiency score obtained in the first stage will be used as a dependent variable in the second stage and re-analyzing the firm's characteristics and other environmental variables.

3.3. Sources of Data

This study uses data at the firms of plastic products manufacturing firms, in Malaysia. The data provided by the Department of Statistics, Malaysia (DOSM) is the latest data census data for the year 2015. DOS has chosen firms perceived in accordance with the needs and objectives of the study which comprise dependent variables and independent variables. The selection of data is done randomly in stages of simulated process such as firm size identification, big firms, small and medium firms, the number of outputs issued and the number of employees and capital spent [31].

3.4. Data Analysis

This study uses DEAP 2.1, Microsoft Office Excel 2013 and STATA software for data analysis purposes. DEAP 2.1 software is software devoted to providing budgeting for stochastic borders production. This program calculates estimates for the technical competence obtained. Microsoft Office Excel 2013 is used to help analyze and calculate data in parallel to the format used by DEAP 2.1 software. The Tobit Regression Model (STATA) is used to determine the determinants that affect the engineering efficiency of a firm.

4. Results and Discussion

4.1 Descriptive Statistics

Based on data obtained from the Department OF Statistics (DOS), in 2015, 586 firms were involved in the plastic products manufacturing industry in Malaysia. The Department of Statistics, Malaysia (DOS) uses a special code to identify the plastic industry (MSIC222).The technical efficiency gauge is measured through an output-oriented approach, which will produce efficiency in CRS and VRS technologies. With an output-oriented approach, firm performance will be determined through their ability to maximize output output by using a combination of inputs.

Based on [32], this study uses three inputs namely capital, which is the purchase value and fixed assets for construction and improvement during the weighing year (measured in Ringgit Malaysia); laborers, where they are all workers who earn wages and profits as employers or workers. Meanwhile, intermediate inputs are also included in inputs as a production factor which is the value of materials and supplies used including industrial costs, utilities, and so forth. Furthermore, the total sales are referred to as output, the sales volume is the sale of the product that the firm has produced (measured using the Malaysian Ringgit value). All these descriptive variables are shown in Table 1.

This data is data in 2015 comprising 1 industry using 3 digit numbers by Malaysia Standard Industrial Classification (MSIC 2008). There are 586 plastic products manufacturing firms involved in this study obtained from the Department of Statistics, Malaysia.

Based on table 1, the efficiency variables are divided into two, namely the output and input of the plastic industry in Malaysia. In 2015, the average sales volume for the plastic industry in Malaysia was RM 47.8 million, the minimum sales volume was RM 8.08 million while the maximum sales was RM 804 million with standard deviation of 72257.59. Input variables consisted of capital, labor, and intermediate inputs. The capital average for the plastic industry is RM 15.8 million, the minimum capital is RM 4 720 while the maximum is RM 216 million with standard deviation 24200.91. The average number of employees is 183 employees, minimum 4 workers and maximum 4326 with deviation standard is 259.79. The average input of the intermediate plastic industry is RM 35.1 million, the minimum number of intermediate inputs is RM 3.9 million while the maximum is RM 682 million with the standard deviation of 56918.85.

Table 1. Summary of Descriptive Analysis

Variable	Mean	Minimum	Maximum	Standard deviation
Output				
Sales ('000)	47864.93	8081.86	804080.16	72257.59
Input				
Capital ('000)	15803.68	4.72	216108.26	24200.91
Total workers	182.91	4.00	4326.00	259.79
Intermediate input ('000)	35105.61	3956.31	682141.80	56918.85

Source: Department of Statistic Malaysia (DOSM), 2015

4.2 Technical Efficiency Analysis

This section discusses the results of technical competency scores measured using DEAP software program 2.1 [33]. The table below is a comparison between 2 models aimed at achieving the overall technical efficiency of the plastic product manufacturing industry in Malaysia. This table shows the efficiency score of the CCR-CRS model and the BCC-VRS model by 2015.

Table 2. Scale of Plastic Industry Efficiency in Malaysia between CCR-CRS Model and BCC-VRS Model Year 2015.

	Efficiency Score 2015
	CCR-CRS Model
Mean	0.415
	BCC-VRS Model
Mean	0.557

The technique efficiency is estimated by using maximizing output approaches subject to constant input and rated on CRS and VRS. The technical competence score, efficiency scale and position of each firm are also estimated. Budgeting on CRS shows that firms' efficiency levels are much lower than VRS. This is because firms' efficiency levels are estimated at a constant rate of return, with firms presumed to be operating at the optimum level using existing resources. These assumptions become irrelevant to firms that are not operating at optimum levels because they do not utilize the resources available fully efficiently. Hence, the estimation of the CRS model is more relevant to firms in developed countries, not in developing countries.

The table above shows the average efficiency score of the CCR-CRS model is lower than the average efficiency score of the BCC-VRS model. This decision is a reasonable decision as the CCR-CRS model assumes that the lack of input or output increases will always be at a constant rate while the BCC-VRS model assumes the lack of input or output increases have an uneven rate as this model takes into account other factors capable of affecting the efficiency of the technique. Therefore, this study selected the BCC-VRS model to identify the level of plastic industry efficiency in Malaysia.

Based on the results of the BCC-VRS model, the plastic probe manufacturing industry in Malaysia has operated with an efficiency score of 0.557 by 2015. This suggests that firms in Malaysia operate at an efficient level as a whole. However, the efficiency score for the CCR-CRS model also shows that the plastic industry in Malaysia operates in less efficient conditions. The efficiency score for the CCR-CRS model was 0.415 lower than the BCC-VRS model of 0.557. The use of the CCR-CRS model is irrelevant to the Malaysian nation due to an unequal economic situation compared to more consistent Western countries. Additionally, the CCR-CRS model is also irrelevant as this model does not take into account other factors of engineering efficiency in an industry.

4.3 Tobit Regression Result

Tobit's regulatory decision in table 3 shows that the wage rate determining factor has a significant relationship at the one percent significance level and has a positive effect (increased wage increase efficiency). Based on the study conducted by [34], [35], [15] and [36] shows that the wage rate is an important determinant of the efficiency of the plastic products manufacturing industry in Malaysia. In addition, studies conducted by [24] found that reductions in wage rates caused firms to become fractured and caused a situation where productivity was lower as a result of low wage rates. Based on a report by the Department of Statistics, Malaysia (2015), RM 3.094 billion was paid to workers in the plastic manufacturing industry involving 107,188 workers. Based on National Productivity Report (2015), Malaysia recorded 0.6 percent increases in labor productivity and 5 percent of labor cost that shows the increase of labor cost will increase the labor productivity.

Table 3. Tobit Regression Results (Dependent Variable= Efficiency Score)

Independent Variable	Koefisen	Statistik t
Capital-labour	-5.51E-07	-0.011695
ICT	0.000139	4.05391***
Wages Rate	0.001958	3.123877***
R&D	3.83E-05	5.43982***
RatioSEC	0.131849	2.062403**
RatioTIER	0.318853	2.36874**
Training expenses	7.01E-05	1.365678
DFSME(firm size)	-0.028946	-1.616316
C	0.463775	19.81201***

Note: ***significant 1%; **significant 5%; *significant 10%

In addition, research and development (R & D) factors also show a significant value at one percent significance level and have a positive impact. Research as [37], [38], [39], [40], [41] and [42] found that R & D activities were one of the key contributions to improving the firm's efficiency and productivity giving a positive impact on the company and the country. The research and development activities need to be multiplied, including increasing expertise, providing appropriate green technology infrastructure and enhancing strategic collaboration between local firms with international firms and local universities [43]. Additionally, in 2015 the plastic products manufacturing industry in Malaysia also spends huge cost on research and development at RM 127.3 million. There are 586 firms involved in this study and 174 firms have been involved in research and development (R & D) activities. Department of Statistics, Malaysia (2015).

Education level is also a factor contributing to the efficiency of the plastic industry in Malaysia which can be proved in Table 3 where the secondary education level obtaining STPM and diploma approval or its equivalent is significant at the five percent significance level and has a positive impact. Labor force with high level of graduation includes an advanced degree or equivalent with a significant five percent significance. Human capital repairs, especially through education, have been widely discussed as one of the contributors to efficiency in a matter ([44]; [45]; [46]; [47]). [48] state that the school year or education is one of the important roles in identifying firm performance including output, profitability and productivity. Previous studies such as [21], [49] and [50] shows that the school year and education have a positive relationship to the firm's productivity and efficiency growth. Meanwhile, other determinants such as capital-labor ratios, training expenses and firm size were found to have no significant relationship to the plastic product manufacturing industry in Malaysia.

5. Conclusion and Implications

The TE analysis in the study was carried out in 2015 using firm-level data from IMS DOS and involved 586 firms. The results of the analysis were more significant and accurate when using the data at the firm level. Overall, it is arguable that the level of TE of the plastic product manufacturing industry is at moderate level because the BCC-VRS efficiency score is 0.557. Most firms operating in 2015 are at an efficient level because firms operating under the efficiency range of 0.50 are less than 50 percent. This study has also made a different approach compared to previous studies when it comes to determining technical efficiency determinants. An analysis of determinants such as technology and communications spending, wage rates, research and development expenditure and labor and employee grading at secondary and high levels have significant relationships with the engineering efficiency of the plastic product manufacturing industry in Malaysia by 2015.

Among the suggestions for improving the efficiency of the plastic industry is that firms need to take employees who have undergone training in the field of plastic processing. The cost of employee training expenses can be reduced as employees already have the necessary skills. There are several government or vocational skills institutions that offer lean plastic processing such as Pure Technics Skills (Plastic Engineering Technology), Marang Industrial Training Institution (Polymer Technology), Youth & Sports Skills Training Institution (Plastic Mechanical Technology).

The plastic product manufacturing industry can improve the level of technical efficiency by implicating some policies and policy recommendations that should be taken seriously. Firms need to increase workers' wages to motivate and improve efficiency thus increasing the amount of output or output at a minimum. Higher wage rates received by employees will encourage them to work harder to contribute to higher efficiency and productivity (Rahmah, 2009a).Investments in human capital such as training to employees are long-term assets that can provide a positive return over the period of employee service with firms. While various government-sponsored programs and programs can help with the needs of the industry, the programs and training are more effective if it is organized by a firm. The National Perantis Scheme introduced in 1996 provides for exemptions on training expenses to employees and is a measure of government encouraging employers' participation to provide training to employees.

Most of the research done by the researchers did not involve TE issues and issues in the plastic product manufacturing industry. Therefore, further studies that can be done are to identify the level of TFP and the determinants in the plastic product manufacturing industry. An empirical study can be used to identify factors affecting TFP either internal or external factors. The results of the study can improve the existing factors in this study. Additions to variables that can influence TFPs in the transport manufacturing industry can be made such as foreign direct investments, exports, imports and economic openings. The second suggestion that can be done is when the review study identifies and makes comparisons as a result of the use of two models of different boundary approaches to measure TE in this study i.e. DEA and SFA. The comparison of these results can indicate a significant difference or similarity to the TE level.

Challenges locally and overseas have demanded the manufacturing industry of plastic products to be more ready next year. Industries that are not willing to increase the TE level will certainly not be able to increase the country's economic growth as a result of economic openness and trade liberalization. Based on the findings of the research, all the questions and objectives of the study can be achieved entirely in the knowledge limited by researchers. While the proposals proposed are beneficial to policy makers, industry and stakeholders.

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