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Inefficiency of Malaysian palm oil refineries and the impact of different factors on its inefficiency

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ABSTRACT

This study aimed to analyze changes in the inefficiency of Malaysian palm oil refineries using DEA window analysis method over the period 1996 to 2009. We investigated the effects of different factors on inefficiency of Malaysian palm oil refineries. Based on empirical results, the effect of all factors such as vertical integration, types of ownership, foreign investment, location, experience, and liberalization on inefficiency of refineries was significant. Experience, liberalization, and joint venture between private and public sectors showed an increase in efficiency, while joint venture between local and foreign investment and vertical integration increased refineries' inefficiency. However, palm oil refineries which were located in the states of Sabah and Sarawak were less technically inefficient than those located in peninsular Malaysia.

Introduction

The processed palm oil (PPO) industry is an old industry in Malaysia after almost 50 years of history. The PPO revenue is one of the major components in the Malaysian gross domestic product (GDP), since almost 4.7 of GDP in 2010 was almost equal to the export value of PPO products. Although Malaysia is the dominant PPO exporter in the world with an increasing export trend, its market share was reduced considerably from 93.8 per cent in 1989 to 67 per cent in 2009.

According to classical trade theories, if one country produces all of the commodities more efficiently than the others, then that country will benefit from international trade. Reduction in manufacturing costs by improving efficiency through the production chain is the main contributor to the global competitiveness of an industry. Under the condition that the firms and industries are performing efficiently, the risk of losing market share due to extra costs of inefficiencies would be removed. Since inefficiency costs put pressure on the profit margins of producers or increase their output prices, it leads to loss of market share especially when the elasticity of world demand is high. Therefore, one way to increase the competitiveness of the PPO refineries in the world market is minimizing their inefficiency. Therefore, the objective of the study is to investigate the inefficiency trends of Malaysian palm oil refineries from 1996 to 2009. Furthermore, the factors that could have affected the efficiency of the industry have been studied to find a solution for increasing the efficiency and the competitiveness of Malaysian PPO in the world market. The important factors that we investigate them in this study are vertical integration, ownership, experience, foreign investment, and location and liberalization.

The integration between upstream crude palm oil (CPO) mills and downstream (refineries) can be related to the inefficiency of refineries due to some reasons. The first reason is maintaining the quality needs of products since the free fatty acid (FFA) content of the CPO will increase very rapidly and it cannot be stored for very long before the refining processes take place. Moreover, production costs can be reduced when the refineries are integrated. These refineries can provide CPO at cheaper prices than spot prices since they are not typically forced to pay premium prices on the spot market. Also, integrated refineries are guaranteed of a continuous of supply of raw material (CPO). Finally, overhead expenses should be shared through the production chain (Jalil, 1996). Based on these reasons, it would be interesting to know whether the integrated refineries have a lower degree of inefficiency than the non-integrated ones.

The effect of ownership on inefficiency in the Malaysian palm oil refining industry is important. Over the past decades, the role of the Malaysian government's efforts in managing some of the refineries was more considerable, while during the 1990s the government started privatization process of the refineries. At the present time, some of these refineries are completely private and in some of them, the government has less than a 35 per cent share.

The experience of the refineries based on the year of their establishment varies from less than five years to more than 40 years in Malaysia. Since learning by doing is one of the sources of changes in efficiency of firm, the study investigates its effect on the inefficiency of refineries. Some of the refineries in Malaysia have foreign as well as local investors while the others have just local investors. Since this factor can have an effect on the quality of the management and the decision-making of the refineries, the study also investigates its effect on inefficiency.

Since the geographical location of the Sabah and Sarawak (or East Malaysia) are different than peninsular Malaysia, according to their access to the market and having the wide boundary with Indonesia to compensate for CPO shortage in the Malaysian domestic market, this factor may also produce different level of inefficiency. In 2001 and 2002, the Malaysian government temporarily lifted the CPO export tax in Sabah and Sarawak. Since this could be considered as tariff liberalization, the study will compare the inefficiency of refineries in Sabah and Sarawak in 2001 and 2002 with 1996 to 2009.

This study tries to recognize and rank the most efficient kinds of refineries. This might help policy makers encourage the refineries to move toward the best structures based on the demonstrated effects of all these factors.

The literature Review

Assessing the relative efficiency of decision making units (DMUs) related to special properties like size, investment, and experience is the shared interest between policy makers and economists (Buckley, Cross., & Horn, 2012; Chung, 2015; Gordon, 2014; Jung, 1999; Mendelsohn & Fels, 2014; Pavlínek, 1998; Petit, Sanna-Randaccio & Sestini, 2012). Among the DMUs, they usually look for simple effective ways at different levels of efficiency in order to find strategic solutions to reduce inefficiency of industries under consideration. Dios-Palomares and Martinez-Paz (2011) believed that the next step is to investigate the potential impacts of factors which might be related to the management of resources after efficiency estimation is made. This can be done in various different ways. For example Wu, Yeung, Mok, and Han (2007) tested the effect of the contribution of capital intensity, R & D, and product differentiation on the technical efficiency improvement in clock and watch industry in southern China using DEA method. Ma, Evans, Fuller, and Stewart (2002) tried to study the effect of product structure, size, and administrative level of sample enterprises on the production efficiency and productivity of China’s iron and steel industry. Mansson (2004) later looked at the relationship between different level of integration and technical efficiency in Swedish sawmill industry, while Chandra, Cooper, Li, and Rahman (1998) tried to find the optimum level of vertical integration by considering the efficiency scores of the Canadian textile companies based on the rate of returns to scale.

Vertical integration model is also used as a benchmark in many other studies (Gregor, 2008; Guo, Bandyopadhyay, Kenneth Cheng, & Yang, 2010; Kamatsiko, 2015; Li & Tang, 2011; Mejtoft, 2010; Ó Uallacháin, 1997; Yu, Huynh, & McGehee, 2011). Dios-Palomares and Martinez-Paz (2011) investigated the effect of different important factors affecting the efficiency of Spanish olive oil industry like skilled and experienced labor force. He and Weng (2012) later investigated the effect of ownership, autonomy, and size on efficiency of forest product processing mills in China. Margaritis and Psillaki (2009) studied the French manufacturing firms. They believed that factors such as size, profitability, asset structure, growth opportunities, and ownership structure also have strong direct effects on efficiency. For the purpose of the study, we will study how much vertical integration, liberalization, experience, location, ownership, and type of investment have the effect on the inefficiencies of Malaysian palm oil refining industry.

Although the purpose of all the above mentioned studies is to investigate the effects of the different factors on efficiency, they all use different approaches in their investigation. Tobit model and OLS regression model seems to be the most commonly used method. Recently the truncated regression model with bootstrapping procedure is also used in the studies. Other approaches like Mann-Whitney test and Pearson rank correlation have also been used in the literature. For example, Dios-Palomares and Martinez-Paz (2011) and He and Weng (2012) used truncated regression model with bootstrapping procedure. Mansson (2004) applied the Mann–Whitney test while Wu et al. (2007) used Tobit model. Ma et al. (2002) just compared the mean efficiency of different groups. Other studies also applied some other statistical tests to compare the efficiency of different group of DMUs (Banker, 1993; Banker & Chang, 1995; Banker, Janakiraman & Natarajan, 2004). Since all of the factors which we intended to investigate are highly polarized, statistical tests similar to Banker (1993) and Banker and Chang (1995) seemed to be most appropriate for our studies.

Method

In order to study the sources of inefficiency in the Malaysian palm oil refineries, we classified the refineries into two groups based on five different factors of integration, location, ownership, liberalization, and the types of investors. Such differences could be the source of different rates of inefficiencies in the refineries.

To compare the inefficiencies between the two groups of refineries, we applied test statistics similar to Banker (1993) and Banker and Chang (1995). Following Banker and Chang (1995) the technical inefficiency estimates could be calculated by solving the following BCC linear program model.

$$\theta^* = max \;\; \theta$$

$$s.t. \quad \sum_{j=1}^{n} x_{ij}\lambda_j \leq x_{io} \qquad i = 1,2,\ldots,m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j \geq \theta y_{ro} \qquad r = 1,2,\ldots,s$$

$$\sum_{j=1}^{n} \lambda_j = 1 \qquad \lambda_j \geq 0$$

Where θ^* represents estimated inefficiency score which is greater than one,

s is the number of outputs,

m is the number of inputs,

n is the number of refineries,

x_{ij} is the amount of input (i) which has been applied by j the refinery,

x_{i0} is the amount of input (i) which has been applied by refineries under evaluation,

y_{rj} is the amount of output (r) which has been applied by j the refinery,

y_{r0} is the amount of output (r) which has been used by the refineries under evaluation,

λ_j is the level of activity of efficient Decision Making Unit (DMU) or weights of inputs and outputs that define production frontier. It can also denote individual intensity variables which are achieved when solving the efficiency problem.

Banker (1993) proved that for any given set of DMUs, the asymptotic distribution of the DEA inefficiency estimators is the same as their true distribution. He employed this property to suggest statistical tests of hypotheses by using the DEA inefficiency estimators. These hypotheses testing could be applied to determine whether one type of DMUs is more efficient than the other. Banker also explained that since the mean and variance of inefficiency scores are unknown therefore some distributional assumption must be made to evaluate parameters and create good statistical test procedures. Based on Banker's point of view, if we suppose that N_1 is a sample of subgroup G_1 and N_2 is a sample of subgroup G_2, the null hypothesis of no difference in technical inefficiency between the two subgroups of refineries can be tested by employing the following procedures: Firstly if θ_j is distributed as exponential over the range of [0, ∞); therefore, there was no difference between inefficiency of two groups of refineries regarding to the null hypothesis. Therefore the test statistic will be:

$$\frac{\sum_{j \in G_1} (\theta_j - 1)^2 / N_1}{\sum_{j \in G_2} (\theta_j - 1)^2 / N_2}$$

θ_j is the technical efficiency score and its value might be evaluated relative to the critical value of F distribution with ($2N_1$, $2N_2$) degrees of freedom. Secondly, if θ_j is distributed as half normal over the range of [0, ∞); hence, there was no difference between the two groups of refineries considering the null hypothesis.

Similar to the previously examined test, the value of this test statistic can also be evaluated relative to the critical values of the F distribution with (N_1, N_2) degrees of freedom. Finally, if no parametric assumptions are preserved about the probability distribution of inefficiency, then Kolmogorov-Smirnov (K-S) type of nonparametric tests may be utilized instead of the above parametric tests (Banker, 1993; Banker, Janakiraman, & Natarajan, 2004). The K-S test is a nonparametric test which can be used to compare two samples. K-S statistic quantifies a distance between the empirical distribution function of two samples. Therefore, the two samples were drawn from the same distribution and it meant that the distributions of the two samples were similar.

This study focused on employing primary data collected from the field survey of 27 active refineries out of all 50 active refineries in West and East Malaysia from 1996 to 2009. The data collection was done by applying structural questionnaires that have been sent to refineries. The questionnaires provide more reliable information in relation to inputs and outputs which are not usually available in secondary data. Refineries receive crude palm oil (CPO) as input and then transform and refine it into pure plant oil (PPO). The most important products of the refineries are consisted of refined bleached deodorized palm oil (RBD Palm oil), refined bleached deodorized palm stearin (RBD palm stearin), refined bleached deodorized palm olein palm oil (RBD palm olein), and palm fatty acid distillate (PFAD) in metric tons.

Besides CPO, the refineries use other important inputs such as capital, labor, fuel and electricity. The declared total refining loss of CPO during the refining process for all firms is usually less than one per cent, i.e., the CPO is considered to have been efficiently utilized during the refining process. Henceforth, this study focused on capital cost, labor, and total utility and taking them as other inputs of the refining process.

The limitation of the method was that when comparing the inefficiency between the two different groups, the samples size should be large (Banker, 1993; Banker & Chang, 1995). To overcome the problem of a small sample size, we used a window DEA approach to increase the volume of our sample similar to Banker et al. (2004) and Bosetti, Cassinelli, and Lanza (2003) studies. In this approach, every refinery in each different year is treated as a different refinery which helps increase the volume of the sample. It means that a refinery's performance in each year is compared with its performance in other years and with the performance of the other refineries. However, the panel data is not considered a balanced panel data since some of the refineries have been established between 1996 and 2009. Apparently, some refineries' data from the beginning part of the study (1996) was not available. Since we used the window DEA approach, the capital and fuel costs were converted to real costs by applying Malaysia consumer price index (CPI). Table 1 (see Appendix 1) presents the basic statistics for input and output variables from 1996 to 2009 including mean, standard deviation, minimum, and maximum.

Results

Banker and Change (2006) stated that DEA method is very sensitive to the presence of outlier data and removing the outlier data by applying the super efficiency model increases the accuracy of efficiency scores. Therefore, we first applied the Anderson and Peterson (1993) method to calculate the super efficiency scores of efficient refineries. Then we used the conventional DEA approach on the remaining observations and calculate the more accurate inefficiency scores that are shown in Table 2 (see Appendix 2).

Based on the results, the average inefficiency of firm 7 was one and the average inefficiency scores of firms 6, 11, 13 and 26 were also near to one. It means that these firms were mostly efficient from 1996 to 2009. The highest inefficiency rate was related to firm 23 while the inefficiency rates of firms 8 and 20 were rather high. As shown in Figure 1, the inefficiency rate of the palm oil refineries increased from 1.18 in 1996 to 2.02 in 2009, although it decreased slightly from 1.18 to 1.06 between 1996 and 2001. The lowest inefficiency score was related to 2001. The comparisons of CPO price and inefficiency rates showed that the lowest inefficiency and CPO price were related to 2001. When the CPO price was low in the world market, Malaysian CPO exporters did not have enough incentive to export CPO. As a result, there was enough CPO in the domestic market for PPO producers, and in this case they produced more PPO while the amount of capital and labor were the same as before in a way that produce less inefficiency in the refineries. In 2007 and 2008 the prices of CPO and PPO were very close to each other and there was also a CPO shortage on the domestic market due to unfavorable weather conditions in 2007. So, refineries especially integrated ones did not have motivation to process the CPO since they could still sell CPO at the same price as PPO without paying extra costs to refine the CPO. Henceforth, there was a considerable increase in inefficiency of refineries since they had PPO spare production capacity.

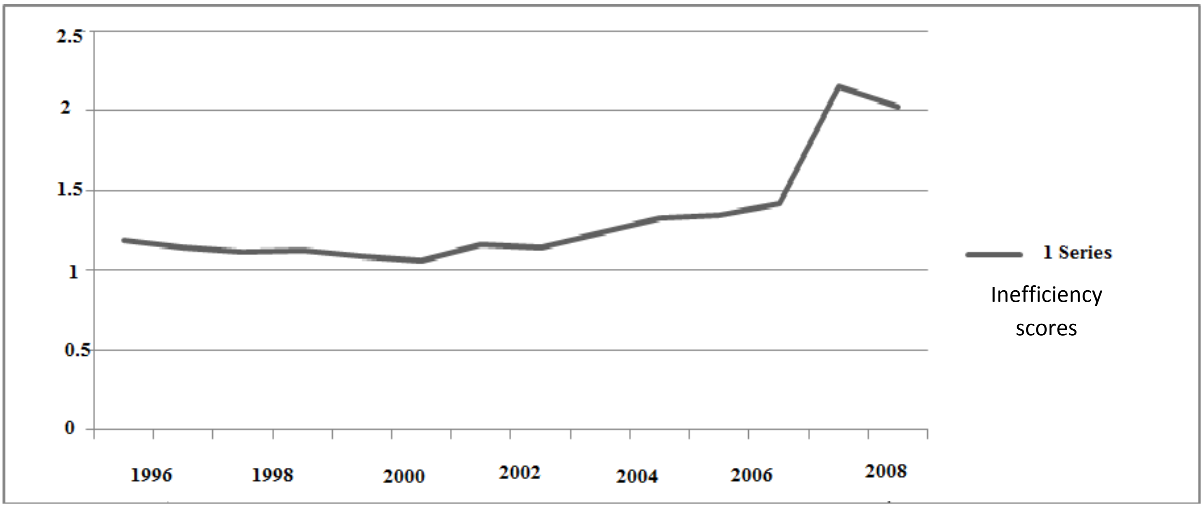

Figure 1. Trend of technical inefficiency (output oriented) of the palm oil refineries (1996-2009)

Based on the inefficiency scores, we categorized the refineries as reflected in Table 3 below.

Table 3
Groping Refineries based on Factors that Affect Inefficiency

	Inefficiency Determinant	Number of the Refineries in Group	Mean Inefficiency Scores in Group
Integration	Integrated	226	1.35
	Unintegrated	50	1.31
Ownership	Private	200	1.85
	Government and Private	76	1.16
Investor	Local	196	1.64
	Local and Foreign	118	1.73
Location	Peninsular Malaysia	162	1.96
	Sabah and Sarawak	115	1.20
Experience	More than 20 years	187	1.20
	Less than 20 years	40	2.05
Liberalization	Years 2001 and 2002(no CPO export tax)	17	1.12
	All years during (1996 to 2009) other than 2001 and 2002	98	1.21

To analyze these factors individually, we first look at vertical integration. Those refineries that have palm oil mills are considered integrated. In our sample only 4 refineries out of 27 are non-integrated. After applying a window approach during 1996 to 2009 and removing the outliers, the number of the integrated refineries in our sample is 226 while the second group comprises non-integrated ones consisted of 50 refineries.

Throughout the past few decades, the role of Malaysian government in managing some of the refineries was more considerable, while during the 1990s the government started a privatization process in these refineries. Palm oil refineries now have two types of ownership. Some of them are 100 per cent private and in some of them the government has less than a 35 per cent share. However the majority of refiners are 100 per cent private. Therefore, we divided them into two groups based on the differences in ownership including private and mixed. In our sample 7 refineries out of 27 have mixed ownership. After paneling the data from 1996 to 2009 and removing the outliers, the number of the 100 per cent private refineries in our sample reached 200 ones while the second group comprised of 76 refineries.

In Malaysia, most of the palm oil refineries' investors are local but still there are some refineries that are joint ventures with foreign as well as local investors. In this study, we classified the refineries into two groups, namely local and mixed investors. In our sample 7 out of 25[1] refineries were joint ventures. After using panel data and removing the outliers, the number of local refineries in our sample was 196 while the second group included 118 refineries.

The difference between geographical locations of the firms from an economic point of view was important since it could create different access to markets or key raw materials for producers. In case of the palm oil refineries in Malaysia, they could be divided into two different groups. In 2009, 16 refineries out of 51 were located in eastern Malaysia (11 in Sabah and 5 in Sarawak) and rests of them were located in peninsular Malaysia. Our sample contained 10 refineries in Sabah and Sarawak and 17 refineries in peninsular Malaysia. After applying panel data and removing the outliers, our sample comprised of 115 refineries was remained in Sabah and Sarawak.

Processed palm oil industry is known as an old industry in Malaysia and most of the refineries have more than 30 years experience in PPO production. Therefore, it is expected that the longer serving refineries exists, the more efficient they will be due to their experiences in the trade. We again divided the refineries into two groups, namely refineries

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[1] Two of the refineries did not announce their investors so we eliminate them from this inefficiency comparison

with less and more than 20 years experience. In our sample, 7 refineries out of 23[2] were established less than 20 years ago. Hence, the panel data comprised of 40 new and 187 old refineries.

Malaysian government cut the export tax rate of CPO in 2001 and 2002 in Sabah and Sarawak refineries. In this study, we investigated the impact of the export tax cut on inefficiency of the Sabah and Sarawak refineries. Our sample comprised of 10 refineries in Sabah and Sarawak refineries. After using the panel data and removing the outliers, we had a sample contains 98 refineries which 17 of them were related to 2001 and 2002.

Table 4 shows the result of the significant impact of the above mentioned factors on inefficiency of the Malaysian palm oil refineries based on the Banker's sum of squares ratio test and K–S test. All the factors show that it has at least one (if not all) significant impact on any of given tests.

Table 4
The Result of Comparing in Efficiency between Grouped Refineries

Test Factor	Banker's Sum Ratio Test (Exponential)	Banker's Sum of Squares Ratio Test (Half Normal)	Kolmogorov–Smirnov Test (Unknown)
Integration	1.12	7.18*	0.17**
Ownership	2.43*	27*	0.13
Investor	0.86	4.40*	0.20*
Location	2.14*	30.76*	0.19*
Experience	0.21	0.02	0.22*
Liberalization	1.67*	3.44*	0.36

Note: **Significant at 10%
*Significant at 5%

The result of the tests showed that according to the K-S test, the difference between inefficiency of the integrated and non-integrated refineries was significant at the 10 per cent while based on Banker's sum squares ratio test, it was significant at the 5 per cent. Since the integrated refineries could deliberately choose to export CPO or PPO, when the prices of CPO and PPO were very close to each other, they might choose to export CPO instead of PPO and saved more costs related to PPO producing. The significant reduction in the differences between PPO and CPO prices in the world market during 1996 to 2009 could be the possible reason behind the existence of more inefficiency in the integrated refineries. However, we expected that the inefficiency of this group to be less than non-integrated refineries since these integrated refineries can secure their own access to the CPO when the CPO supply is not stable in the market.

Based on Banker's sum squares ratio tests, the difference in inefficiencies of government linked refineries and private refineries were significant at the 5 per cent. Mixed ownership

[2] 4 refineries did not announce their establishment year

refineries were more efficient than the private ones since the average energy inefficiency of the private refineries (1.85) was more than for mixed ownership refineries (1.16). It could be attributed to secure supplies of inputs like fuel, CPO, and loans to expand the capital for the refineries that had strong government connection. Lack of the CPO and fuel were two reasons for stopping the operations in some years which have been reported by refineries in the questionnaires. For example at the time of CPO shortage in the market when domestic producers had more interest in exporting rather than selling the CPO to domestic consumers, getting the approvals to import CPO, and other bureaucratic steps were most likely easier for refineries which had government connection.

Based on K-S test and Banker's sum of squares ratio test, the effect of investor types in refineries' inefficiency was significant at the 5 per cent. Since the average inefficiency of the local refineries was 1.64 while the value for the mixed investor refineries was 1.73, the performance of local investor refineries was better than mixed investor refineries' performance. These differences could be attributed to the experience of local refineries which applied to manage their refineries better than the other group. However, according to Banker's sum of squares ratio test there was no significant difference between the efficiency of these two groups.

The impact of location based on all three tests was significant on the inefficiency of the palm oil refineries. The average inefficiency of the Sabah and Sarawak refineries was 1.20 while the average inefficiency of the refineries located in peninsular Malaysia was about 1.96. It showed that the performance of Sabah and Sarawak refineries was better than those of Peninsular Malaysia. It could be related to their access to the CPO and PPO markets since they all were located very close to the ports. One of the reasons for the refineries to ceasing operation of refineries was the fullness of their storage tanks after production, so access to the market by being close to the ports could be one of the advantages that Sabah and Sarawak refineries benefit from. Additionally, since Indonesia has a border with Sabah and Sarawak refiners, obtaining foreign CPO for the refineries in addition to domestic CPO was easier. In 2009, 46 per cent of the matured oil palm planted areas were located in Sabah and Sarawak while 42 per cent of production capacity was related to them. It indicated that they had better access to CPO rather than peninsular refineries. The average inefficiency of the new refineries was 2.05 and for old refineries it changed to 1.23. It means that on average, the old refineries were more efficient than the new ones. Based on the K-S test, the difference at the

5 per cent was significant. But, Banker's sum of squares ratio tests did not support the hypothesis of a significant difference between the inefficiency of the old and new refineries.

The average inefficiency rate of Sabah and Sarawak refineries in 2001 and 2002 was 1.12 while this amount was 1.21 in the other years of the investigated period. It means that the inefficiency of the refineries decreased due to the export tax cut for CPO. The result of the Banker's sum of squares ratio test supported the hypothesis of a significant difference between inefficiency of the refineries under trade liberalization, although the K-S test did not support this hypothesis.

From trade liberalization dimension, rationalization under new reformed tariff attempts to increase the efficiency of industry through eliminating inefficient firms or encouraging them to be more efficient. In such a situation, trade liberalization does produce positive results theoretically. Globerman (1990) indicated that free trade stimulates competition and therefore leads to more efficiency. Similarly, we can conclude that rationalization took place in Sabah and Sarawak refiners in years 2001 and 2002 and this has encouraged refineries to be more efficient.

Conclusion

Most of the studies related to efficiency and the factors that affect it applied Tobit or OLS approaches. In this study, the factors that we considered were all polarized. Hence, instead of using dummy variables in OLS or Tobit methods to investigate the effects of these factors, we applied Banker's method (1993, 1995). Furthermore, there are relatively few studies in manufacturing where they considered vertical integration and liberalization effects on the efficiency.

Ranking these factors based on the degree of their significance, the most important one that had effects on the efficiency was location, and this has been confirmed by all three tests. The weak factors such as experience, fringe investment, and integration were accepted by K-S test. The other factors of ownership and liberalization were ranked between these two groups since their significance were confirmed based on two out of three tests.

In sum, performance of Sabah and Sarawak refiners was better than peninsular refineries since they had better access to input and output markets. Non-integrated refineries had much better performance than integrated refineries. Government joint ventures had a positive impact on the efficiency of refineries, since it can be concerned to ensure a secure supply of inputs. Local refineries were more efficient than the refineries that are joint ventures between local and foreign investors. CPO export tax cut by Malaysia had a positive impact on technical efficiency of the refineries by increasing the competition. The non-integrated refineries had better performance than integrated ones, since the integrated refineries could choose between CPO process and export when the price difference between CPO and PPO was very low. The government-link refineries had a positive impact on efficiency, since it might be able to secure the supply of inputs easier than the others. In addition, the local refineries had better efficiency than the refineries owned foreign investors. This could be related to the experience of local refineries relative to those of foreign ownership. Malaysia's government's export tax cut had a positive impact on technical efficiency of refineries through an increase in competition. So the government of Malaysia can consider the effects of these factors at the time of awarding licenses to applicants who are interested in establishing new refineries in order to reduce the presence of inefficiency in the palm oil refining industry.

References

Andersen, P., & Petersen, N. C. (1993). A procedure for ranking efficient units in data envelopment analysis. *Management science*, *39*(10), 1261–1264.

Banker, R. D. (1993). Maximum likelihood, consistency, and data envelopment analysis: A statistical foundation. *Management science*, *39*(10), 1265–1273.

Banker, R. D., & Chang, H. (1995). A simulation study of hypothesis tests for differences in efficiencies. *International Journal of Production Economics, 39*(1/2), 37–54.

Banker, R. D., & Chang, H. (2006). The super-efficiency procedure for outlier identification, not for ranking efficient units. *European Journal of Operational Research, 175*(2), 1311–1320.

Banker, R. D., Janakiraman, S., & Natarajan, R. (2004). Analysis of trends in technical and allocative efficiency: An application to Texas public school districts. *European Journal of Operational Research, 154*(2), 477–491.

Bosetti, V., Cassinelli, M., & Lanza, A. (2004). *Using data envelopment analysis to evaluate environmentally conscious tourism management*. Paper presented for the Conference Tourism and Sustainable Development, Chia Sardegna.

Buckley, P. J., Cross, A. R., & Horn, S. A. (2012). Japanese foreign direct investment in India: An institutional theory approach. *Business History, 54*(5), 657–688.

Chandra, P., Cooper, W. W., Li, S., & Rahman, A. (1998). Using DEA to evaluate 29 Canadian textile companies: Considering returns to scale. *International Journal of Production Economics, 54*(2), 129–141.

Chung, K. (2015). Foreign debt, foreign direct investment, and volatility. *International Economic Journal, 24*(2), 171–196.

Dios-Palomares, R., & Martinez-Paz, J. M. (2011). Technical, quality, and environmental efficiency of the olive oil industry. *Food Policy, 36*(4), 526–534.

Globerman, S. (1990). Trade liberalization and competitive behavior: A note assessing the evidence and the public policy implications. *Journal of Policy Analysis & Management, 9*(1), 80–88.

Gordon, A. (2014). Reverse flow foreign investment: Colonial Indonesia's investment in metropolitan countries. *Journal of Contemporary Asia, 44*(1), 108–124.

Gregor, R. J. (2008). Interdisciplinary vertical integration: The future of biomechanics. *Quest, 60*(1), 31–44.

Guo, H., Bandyopadhyay, S., Kenneth Cheng, H., & Yang, Y. C. (2010).Net neutrality and vertical integration of content and broadband services. *Journal of Management Information Systems, 27*(2), 243–276.

He, H., & Weng, Q. (2012). Ownership, autonomy, incentives and efficiency: Evidence from the forest product processing industry in China. *Journal of Forest Economics, 18*(3), 177–193.

Jalil, S. H. A. (1996). *Capacity utilization in the Malaysian palm oil refining industry* (Unpublished doctoral dissertation). Universiti Pertanian, Malaysia.

Jung, K. H. (1999). Foreign direct investment and corporate restructuring in East Asia. *The Pacific Review, 12*(2), 271–290.

Kamatsiko, V. V. (2015) Grassroots peace building and vertical integration: A case study of the peace-rings approach. *Journal of Peace building & Development, 10*(1), 56–71.

Li, H. L., & Tang, M. J. (2011). Vertical integration, escalating commitment, and technological performance: Evidence from firms in the US computer industry. *Technology Analysis & Strategic Management, 23*(3), 279–296.

Ma, J., Evans, D. G., Fuller, R. J., & Stewart, D. F. (2002). Technical efficiency and productivity change of China's iron and steel industry. *International Journal of Production Economics, 76*(3), 293–312.

Mansson, J. (2004). Vertical integration and efficiency: Ownership in the Swedish sawmill industry. *Review of Industrial Organization, 24*(1), 25–36.

Margaritis, D., & Psillaki, M. (2009). Capital structure, equity ownership, and firm performance. *Journal of Banking & Finance, 34*(3), 621–632.

Mejtoft, T. (2010). Moving closer to the customers: Effects of vertical integration in the Swedish commercial printing industry. *Journal of Strategic Marketing, 18*(7), 599–611.

Mendelsohn, R., & Fels, A. (2014). Australia's foreign investment review board and the regulation of Chinese investment. *China Economic Journal, 7*(1), 59–83.

Ó Uallacháin, B. (1997). Restructuring the American semiconductor industry: Vertical integration of design houses and wafer fabricators. *Annals of the Association of American Geographers, 87*(2), 217–237.

Pavlínek, P. (1998). Foreign direct investment in the Czech Republic. *The Professional Geographer, 50*(1), 71–85.

Petit, M. L., Sanna-Randaccio, F., & Sestini, R. (2012). R & D and foreign direct investment with asymmetric spillovers. *Economics of Innovation & New Technology, 21*(2), 125–150.

Wu, Z. B., Yeung, G., Mok, V., & Han, Z. (2007). Firm-specific knowledge and technical efficiency of watch and clock manufacturing firms in China. *International Journal of Production Economics, 107*(2), 317–332.

Yu, J., Huynh, N. T., & McGehee, T. L. (2011). Vertical integration of geographic information sciences: A recruitment model for GIS education. *Journal of Geography, 110*(5), 191–199.