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# Innovation and technical efficiency in Malaysian family manufacturing industries

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ABSTRACT

This study investigates the technical efficiency for each industry in the Malaysian manufacturing sector is estimated by using Data Envelopment Analysis (DEA). In order to pursue a balance of innovation between long-term and short-term performance strategy, we integrate the Balance Scorecard (BSC) approach with DEA. Furthermore, this paper looks at the determinants of efficiency using the Tobit regression model. In measuring the level of firms' efficiency and innovation, the wood and wood based products industry is emphasized due to its importance in the economic growth of manufacturing sector. In the wood and wood based products industry, the highest level of technical efficiency was achieved by two sub-sectors i.e. veneer sheets and plywood and laminboard, particle board and other panels board, with the mean value of technical efficiency of 1.081 and 1.097 respectively. Generally, the majority of the manufacturing firms are operating technical inefficiently. The distribution of DEA and DEA-BCS technical efficiency in Malaysian Manufacturing Industries show that most of the industries have the average technical efficiency scores greater than 1.05 with only 7 industries (13.21%) in DEA-BSC model operating at or near to the most optimal productions.



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## 1.0 Introduction

Previous research acceded that there are myriad of definitions and usage of the term innovation (Jain, 2010). Although formal definitions of innovation appear diverse, one common element in all definition of innovation is novelty. For the purpose of this study, innovation is defined as "the commercially successful exploitation of new technologies, ideas or methods through the introduction of new products or process, or through the improvement of existing ones.

There is clear evidence that innovation play a crucial role to long term profitability and growth in firms (Freel, 2000). There can be little doubt that today's firms must be able to move in the world of innovation. The successful firms will be firms which fully understand innovative business differs from non innovative business and is able to respond accordingly thereby successfully "being innovative".

The importance of manufacturing sector in contributing to Malaysian economic growth is not deniable. With this rapid expansion of the manufacturing sector in the last three decades has transformed Malaysia from an agricultural based economy to a rapidly industrializing country (Ministry of International Trade and Industry, 2008)

During the period of 1996 to 2005, the trade and economic policy undertook progressive liberalization to achieve the long-term objectives of freer and open trade as well as strengthening the domestic capacity to participate in an increasingly open trading environment. Additionally, this export-led growth is vital in the present transition for Malaysia's economy to transform into the high-tech and capital-intensive industries as well as manufacturing related services (Third Industrial Master Plan, 2006 - 2020).

Most of the industrialized countries like Japan, USA and other G8 countries have a strong base of manufacturing industry in order to achieve higher economic growth. In tandem with the objective to transform into the high-tech and capital-intensive industries, it is vital in strengthening the manufacturing firm sectors to improve productivity. The majority of manufacturing firms adapt low technology and the majority of workers are with low educational level too. Attempts are made in Malaysia to create favorable conditions for the growth of manufacturing firms, especially by establishing lending institutions for financing of manufacturing firms, worker and/or management training centers, and industrial zones (Third Industrial Master Plan, 2006 - 2020). As Arrow (1977) notes, market failures in developing countries often constraint the ability of firms to achieve first-best efficiency. Therefore, an improved understanding of the factors influencing efficiency can enhance the ability of policy makers to assist growth of manufacturing firms.

One of the pertinent issues facing the manufacturing firms is inability to produce efficiently due to lack of skills and low technology. With limited resources in hand, the likely strategy is to optimize its utilization, reducing cost of production and able to be at the competitive edge when the firms are operating efficiently. Additionally, the improvement in national competitiveness depends highly on increasing productivity in manufacturing industries and the firms must have a good combination of inputs, where the majority will be laid to human capital.

In a small and open economy like Malaysia, productivity enhancement of the manufacturing sector is especially crucial in the growth and continuous development of the economy. Thus in this analysis will evaluate the efficiency of Malaysian manufacturing industry and attempts to identify its influencing factors.

The remainder of the paper is organized as follows. Section 2 reviews the relevant theoretical literature on performance and efficiency. In section 3, we discuss the methodological framework of Data Envelopment Analysis (DEA), balanced scorecard (BSC) and Tobit regression. Next, section 4 discusses the empirical results on technical efficiency of the wood and wood based products industries. Then the analysis is extended to include all sub-industries of the manufacturing sector in Malaysia to conduct comparative efficiency analysis, first, by individuals sectors then by pooling all industries together based on the three and five digits MSIC code. Further, the determinants of firms' performance and efficiency across the manufacturing industries will be identified using the Tobit model. The final section summarizes all the findings and concludes the study.

## 2.0 Literature review

Data Envelopment Analysis (DEA) was created with the primary purpose to compute the technical efficiency of the firms. In measuring technical efficiency, the transformation of inputs such as employee and raw materials into outputs is compared to the best practice firms.

Charnes et al. (1978) were the first to describe the DEA model (the CCR model) which assuming the circumstance is the constant return to scale and used a mathematical programming model to identify the efficiency frontier based on the concept of the Pareto optimum when using multiple measures. The BCC model assumes under a variable returns to scale setting which introduced by Banker et al. (1984) that used the four postulates of production possibility aggregation and Shephard's distance function for measuring the technical efficiency (TE) and scale efficiency (SE). The operation of different returns to scale which may causes the inefficiencies, and thus a thorough understanding of the state of returns to scale of specific decision-making units can offer the information required by an administrator to further improve the firms' efficiency (Boussofiane et al., 1991).

Kaplan and Norton (1993) introduced the concept of Balanced Scorecard (BSC) which is not only a tool for performance assessment, but it also overcomes the drawbacks of traditional performance assessment by putting in the factors of environmental diversification and considers finance, customer, internal process, and learning and growth dimensions together in order to respond to environmental competition and challenges.

Jackson (1999) pointed out that the uncertain nature of strategies was the main reason for firms to focus on short-term financial gains. Therefore the performance indicators in Balance Scorecard should be set on the basis of business success factors and should be closely linked with organization's operational strategies and compensation policies. The advantage of Balanced Scorecard was that it helped business to put organizational strategies, organizational structure, and business visions together as the core of management system (Chow et al., 1997). By implementing the BSC, business organization is able to turn its long-term operational strategies into action and reach the balance between long-term competitiveness and short-term financial profits.

DEA is often supplemented with regression analysis to identify the significant factors contributing to superior performance of the DMUs on the frontier. One of those regression analyses is Tobit regression model which was first suggested in econometrics literature by Tobin (1958). In the first stage they use DEA and calculate the efficiency scores using traditional inputs i.e., variables that are controlled by DMUs. The second stage involves the use of Maximum Likelihood estimation of the Tobit regression model and provides efficiency measures based on variables that are not included in the DEA.

Danlin, et al. (2001) studied technical efficiency in cotton industry in the Soviet Union by using a similar approach as above. Besides that, a similar procedure is conducted in transportation studies. For example, Oum and Yue (1994) use DEA efficiency scores with a Tobit model to analyses the influence of certain variables on the performance of European railways as did Kerstens (1996), who evaluates the performance of French urban transit companies.

Chen and Yeh (2005) applied DEA to analyze the comparative performance of the six high-tech manufacturing industries currently developed in Taiwan. The results show that the semiconductor and computer industries are the best performers, but the biotech industry has the worst performance. Meanwhile, communications, photo-electronics, and precision equipment industries have medium performance, while the communications and photo-electronics industries have a satisfactory average scale efficiency score, but a poor pure technical efficiency score.

In Malaysia, Mohd Noor and Ismail (2004) studied technical efficiency and its determinants for 138 manufacturing firms. This study found that level of mechanization and firm size significant positively determined the level of technical efficiency. By using DEA and Tobit model, Rahmah Ismail and Noorasiah Sulaiman (2007) showed that the majority of Malay firms in manufacturing sector are operating inefficiently. More efficient firms are found in the metal and fabricated metal products. They found that the important factors that determine positively level of firms' efficiency are percentage of R&D expenditure, percentage of training expenditure and level of technology. Despite that, not all types of industry portray these variables as efficiency determinants.

Given the literature, we examine the determinants of efficiency under five broad headings (Caves, 1992; and Mayes et al. 1994). First, lack of competition is believed to induce inefficiency. A measure is used to estimate the effects of competitive conditions on inefficiency: advertising and promotional expenses. Second, the structural heterogeneity between firms can lead to structural efficiency differences. These may include patent, export and import of raw materials and packing materials. Third, managerial and organizational factors may affect the activities of any firm. These factors include staff training cost, firms' oversea investment and number of staff where the number of staff is one of the indicators to determine the firm size. Fourth, dynamic factors are thought to foster efficiency. These include research and development expenditure, information technology expenses, E-commerce sales and purchases. Finally, public policy may influence the incentives to improve efficiency.

## 3.0 Methodology framework

### 3.01 Technical and allocative efficiency

Farrell (1957) introduced a measure of efficiency to take into account all inputs and outputs which is known as technical efficiency. The firm is analyzed within a group of comparable firms and is evaluated by comparing it with some ideally performing firm. This ideally performing firm is found by one of the following means.
(i) Theoretical - the entire process is represented as a theoretical or "ideal" production function where the outputs produced by the process are represented as a function of the inputs. This function provides the expected performance and the ideally performing firm from the comparison.
(ii) Empirical - unlike the theoretical approach that is impossible to operationally achieve, the performance of the firm is determined by comparing it to a relative production combination that is achievable in practice.
By definition (Farrell 1957), the total economic efficiency of the firm P is defined as follows:
Total economic efficiency = Allocative efficiency x Technical efficiency

### The CCR Model

Charnes, Cooper and Rhodes (1978) developed a fractional programming model to determine the efficiency score of each of the firms in a data set of comparable units which is known as the CCR model. This model determines the best set of weights for each firm when the problem is solved for each firm under consideration. The CCR model is a fractional program. In order to solve the CCR model easily, the model has to be converted into a linear program.

$$\text{Max } h_0 = \sum_{r=1}^{s} \mu_r y_{rj_0} \qquad \text{for firm}_0$$

$$\text{Subject to } \sum_{i=1}^{m} v_i x_{ij_0} = 1$$

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \qquad j = 1, 2, 3, \ldots n$$

$$v_i \ge \varepsilon \qquad i = 1, 2, 3, \ldots m$$

$$\mu_r \ge \varepsilon \qquad r = 1, 2, 3, \ldots s$$

The above model is developed from the fractional program and the input and output variables are multiplied with their respective weights, therefore it is known as the multiplier model. This model has $m+s$ variables and $1+n+m+s$ constraints.

### The BCC Model

A modification to the CCR (constant returns to scale) mode1 by adding a convexity constraint was presented by Banker, Charnes, Cooper (1984). The presence of the convexity constraint decreases the feasible region from conical (or convex cone) hull in CCR to convex hull of firms. All firms were assumed to be efficient in their current scale so that the efficiency measured was independent of scale considerations (variable returns to scale) which now the model is known as BCC.

The production possibility set in the figure is the set of all technically feasible combinations of inputs and outputs, representing the technology of a firm. The envelopment form of the BCC model would be the same as the dual for the CCR model but with an additional constraint,

$$\sum_{j=1}^{n} \lambda_j = 1$$

### Balanced Scorecard (BSC)

The BSC is a methodology aimed at revealing problem areas within organizations and pointing out areas for improvement which was first proposed by Kaplan and Norton (1992, 1996). Wright et al. (1999) proposed BSC for firms looks at the four perspective such as financial, customer, internal process, and learning and innovation in order to aid in the gathering and selection of the appropriate performance measures for the firm.

### Combining the Balanced Scorecard and the DEA Model

DEA model always identifies the most suitable weights for the output and input items and then calculate its efficiency, but it cannot be directed against the historical evolution trend of every firm's present operational focal point, which is the goal necessary to determine its performance. The combination of financial proportion indices and the DEA model can overcome this shortcoming and revise the DEA model, regarding financial indices as output items for conducting the performance assessment.

### Second-Stage Tobit Model

It is also of considerable interest to explain the DEA efficiency scores after having measured the relative efficiencies. The results of investigating the determinants of technical efficiency are expected to be able to guide policies which aimed at improving performance of the industries. In the first stage DEA is use and calculate the efficiency scores using inputs whilst in the second stage involves the use of Maximum Likelihood estimation of the Tobit regression model and provides efficiency measures based on variables that are not included in the DEA.

DEA efficiency scores are transformed using the following formula (Fethi, 2000):

$$y_i = \eta_i - 1$$

For this purpose, the standard Tobit model can be defined as follows for observation (firm) i:

$$y_i^* = \beta' x_i + \varepsilon_i$$

$$y_i = y_i^* \text{ if } y_i^* > 0, \text{and}$$

$$y_i = 0, \text{otherwise}$$ ,

where $\varepsilon_i \sim N(0, \sigma^2$ $x_i$ and $\beta$ are vectors of explanatory variables and unknown parameters, respectively. The $y_i^*$ is a latent variable and $y_i$ is the technical efficiency score.

The likelihood function (L) is maximized to solve $\beta$ and $\sigma$ based on the observations (firms) in each industry of $y_i$ and $x_i$ is

$$L = \prod_{y_i=0}(1 - F_i)\prod_{y_i>0}\frac{1}{(2\pi\sigma^2)^{1/2}} \times e^{-[1/(2\sigma^2)](y_i - \beta' x_i)^2}$$

Where

$$F_i = \int_{-\infty}^{\beta' x_i/\sigma} \frac{1}{(2\pi)^{1/2}} e^{-t^2/2} dt$$

The first product is over the observations for which the firms are 100% efficient (y = 0) and the second product is over the observations for which firms are inefficient (y>0). $F_i$ is the distribution function of the standard normal evaluated at $\beta' x_i / \sigma$.

## 4.0 Data analysis and results

### 4.01 Technical efficiency of the wood and wood based products industry

The wood and wood based products industry consist of six main sub-sectors which are sawmilling and planing of wood; manufacture of veneer sheets and plywood; manufacture of laminboard, particle board and other panels and board, manufacture of builders' carpentry and joinery, manufacture of wooden and cane containers; and manufacture of wooden and cane furniture.

The technical efficiency estimator is measured through output orientated approach, which will produce efficiency at CRS and VRS technologies. With output orientated approach, the firm's performance will be determined through their ability in maximizing production output by using combination of input.

In table 1 of appendix below and according to CRS results, manufacture of laminboard, particle board and other panels and board indicated the highest percentage of firms (47.27%) that are fully efficient followed by veneer sheets and plywood (29.41%), wooden and cane containers (26.39%), builders' carpentry and joinery (9.47%), sawmilling and planing of wood (6.27%), and wooden and cane furniture (6.12%), respectively. The majority of firms in wood products manufacturing industries have an CRS efficiency score of more than 1.1 especially the firms in the industry of the sawmilling and planing of wood, the builders' carpentry and joinery, wooden and cane container, and the wooden and cane furniture.

The estimation of technical efficiency at VRS produces a higher score. According to VRS results, the analysis shows that manufacture of laminboard, particle board and other panels and board indicated the highest percentage of firms (60%) that are fully efficient which is the firms have efficient operation of the firm itself followed by veneer sheets and plywood (49.58%), wooden and cane containers (43.06%), builders' carpentry and joinery (30.04%), sawmilling and planing of wood (10.98%), and wooden and cane furniture (17.93%), respectively.

Scale efficiency is defined as the ratio of overall efficiency (CRS) to pure technical efficiency (VRS) which is the measure of the ability to avoid waste by operating at or near to the most productive scale. According to SE results, the analysis shows that manufacture of laminboard, particle board and other panels and board indicated the highest percentage of firms (65.45%) that are fully scale efficient followed by veneer sheets and plywood (40.34%), wooden and cane containers (33.33%), and lowest in sawmilling and planing of wood (20.03%), builders' carpentry and joinery (11.93%), and wooden and cane furniture (8.13%).

Table 2 of appendix below shows descriptive statistics of technical efficiency by industry In general, the mean value of technical efficiency is between 1.097 and 2.5041 under CRS specification, where the mean value of each sub-sector is calculated by the geometric mean method. The results imply that a fully efficient sub-sector doesn't exists in wood and wood based products manufacturing industries, but there are some sub-sectors that outperform other sub-sectors. In the highly efficient range, there are laminboard, particle board and other panels board, veneer sheets and plywood with the mean value of technical efficiency of 1.097 and 1.081 respectively. The laminboard, particle board and other panels and board industry achieves the highest technical efficiency followed by veneer sheets which match our expectation due to both sub-sector industries meet the international standards.

In term of SE specification, the mean value of scale efficiency generally is between 1.0252 and 1.1956 which implies that, on the overall, none of the subsector is fully scale efficient though fully scale efficient individual firms in the sub-sector may exist. The diseconomy of scale varies among the sectors. The sub-sectors in the high scale efficient range are veneer sheets and plywood and laminboard, particle board and other panels and board industries with the mean value of scale efficiency of 1.0252 and 1.0310 respectively.

In the CRS specification results, the standard deviation value is between 0.1195 and 0.9209, whereas in the VRS specification results, there are standard deviation value is between 0.1030 and 0.8859. In both specifications, the sawmilling and planing of wood is the highest spread industry followed by builders' carpentry and joinery, wooden and cane furniture, wooden and cane containers, veneer sheets and plywood and laminboard, particle board and other panels and board. In term of SE, the results are consistent with the mean value results as below, where the mean value in SE is smaller compare to CRS and VRS specifications, and then the standard deviation in SE is smaller compare to CRS and VRS specifications. The results above imply that the highly efficient sub-sector industries in wood and wood based products industry typically will be achieve the lowest spread. This is mainly because the highly efficient sub-sector industries will be able to effectively control the firms' productions.

## 4.02 Returns to scale

Table 3 of appendix below reports the nature of the returns to scale of the firms of wood products industry. An increasing returns to scale (IRS) characteristic indicates that a firm could improve its efficiency by scaling up its activities. A decreasing returns to scale (DRS) characteristic indicates that a firm could improve its efficiency by scaling down its activities. A constant returns to scale (CRS) characteristic shows that the firm already operates at it optimal scale and its inefficiency, if any, is due to technical inefficiency and cannot be improved by simply scaling up or down its activities. In the wood and wood products industry, economies of scale varied between the firms in the sub-sectors. The majority of the firms industries were operating at DRS in the following: wooden and cane furniture (85.30%), builders' carpentry and joinery (75.72%), wooden and cane containers (62.50%), sawmilling and planing of wood (60.80%), and veneer sheets and plywood (57.98%) respectively. In contrast, the majority of firms in the laminboard, particle board and other panels and board (47.27%) industry were operating at CRS. The firms operating at DRS should be split into smaller units and partition the operation into specialized function in order to make the firms to be more efficient in terms of utilization of inputs.

## 4.03 Technical efficiency in Malaysian manufacturing industries based on 5 digits MSIC code

Table 4 of appendix below reports the technical efficiency of various (155) industries in 2005 for DEA and DEA-BSC model based on Malaysian Manufacturing Industries 5 digits MSIC code. We found that the DEA-BSC score will be equals to or smaller than the DEA scores. This is because problems related to discrimination between efficient and inefficient decision-making units often arise, particularly if there are a relatively large number of variables with respect to observations.

The results show that there are no efficient industries using the DEA model, however, there are four efficient industries using the extended DEA-BSC model. These industries are the brooms, brushes and mops (36991), carpets and rugs (17220), medical and surgical equipment and orthopeadic appliances (33110) and other articles of paper and paperboard (21099). Some of the industries were strong performers although they were not fully efficient. These industries can be referred to as near efficient industries which achieved a score between 1 and 1.05. With the DEA-BSC model, there are 41 near efficient industries. These are processing and preserving of poultry (15111), manufacture of electronic power cables and wires (31302), recycling of other non-metal waste and scrap (37209), etc. Of these industries, 2 industries are also regarded to be near efficient under the DEA model which is the manufacture of palm kernel oil (15144) and manufacture of glucose, glucose syrup, maltose and manufacture of other starch products(15323 & 15329). This enhances the confidence of the results for these two industries.

Table 5 of appendix below shows the distribution of DEA and DEA-BCS technical efficiency scores in Malaysian Manufacturing Industries. There are some differences between the distribution of DEA and DEA-BSC technical efficiency scores. This is because when the number of variables included increases in the DEA-BSC model, the number of efficient firms is expected to increase and hence the scores of technical efficiency in each industries increase as well. In the DEA model, the range of technical efficiency for the majority of the Malaysian Manufacturing Industries is between 1.11 and 1.4 that comprised 63.88 percent of the distribution, but in DEA-BSC model, the technical efficiency of the industries range between 1.11 and 1.4 that only comprised 41.29 percent of the distribution. Despite that, in the DEA-BSC model, the range of technical efficiency for the majority of the Malaysian Manufacturing Industries is between 1.01 and 1.2 that comprised 81.93 percent of the distribution. This is mainly because the DEA-BSC model has 7 variables compare to DEA model has only 3 variables. Besides that, there are 67 industries (43.22%) performed poorly with a score above 1.3 in DEA model, but only 12 industries (7.76%) performed poorly with a score above 1.3 in DEA-BSC model. Nevertheless, the distribution of DEA and DEA-BCS technical efficiency in Malaysian Manufacturing Industries shows that some of the industries have the scores of technical efficiency below 1.05. These are 3 industries (1.94%) in DEA model and 45 industries (29.03%) in DEA-BSC model were operating at or near to the most optimal productions.

## 4.04 Technical efficiency in Malaysian manufacturing industries based on 3 digits MSIC code

There are no fully efficient industries using the DEA and DEA-BSC model since none of the industry had a score of unity. Some of the industries were strong performers although they were not fully efficient. These industries can be referred to as near efficient industries which achieved a score between 1 and 1.05. With the DEA-BSC model, there are 7 near efficient industries. These are manufacture of motor vehicles (341), optical instruments and photographic equipment (332), recycling of other non-metal waste and scrap (372), dairy products (152), domestic appliances (293) and tin smelting & manufacture of other basic precious and other non-ferrous metals (272). However of these industries, none of them were also regarded to be near efficient under the DEA model. The top performer is the manufacture of motor vehicles (341) with an average efficiency score of 1.02. this is followed by the manufacture of optical instruments and photographic equipment (332) with an average efficiency score of 1.02, recycling of other non-metal waste and scrap (372) with an average efficiency score of 1.02, dairy products (152) with an average efficiency score of 1.04, domestic appliances (293) with an average efficiency score of 1.05 and tin smelting & manufacture of other basic precious and other non-ferrous metals (272) with an average efficiency score of 1.05. Using the DEA-BSC model, as many as 20 industries performed poorly with a score of 1.3 and above.

In fact, the majority of the industries in the Malaysian Manufacturing Industries in the DEA model have a technical efficiency level above 1.41, there are 30 industries which comprise 56.6 percent of the industry. Only 15 industries (43.39%) have a technical efficiency score in the range of 1.11 and 1.4. On the other hand, in DEA-BSC model, there are 10 industries (18.87%) that performed poorly with a score above 1.4 in DEA model. The distribution of DEA and DEA-BCS technical efficiency in Malaysian Manufacturing Industries show that most of the industries have the average technical efficiency scores below 1.05 with only 7 industries (13.21%) in DEA-BSC model operating at or near to the most optimal productions. This shows that there is huge potential for improvement in most of the manufacturing industries in Malaysia.

## 4.05 Determinants of technical efficiency of Malaysian manufacturing industries based on 3 digits MSIC code

Some of independent variables do not have any or too few data based on the Malaysian Standard Industry Classification (MSIC) at 3 digits level and hence there have no details of the variables is this analysis. Besides that, a preliminary analysis reveals that there is multicollinarity between the independent variables. It could be argued that these variables may measure the same phenomenon; therefore some of variables are not included into the model.

It is important to note that the dependent variables in the model are the inefficiency, thus the sign of the coefficients are reversed. A positive coefficient implies an inefficiency increase whereas a negative coefficient means an association with inefficiency decline or increased efficiency. Besides that, only the results of the variables in the Tobit model are significant at 95% level or higher are discussed in this analysis. The discussion will be based on the factors.

*a) Export*

The export variable has negative statistically significant coefficient in the Tobit model of production, processing and preserving of meat, fish, vegetables, oils and fats (151) and general-purpose machinery (291). The sign of the export variable is negative as expected in all the industries and hence increase in the export can increase the firms' efficiency.

*b) Import of raw material*

The import of raw material is only negative statistically significant in the Tobit model of special purpose machinery (292). The sign of the import of raw material variable is negative as expected in all the industries, therefore increasing in the import of raw material can increase the firms' efficiency.

*c) Industrial state*

The industrial state (IND) variables has statistically significant coefficient in Tobit model of production, processing and preserving of meat, fish, vegetables, oils and fats (151), biscuit, cookies, bread, cake and other bakery products (154a), tobacco products (160), spinning, weaving and finishing of textiles (171), publishing (222), basic chemicals (241), plastic products (252), non-metallic mineral products (269), other fabricated metal products; metal working service activities (289), special purpose machinery (292), insulated wires and cables (313), electric lighting equipment (315) and manufacturing (369). However but the signs of the coefficient are mixed, thus it is hard to decide the effect of the industrial state to the industries due to the firms. Furthermore we should be looking at the marginal effects compare to the constant the IND variable is a dummy variable. The marginal effects are statistically negative which when a factory locate in the industrial state will increase the firms' efficiency or the marginal effects are statistically positive which when a factory locate in the industrial state will decrease the firms' efficiency. This is because the industrial states provide better infrastructure and opportunities to firms to improve products quality, but some of the industrial states are far from the customer and resource market.

*d) Firms' oversea investment*

In the Tobit model of plastic products (252), the firms' oversea investment variable is positive statistically significant. This is because small and medium firms comprise of more than 90 per cent of the total manufacturing establishments in Malaysia. Even though the global competitiveness of the manufacturing industry is greatly supported, the small and medium firms are incapable to invest due to lack of fund and skilled worker. The firms undertake overseas investments due to tax deferrals that are less productive (Brumbaugh, 2006).

*e) Advertising and promotional expenses*

The advertising and promotional expenses is negative statistically significant in the Tobit model of special purpose machinery (292). The negative sign of the advertising and promotional expenses variable is as expected in all industries which may indicate that increasing advertising and promotional expenses may increase the firms' efficiency.

*f) Staff*

On the other hand, the staff variable has statistically significant positive coefficient in Tobit model of production, processing and preserving of meat, fish, vegetables, oils and fats (151), grain mill products, starches and starch products and prepared animal feeds (153), products of wood, cork, straw and plaiting materials (202), other chemical products (242), rubber products (251), plastic products (252), tanks, reservoirs and steam generators (281), general-purpose machinery (291), special purpose machinery (292), furniture (361) and manufacturing (369). As a result of more than 90% of manufacturing sector comprises by small and medium firms, the positive sign of the number of staff is matched with our expectation in all the industries, which may indicate that firms should reduce the staffs, but increase the automation of production process to increase the efficiency. Nevertheless, the staffs could be increase proportional to other inputs such as machine, land and so on and the staffs have the right tools to increase the firms' efficiency.

*g) Staff training cost*

Only in Tobit model of structural metal products, tanks, reservoirs and steam generators (281), the staff training cost has statistically significant negative coefficient. This result may reveal that increasing staff training cost can increase the efficiency.

## 4.06 Determinant of technical efficiency of wood and wood based products industries

In the table 6 of appendix above shows the EPURCH independent variables does not has data based on the wood and wood based products industry and hence the variable is excluded from the Tobit model. A preliminary analysis reveals that there is multicollinarity between the independent variables of EXPORT and STAFF with the correlation is 0.8. It could be argued that these variables may measure the same phenomenon; therefore the STAFF variable is not included into the model.

The estimation for the Tobit model of the wood and wood based products is summarized in table 7 below the export variable is only statistically significant negative in the Tobit model of wood and wood based products industry. The sign of the export variable is negative as expected in all the Tobit model and hence increase in the export can increase the firms' efficiency.The industrial state (IND) variable has only statistically significant positive coefficient in Tobit model of wood and wood based products industry. As a result of the IND variable is a dummy variable, therefore we should be looking at the marginal effects compare to the constant. The marginal effects are statistically negative which when a factory locate in the industrial state will reduce the firms' efficiency. This is because the industrial states are Johor, Penang and Selangor which are far from the wood resources. In the Tobit model of wood and wood based products industry, the firms' oversea investment variable is negative statistically significant. The sign of the coefficient is negative which implies increasing in firms' oversea investment mixed can increase the firms' efficiency.

Table 7: Tobit regression coefficient estimates of the DEA-BSC-VRS scores of the 3 digits MSIC code industry

| wood and wood based products industry | | | |
|---|---|---|---|
| Independent variables | Coefficient | z-Statistic | Prob. |
| Constant | 0.986044 | 46.09493 | 0.000** |
| ESALE | -.0000521 | -1.33869 | 0.1807 |
| EXPORT | -.0000379 | -4.33908 | 0.000** |
| IMPPAC | .0000279 | 0.288142 | 0.7732 |
| IMPRAW | .0000885 | 0.183166 | 0.8547 |
| IND | .0602001 | 7.829727 | 0.000** |
| INVESTOS | -0.61101 | -4.53044 | 0.000** |
| PATEN | -.0000584 | -0.42278 | 0.6725 |
| PROMO | 0.000094 | 0.586859 | 0.5573 |
| RD | -.0000132 | -0.29665 | 0.7667 |
| TECHEXP | -.000106 | -1.37647 | 0.1687 |
| TRAINING | -.0087308 | -0.22446 | 0.8224 |

** Significant at 0.01 level

## 5.0 Conclusions

In general, the majority of the firms in the wood and wood based products industry are operating inefficiently but there are only two sub-sector industries that have more than 50% firms, who are operating efficiently. Therefore the firms are encouraged to obtain international certifications which would promote the 'green' image of the industry through sustainable foreign management.

However the veneer sheets and plywood and laminboard, particle board and other panels and board sub sectors have higher scale efficiency than technical efficiency; this means that global inefficiencies are mainly attributed to inefficient operations or management. Thus, in these sub-sector industries, the firms should promote the efficient and effective management of wood resources.

The results from this study show that the determinants of level of firms' efficiency in the wood and wood based products industry are the firm's factory location in the industrial state, level of exports and firms' overseas investment. However, the variable of the firm's factory location in the industrial state explains negatively the level of firms' efficiency in the wood and wood based products industry. Therefore the agro-forestry activities should be encouraged to provide intermediate returns to sustain the viability of forest plantation projects.

The firms' overseas investment is a positively significant determinant of efficiency for the firms in the wood and wood based products industry. The industry seems has a greater incentive to outsource logs and other semi-finished components through outward investments in resource rich countries in order to get extra market share and profits. In addition, the export is also a positively significant determinant for the firms in the wood and wood based products industry. Since export will increase the firms' efficiency and profitability, efforts should be intensified to gain access to non-traditional markets such as India, West Asia and Africa.

## 6.0 Recommendation and strategies of the Malaysian manufacturing industry

The results of technical efficiency in DEA-BSC model in the 3 and 5 digits MSIC code analysis for Malaysian Manufacturing Industries are consistent with each other; generally the majority of the firms in the Malaysian manufacturing industry based on 5 digits or 3 digits MSIC code are operating technical inefficiently. Therefore the firms should optimize its utilization of its resources in order to reduce the cost of production as well as achieve a higher competitive edge.

The results from this study show the determinants of level of efficiency are different by industries. The firms in light and medium industries should focus on their core competencies and strengths within the regional and global networks in order to increase its export. The import of raw material contributes positively to firms' efficiency especially for special purpose machinery industry which can be categorized as a medium industry. Thus the firms should import some non-core products in order to remain competitive, lower the production costs and increase the efficiency. Additionally advertising and promotional expenses contributes positively to firms' efficiency especially for medium industries. The firms of medium industries should increase its advertising and promotional expenses to develop and promote its products brand in order to expand the operations in Malaysia.

Even though the firm's factory location in industrial states significantly influence the firms' efficiency, its effect is hard to decide. Its relationship is positive for light industries. However its relationship is negative for resource-based industries. Therefore the government need to develop the cluster near to the resources as well as the clusters must be supported with the required workforce. The number of staff is found to be significant determinants of firms' efficiency, but it is negatively significant for resource-based industries. This may be due to more than 90% of manufacturing sector comprises of small and medium firms which are labour intensive and generally lack of fund, thus the firms to increase the utilization of automated equipment and machinery to reduce the dependency of labour while attaining higher efficiency and productivity.

The staff training cost is a positively significant determinant of efficiency for the firms of structural metal products, tanks, reservoirs and steam generators industry which can be categorized in heavy industries. Owing to move towards a more knowledge-based operating environment, the firms should emphasize and conduct on a higher level of creativity, innovation and other enabling skills in training systems to improve the employees' skills as well as increase the firms' efficiency and performance.

Finally, it is important for the government and the manufacturing sector to understand the strengths and weaknesses in order to develop and promote the Malaysian brands and enhancing exports through in order to improve the firm's efficiency and productivity whilst make enhancing Malaysia's position as a major trading nation.

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## APPENDIX

Table 1: Distribution of technical efficiency of industry of wood and wood based products

| Range of efficiency/ industry | Technical efficiency (CRS) | | Pure Technical efficiency (VRS) | | Scale efficiency (SE) | |
|---|---|---|---|---|---|---|
| **Sawmilling and planing of wood** | **Frequency** | **(%)** | **Frequency** | **(%)** | **Frequency** | **(%)** |
| 1 | 36 | (6.27) | 63 | (10.98) | 115 | (20.03) |
| 1.01-1.1 | 7 | (1.22) | 10 | (1.74) | 193 | (33.62) |
| 1.11-1.2 | 9 | (1.57) | 18 | (3.14) | 64 | (11.15) |
| 1.21-1.3 | 4 | (0.70) | 13 | (2.26) | 50 | (8.71) |
| 1.31-1.4 | 10 | (1.74) | 16 | (2.79) | 32 | (5.57) |
| >1.41 | 508 | (88.50) | 454 | (79.09) | 120 | (20.91) |
| Total | 574 | (100) | 574 | (100) | 574 | (100) |
| Veneer sheets and plywood | | | | | | |
| 1 | 35 | (29.41) | 59 | (49.58) | 48 | (40.34) |
| 1.01-1.1 | 31 | (26.05) | 19 | (15.97) | 63 | (52.94) |
| 1.11-1.2 | 32 | (26.89) | 28 | (23.53) | 7 | (5.88) |
| 1.21-1.3 | 16 | (13.45) | 8 | (6.72) | 1 | (0.84) |
| 1.31-1.4 | 2 | (1.68) | 2 | (1.68) | 0 | (0.00) |
| >1.41 | 3 | (2.52) | 3 | (2.52) | 0 | (0.00) |
| Total | 119 | (100) | 119 | (100) | 119 | (100) |
| Laminboard, particle board and other panels and board | | | | | | |
| 1 | 26 | (47.27) | 33 | (60.00) | 36 | (65.45) |
| 1.01-1.1 | 5 | (9.09) | 5 | (9.09) | 13 | (23.64) |
| 1.11-1.2 | 12 | (21.82) | 10 | (18.18) | 4 | (7.27) |
| 1.21-1.3 | 7 | (12.73) | 5 | (9.09) | 1 | (1.82) |
| 1.31-1.4 | 5 | (9.09) | 2 | (3.64) | 1 | (1.82) |
| >1.41 | 0 | (0.00) | 0 | (0.00) | 0 | (0.00) |
| Total | 55 | (100) | 55 | (100) | 55 | (100) |
| Builders' carpentry and joinery | | | | | | |
| 1 | 23 | (9.47) | 73 | (30.04) | 29 | (11.93) |
| 1.01-1.1 | 6 | (2.47) | 20 | (8.23) | 42 | (17.28) |
| 1.11-1.2 | 6 | (2.47) | 31 | (12.76) | 22 | (9.05) |
| 1.21-1.3 | 8 | (3.29) | 25 | (10.29) | 19 | (7.82) |
| 1.31-1.4 | 11 | (4.53) | 16 | (6.58) | 23 | (9.47) |
| >1.41 | 189 | (77.78) | 78 | (32.10) | 108 | (44.44) |
| Total | 243 | (100) | 243 | (100) | 243 | (100) |
| Wooden and cane containers | | | | | | |
| 1 | 19 | (26.39) | 31 | (43.06) | 24 | (33.33) |
| 1.01-1.1 | 5 | (6.94) | 11 | (15.28) | 15 | (20.83) |
| 1.11-1.2 | 7 | (9.72) | 10 | (13.89) | 9 | (12.50) |
| 1.21-1.3 | 8 | (11.11) | 9 | (12.50) | 9 | (12.50) |
| 1.31-1.4 | 6 | (8.33) | 4 | (5.56) | 8 | (11.11) |
| >1.41 | 27 | (37.50) | 7 | (9.72) | 7 | (9.72) |
| Total | 72 | (100) | 72 | (100) | 72 | (100) |
| Wooden and cane furniture | | | | | | |
| 1 | 55 | (6.12) | 161 | (17.93) | 73 | (8.13) |
| 1.01-1.1 | 28 | (3.12) | 97 | (10.80) | 155 | (17.26) |
| 1.11-1.2 | 27 | (3.01) | 116 | (12.92) | 83 | (9.24) |
| 1.21-1.3 | 44 | (4.90) | 111 | (12.36) | 89 | (9.91) |
| 1.31-1.4 | 34 | (3.79) | 110 | (12.25) | 79 | (8.80) |
| >1.41 | 710 | (79.06) | 303 | (33.74) | 419 | (46.66) |
| Total | 898 | (100) | 898 | (100) | 898 | (100) |

Table 2: Descriptive statistics of firms' technical efficiency by industry

| Technical efficiency | CRS | VRS | Scale |
|---|---|---|---|
| **Sawmilling and planing of wood** | | | |
| Minimum value | 1.0000 | 1.0000 | 1.0000 |
| Maximum value | 7.3098 | 5.2290 | 3.3870 |
| Mean value | 2.5041 | 2.0944 | 1.1956 |
| Standard deviation | 0.9209 | 0.8859 | 0.3393 |
| **Veneer sheets and plywood** | | | |
| Minimum value | 1.0000 | 1.0000 | 1.0000 |
| Maximum value | 1.6545 | 1.5622 | 1.2421 |
| Mean value | 1.0981 | 1.0710 | 1.0252 |
| Standard deviation | 0.1214 | 0.1112 | 0.0425 |
| **Laminboard, particle board and other panels and board** | | | |
| Minimum value | 1.0000 | 1.0000 | 1.0000 |
| Maximum value | 1.3793 | 1.3379 | 1.3793 |
| Mean value | 1.0970 | 1.0640 | 1.0310 |
| Standard deviation | 0.1195 | 0.1030 | 0.0687 |
| **Builders' carpentry and joinery** | | | |
| Minimum value | 1.0000 | 1.0000 | 1.0000 |
| Maximum value | 4.1194 | 3.4060 | 2.9516 |
| Mean value | 1.8587 | 1.3075 | 1.4216 |
| Standard deviation | 0.7251 | 0.4917 | 0.4970 |
| **Wooden and cane containers** | | | |
| Minimum value | 1.0000 | 1.0000 | 1.0000 |
| Maximum value | 3.1263 | 2.3253 | 2.1929 |
| Mean value | 1.3234 | 1.1368 | 1.1641 |
| Standard deviation | 0.4281 | 0.2611 | 0.2640 |
| **Wooden and cane furniture** | | | |
| Minimum value | 1.0000 | 1.0000 | 1.0000 |
| Maximum value | 3.7353 | 3.0755 | 3.0666 |
| Mean value | 1.8005 | 1.2994 | 1.3856 |
| Standard deviation | 0.5093 | 0.3181 | 0.3604 |
| Industry Average | 1.5404 | 1.2901 | 1.1940 |

Table 3: Technical efficiency of industry of wood products

| Returns to scale/ | CRS | | IRS | | DRS | | Total |
|---|---|---|---|---|---|---|---|
| Industry | Frequency | % | Frequency | % | Frequency | % | |
| Sawmilling and planing of wood | 38 | 6.62 | 187 | 32.58 | 349 | 60.80 | 574 |
| Veneer sheets and plywood | 35 | 29.41 | 15 | 12.61 | 69 | 57.98 | 119 |
| Laminboard, particle board and other panels and board | 26 | 47.27 | 7 | 12.73 | 22 | 40.00 | 55 |
| Builders' carpentry and joinery | 24 | 9.88 | 35 | 14.40 | 184 | 75.72 | 243 |
| Wooden and cane containers | 20 | 27.78 | 7 | 9.72 | 45 | 62.50 | 72 |
| Wooden and cane furniture | 55 | 6.12 | 77 | 8.57 | 766 | 85.30 | 898 |
| Total | 198 | 10.1 | 328 | 16.72 | 1435 | 73.18 | 1961 |

Table 4: Technical efficiency of Malaysian Manufacturing Industries (5 digits MSIC code) for DEA and DEA-BSC model

| MSIC Code | Description | Number of Firms | DEA Score | DEA-BSC Score | MSIC Code | Description | Number of Firms | DEA Score | DEA-BSC Score |
|---|---|---|---|---|---|---|---|---|---|
| **15111** | Processing and preserving of poultry and poultry products | 21 | 1.10 | 1.01 | **25191** | Rubber remilling and latex processing | 89 | 1.23 | 1.07 |
| **15119** | Production, processing and preserving of other meat and meat products | 37 | 1.13 | 1.02 | **25193** | Manufacture of rubber gloves | 80 | 1.37 | 1.12 |
| **15120** | Processing and preserving of fish | 192 | 2.01 | 1.26 | **25199** | Manufacture of other rubber products | 198 | 1.44 | 1.19 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | and fish products | | | | | | | | |
| **15139** | Canning and preserving of other fruits and vegetables | 41 | 1.19 | 1.06 | **25201** | Manufacture of plastic blow moulded products | 177 | 1.32 | 1.15 |
| **15141** | Manufacture of coconut oil | 15 | 1.09 | 1.02 | **25202** | Manufacture of plastic extruded products | 69 | 1.49 | 1.16 |
| **15142** | Manufacture of crude palm oil | 327 | 1.28 | 1.20 | **25203** | Manufacture of plastic bags and firms | 263 | 1.47 | 1.17 |
| **15143** | Manufacture of refined palm oil | 32 | 1.08 | 1.02 | **25205** | Manufacture of plastic foam products | 44 | 1.16 | 1.08 |
| **15144** | Manufacture of palm kernel oil | 34 | 1.05 | 1.01 | **25206** | Manufacture of plastic injection moulded products and components | 249 | 1.55 | 1.27 |
| **15149** | Manufacture of other vegetable and animal oils and fats | 43 | 1.27 | 1.07 | **25209** | Manufacture of other plastic products | 394 | 2.98 | 1.99 |
| **15201** | Manufacture of ice cream | 28 | 1.10 | 1.02 | **26100** | Manufacture of glass and glass products | 147 | 1.34 | 1.17 |
| **15202& 15209** | Manufacture of condensed, powdered and evaporated milk and manufacture of other dairy products | 14 | 1.10 | 1.03 | **26910** | Manufacture of non-structural and non-refractory ceramic ware | 77 | 1.32 | 1.09 |
| **15311** | Rice milling | 174 | 1.19 | 1.08 | **26920** | Manufacture of refractory ceramic products | 104 | 1.46 | 1.14 |
| **15312** | Flour milling | 17 | 1.18 | 1.07 | **26930** | Manufacture of non-refractory clay and ceramic products | 90 | 1.64 | 1.20 |
| **15323& 15329** | Manufacture of glucose, glucose syrup, maltose and manufacture of other starch products | 20 | 1.04 | 1.02 | **26941** | Manufacture of hydraulic cement | 25 | 1.14 | 1.04 |
| **15330** | Manufacture of prepared animal feeds | 74 | 1.29 | 1.08 | **26942** | Manufacture of lime and plaster | 34 | 1.31 | 1.05 |
| **15411** | Manufacture of biscuits and cookies | 121 | 1.33 | 1.14 | **26951** | Manufacture of ready-mix concrete | 99 | 1.21 | 1.09 |
| **15412** | Manufacture of bread, cakes and other bakery products | 632 | 2.25 | 1.73 | **26959** | Manufacture of other articles of concrete, cement and plaster | 249 | 1.49 | 1.16 |
| **15431** | Manufacture of cocoa products | 15 | 1.10 | 1.01 | **26960** | Cutting, shaping and finishing of stone | 54 | 1.24 | 1.05 |
| **15432** | Manufacture of chocolate and chocolate products | 39 | 1.19 | 1.05 | **26990** | Manufacture of other non-metallic mineral products | 90 | 1.42 | 1.15 |
| **15440** | Manufacture of macaroni, noodles and similar products | 202 | 1.28 | 1.16 | **27100** | Manufacture of basic iron and steel products | 360 | 2.52 | 1.70 |
| **15491** | Manufacture of ice(excluding dry ice) | 110 | 1.31 | 1.14 | **27201& 27209** | Tin smelting & manufacture of other basic precious and other non-ferrous metals | 102 | 1.16 | 1.05 |
| **15492** | Manufacture of coffee | 104 | 1.22 | 1.06 | **27310** | Casting of iron and steel | 226 | 1.34 | 1.16 |
| **15494** | Manufacture of spices and curry powder | 65 | 1.11 | 1.03 | **27320** | Casting of non-ferrous metals | 29 | 1.14 | 1.02 |
| **15495** | Manufacture of nut | 22 | 1.10 | 1.01 | **28110** | Manufacture of | 952 | 1.70 | 1.32 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | and nut products | | | | | structural metal products | | | |
| **15496** | Manufacture of sauces including flavouring extracts such as monosodium glutamate | 94 | 1.29 | 1.17 | **28120** | Manufacture of tanks, reservoirs and containers of metal | 57 | 1.29 | 1.13 |
| **15497** | Manufacture of snack:cracker/chips | 163 | 1.35 | 1.16 | **28910** | Forging, pressing, stamping and roll-forming of metal; powder metallurgy | 177 | 1.23 | 1.10 |
| **15499** | Manufacture of other food products | 195 | 1.38 | 1.24 | **28920** | Treatment and coating of metals, general mechanical engineering on a fee or contract basis | 72 | 1.31 | 1.08 |
| **15510** | Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials | 25 | 1.20 | 1.03 | **28930** | Manufacture of cutlery, hand tools and general hardware | 53 | 1.19 | 1.07 |
| **15541** | Manufacture of soft drinks | 87 | 1.39 | 1.11 | **28991** | Manufacture of tin cans and metal boxes | 57 | 1.36 | 1.06 |
| **15542** | Production of mineral water | 31 | 1.30 | 1.06 | **28992** | Manufacture of wire, wire products and metal fasteners | 198 | 1.32 | 1.16 |
| **16000** | Manufacture of tobacco products | 163 | 1.40 | 1.24 | **28993** | Manufacture of brass, copper, pewter and aluminium products | 165 | 1.41 | 1.14 |
| **17111** | Natural fibre spinning; weaving of textiles | 33 | 1.17 | 1.04 | **28999** | Manufacture of other fabricated metal products | 162 | 2.03 | 1.33 |
| **17112** | Man-made fibre spinning; weaving of textiles | 27 | 1.12 | 1.03 | **29120** | Manufacture of pumps, compressors, taps and valves | 37 | 1.19 | 1.05 |
| **17121** | Dyeing, bleaching, printing and finishing of yarns and fabrics | 45 | 1.10 | 1.04 | **29130** | Manufacture of bearings, gears, gearing and driving elements | 31 | 1.23 | 1.03 |
| **17122** | Batik making | 71 | 1.50 | 1.25 | **29150** | Manufacture of lifting and handling equipment | 36 | 1.21 | 1.07 |
| **17210** | Manufacture of made-up textile articles except apparel | 108 | 1.25 | 1.11 | **29191** | Manufacture of air-conditioning, refrigerating and ventilating machinery | 92 | 1.30 | 1.06 |
| **17220** | Manufacture of carpets and rugs | 15 | 1.07 | 1.00 | **29199** | Manufacture of other general-purpose machinery | 110 | 1.51 | 1.15 |
| **17291** | Handicraft spinning and weaving | 24 | 1.10 | 1.01 | **29210** | Manufacture of agricultural and forestry machinery | 64 | 1.30 | 1.15 |
| **17299** | Manufacture of other textiles | 46 | 1.58 | 1.07 | **29220** | Manufacture of machine tools | 304 | 1.50 | 1.26 |
| **17300** | Manufacture of knitted and crocheted fabrics and articles | 84 | 1.55 | 1.21 | **29240** | Manufacture of machinery for mining, quarrying and construction | 41 | 1.14 | 1.06 |
| **18101** | Manufacture of clothings | 452 | 1.64 | 1.25 | **29250** | Manufacture of machinery for food, beverage and tobacco processing | 23 | 1.12 | 1.01 |
| **18102** | Custom tailoring and dressmaking | 634 | 2.04 | 1.49 | **29270& 29290** | Manufacture of weapons and ammunition and manufacture of other | 80 | 1.22 | 1.15 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | special-purpose machinery | | | |
| **18109& 18200** | Manufacture of miscellaneous wearing apparel and dressing and dyeing of fur; Manufacture of article of fur | 42 | 1.28 | 1.08 | **29300** | Manufacture of domestic appliances | 47 | 1.15 | 1.05 |
| **19120** | Manufacture of luggage, handbags and the like, saddlery and harness of leather and leather substitutes | 47 | 1.23 | 1.06 | **30002** | Manufacture of computers and computer peripherals | 59 | 1.33 | 1.12 |
| **19200** | Manufacture of footwear | 168 | 2.26 | 1.48 | **31100** | Manufacture of electric motors, generators and transformers | 58 | 1.29 | 1.06 |
| **20100** | Sawmilling and planing of wood | 574 | 2.97 | 2.09 | **31200** | Manufacture of electricity distribution and control apparatus | 117 | 1.40 | 1.13 |
| **20211** | Manufacture of veneer sheets and plywood | 119 | 1.16 | 1.07 | **31301** | Manufacture of telecommunication cables and wires | 20 | 1.16 | 1.03 |
| **20212** | Manufacture of laminboard, particle board and other panels and board | 55 | 1.17 | 1.06 | **31302** | Manufacture of electronic power cables and wires | 24 | 1.09 | 1.01 |
| **20220** | Manufacture of builders' carpentry and joinery | 243 | 1.63 | 1.31 | **31309** | Manufacture of other insulated wires and cables | 76 | 1.18 | 1.07 |
| **20230** | Manufacture of wooden and cane containers | 72 | 1.32 | 1.14 | **31400** | Manufacture of accumulators, primary cells and primary batteries | 20 | 1.23 | 1.05 |
| **20291** | Manufacture of wood charcoal | 35 | 1.27 | 1.07 | **31500** | Manufacture of electric lighting equipment | 41 | 1.27 | 1.07 |
| **20299** | Manufacture of other products of wood, cane, articles of cork, straw and plaiting materials | 115 | 1.34 | 1.13 | **31900** | Manufacture of other electric equipment | 78 | 1.29 | 1.11 |
| **21010** | Manufacture of pulp, paper and paperboard | 99 | 1.20 | 1.09 | **32101** | Manufacture of semi-conductor devices | 86 | 1.95 | 1.18 |
| **21020** | Manufacture of corrugated paper and paperboard and of containers of paper and paperboard | 205 | 1.57 | 1.18 | **32102** | Manufacture of electronic valves and tubes and printed circuit boards | 115 | 1.62 | 1.24 |
| **21092** | Manufacture of envelopes, letter-card, correspondence cards or plain postcards | 20 | 1.38 | 1.07 | **32109** | Manufacture of other electronic components | 58 | 1.26 | 1.11 |
| **21093** | Manufacture of toilet paper, cleansing tissue, towels, serviettes | 19 | 1.18 | 1.04 | **32200** | Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy | 31 | 1.19 | 1.08 |
| **21095** | Manufacture of sanitary towels and tampons, disposable napkins | 11 | 1.38 | 1.02 | **32300** | Manufacture of television and radio receivers, sound or video recording or | 121 | 1.37 | 1.17 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | and napkin liners for babies | | | | | reproducing apparatus and associated goods | | | |
| **21096** | Manufacture of gummed or adhesive paper in strips or rolls and labels and wall paper | 40 | 1.27 | 1.14 | **33110** | Manufacture of medical and surgical equipment and orthopaedic appliances | 11 | 1.13 | 1.00 |
| **21097** | Manufacture of effigies, funeral paper goods, joss paper | 34 | 1.24 | 1.14 | **33120** | Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment | 23 | 1.17 | 1.02 |
| **21099** | Manufacture of other articles of paper and paperboard | 23 | 1.12 | 1.00 | **33201** | Manufacture of optical instruments | 13 | 1.14 | 1.01 |
| **22110** | Publishing of books, brochures, musical books, maps and other publications | 115 | 1.56 | 1.31 | **34100** | Manufacture of motor vehicles | 17 | 1.28 | 1.02 |
| **22120** | Publishing of newspapers, journals and periodicals | 45 | 1.28 | 1.09 | **34200** | Manufacture of bodies(coachwork) for motor vehicles; manufacture of trailers and semitrailers | 69 | 1.36 | 1.13 |
| **22190** | Other publishing | 32 | 1.19 | 1.06 | **34300** | Manufacture of parts and accessories of bodies for motor vehicles and their engines | 160 | 1.42 | 1.20 |
| **22210** | Printing | 594 | 1.54 | 1.36 | **35110** | Building and repairing of ships | 119 | 1.44 | 1.15 |
| **22220** | Service activities related to printing | 329 | 1.70 | 1.43 | **35120** | Building and repairing of pleasure and sporting boats | 24 | 1.09 | 1.03 |
| **23100& 23200** | Manufacture of coke oven products and manufacture of refined petroleum products | 25 | 1.23 | 1.08 | **35910** | Manufacture of motorcycles | 44 | 1.33 | 1.07 |
| **24111** | Manufacture of industrial gases, whether compressed, liquefied or in solid state | 41 | 1.79 | 1.25 | **35920** | Manufacture of bicycles and invalid carriages | 28 | 1.71 | 1.08 |
| **24119** | Manufacture of other basic industrial chemicals except fertilizers and nitrogen compounds | 89 | 1.39 | 1.12 | **36101** | Manufacture of wooden and cane furniture | 901 | 1.67 | 1.30 |
| **24120** | Manufacture of fertilizers and nitrogen compounds | 31 | 1.44 | 1.14 | **36102** | Manufacture of metal furniture | 125 | 1.22 | 1.08 |
| **24130** | Manufacture of plastics in primary forms and of synthetic rubber | 109 | 1.24 | 1.14 | **36109** | Manufacture of other furniture except of stone, concrete or ceramic | 126 | 1.19 | 1.08 |
| **24210** | Manufacture of pesticides and other agrochemical products | 26 | 1.13 | 1.05 | **36910** | Manufacture of jewellery and related articles | 108 | 1.26 | 1.13 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **24221** | Manufacture of paints, varnishes and similar coatings ink and mastics | 106 | 1.36 | 1.16 | **36930** | Manufacture of sports goods | 27 | 1.19 | 1.04 |
| **24222** | Manufacture of printing ink | 27 | 1.18 | 1.06 | **36940** | Manufacture of games and toys | 26 | 1.10 | 1.03 |
| **24230** | Manufacture of pharmaceuticals, medicinal chemicals and botanical products | 118 | 1.46 | 1.21 | **36991** | Manufacture of brooms, brushes and mops | 14 | 1.05 | 1.00 |
| **24240** | Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations | 108 | 1.34 | 1.15 | **36992** | Manufacture of pens, pencils, office and artists'' supplies | 43 | 1.17 | 1.04 |
| **24290** | Manufacture of other chemical products | 101 | 1.72 | 1.20 | **36999** | Other manufacturing | 254 | 1.44 | 1.16 |
| **25111** | Manufacture of rubber tyres and tubes | 26 | 1.19 | 1.05 | **37209** | Recycling of other non-metal waste and scrap | 43 | 1.14 | 1.03 |
| **25112** | Retreading and rebuilding of rubber tyres | 43 | 1.14 | 1.07 | | | | | |

Table 5: Distribution of technical efficiency in Malaysian Manufacturing Industries

| **Range of efficiency** | **DEA** | | **DEA-BSC** | |
|---|---|---|---|---|
| | **Number of industries** | **(%)** | **Number of industries** | **(%)** |
| 1 | 0 | (0.00) | 4 | (2.58) |
| 1.01-1.05 | 3 | (1.94) | 41 | (26.45) |
| 1.06-1.1 | 13 | (8.39) | 39 | (25.16) |
| 1.11-1.2 | 38 | (24.52) | 47 | (30.32) |
| 1.21-1.3 | 34 | (21.94) | 12 | (7.74) |
| 1.31-1.4 | 27 | (17.42) | 5 | (3.23) |
| 1.41-1.5 | 14 | (9.03) | 3 | (1.94) |
| 1.51-2 | 18 | (11.61) | 3 | (1.94) |
| >2 | 8 | (5.16) | 1 | (0.65) |
| Total | 155 | (100.00) | 155 | (100.00) |

Table 6: Tobit model of the DEA-BSC-CRS scores of the wood and wood based products industry

| **Excluded variable** | **Reasons** |
|---|---|
| EPURCH | Data not available |
| STAFF | The correlation with EXPORT is 0.80. |

Tobit model:

$$\begin{aligned} EFF_i = \alpha_0 & + \alpha_1 \, ESALE_i + \alpha_2 \, EXPORT_i + \alpha_3 \, IMPPAC_i + \alpha_4 \, IMPRAW_i \\ & + \alpha_5 \, IND_i + \alpha_6 \, INVESTOS_i + \alpha_7 \, PATEN_i + \alpha_8 \, PROMO_i \\ & + \alpha_9 \, RD_i + \alpha_{10} \, TECHEXP_i + \alpha_{11} \, TRAINING_i + \alpha_{12} \, \varepsilon_i \end{aligned}$$