agriculture

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Technical Efficiency and Export Potential of the World Palm Oil Market

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Abstract: Palm oils have been proven to have the highest yield among vegetable oils, which is one of the critical factors in ensuring global food security. However, the world palm oil market has not been entirely utilised due to intervention policies that disrupt the global trade flow. Hence, this study aims to identify the technical efficiency of palm oil exports and then analyse the export potential of two leading producers and exporters of palm oil, Malaysia and Indonesia. A stochastic frontier model (SFM) has been used to estimate the level of technical efficiency across two countries for a sample of 59 major palm oil importing countries during 2009–2019. Palm oil export potential is then calculated using the value of technical export efficiency obtained from the SFM. The main findings revealed the technical inefficiency of world palm oil exports. Comparing the two countries, the Indonesian average technical efficiency value is higher than Malaysian throughout the year. Moreover, the technical efficiency estimates reveal that Malaysia and Indonesia dominate different markets, except in the Netherlands. In terms of export potential, the study found that both major exporting countries of palm oil have great potential to tap more into the same countries, namely China, India, Thailand and the United States. The policy implications of this study suggest that policymakers from both countries should set up a new combined strategy to maximise the palm oil export to their trading partners. Low technical efficiency values in several importing countries show great potential to explore further. Hence, there is a vast potential market for palm oil export to be tapped in those countries.

Keywords: palm oil; trade; technical efficiency; export potential; stochastic frontier analysis

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Citation: Ahmad Hamidi, H.N.; Khalid, N.; Karim, Z.A.; Zainuddin, M.R.K.V. Technical Efficiency and Export Potential of the World Palm Oil Market. *Agriculture* **2022**, *12*, 1918. https://doi.org/10.3390/agriculture12111918

Academic Editor: Laura Onofri

Received: 28 October 2022
Accepted: 9 November 2022
Published: 15 November 2022

1. Introduction

The palm oil industry is an essential component in the agricultural sector that contributes to the national income of Malaysia and Indonesia. Not only that, but this industry also helps improve the living standards and welfare of the people in both countries. For instance, this industry has contributed to the Malaysian economy by 3.6 per cent of its gross domestic product (GDP) [1], while Indonesia by 3.5 per cent of its GDP in 2020 [2]. It is also reported that there are about three million people in Malaysia whose livelihood depends on the palm oil industry, of which 650 thousand of the figures are smallholders [3]. While for Indonesia, the palm oil industry is a source of livelihood for about 50 million people [4]. For these reasons, it is not surprising that these two major palm oil exporting countries always give their best in developing this industry to remain competitive in the international market.

In terms of trade, both countries dominate the international market of palm oil exports. In 2020, Indonesia had a 56% market share, followed by Malaysia, 32%. Although Malaysia is the world market leader before 2008, rapid palm oil plantation expansion in Indonesia has contributed to its domination since 2008. Recent statistics from Comtrade [5] show that Indonesia exported 25.9 million tonnes (USD 17.3 billion) of palm oil in 2020, while

Malaysia exported 14.6 million tonnes (USD 9.8 billion). Interestingly, the global domestic consumption of palm oil has also expanded drastically from just 10% of total vegetable oil consumption in the 1970s to more than 38% in 2019 [6]. In comparison, soybean oil has dropped slightly from 36% to 29% for the same period. The expansion of palm oil consumption mainly contributed to the high usage of palm oil in food industries and industrial applications. Moreover, globalisation also plays a vital role in the rising of palm oil consumption as countries are involved in various trade agreements to promote export further. This can also be seen in the case of palm oil export, as the major exporters actively participate in various trade agreements to reduce trade barriers further and focus on tariffs and non-tariff measures.

Despite the rising global palm oil consumption, palm oils demand in certain importing countries still needs to be at its optimum level [7,8]. The usage of substitution oils and trade barriers have reduced palm oil imports in those countries [7]. Thus, creating more market potential is crucial in optimising export. As seen in Figure 1, the household consumption of palm oil in the ten major importing countries is still low, especially in countries with large populations, such as China, India and European Union countries. In addition, a study by Puah [9] also says that palm oil consumption in Eastern Europe is considered low and still not fully developed. However, palm oil is sold at a relatively low price compared to other oils in the region. Similarly, Iranian and Central Asia also has market potential that can be explored and enhanced [8,10].

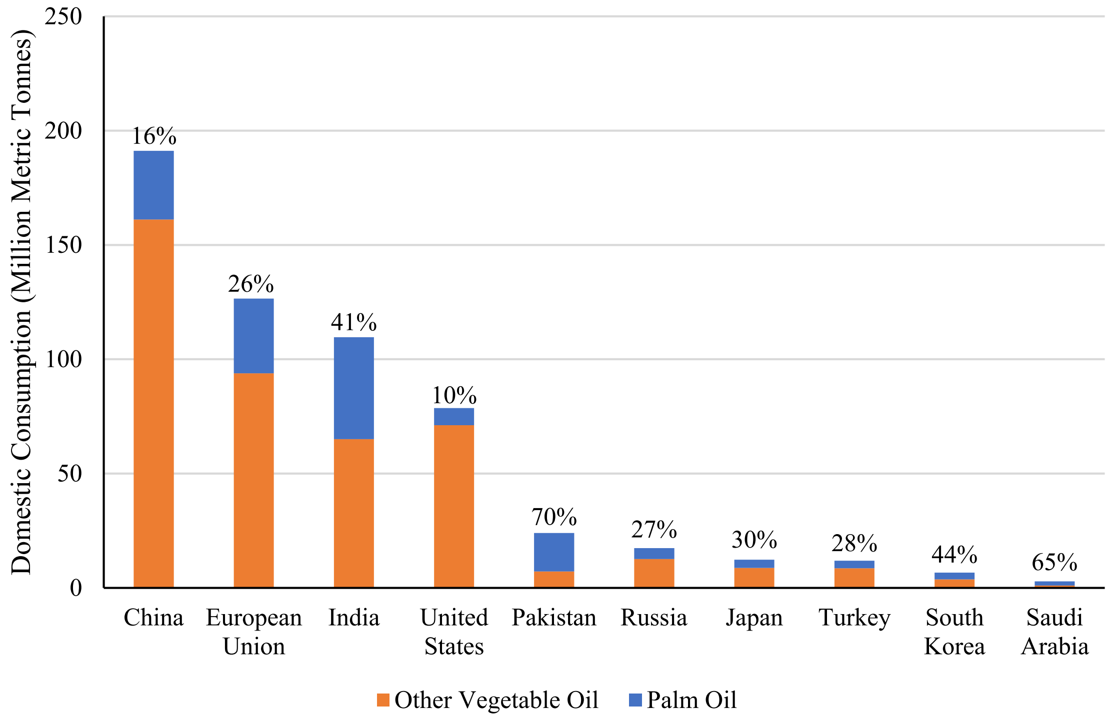

Figure 1. Domestic Consumption of Palm Oil in 10 Major Importing Countries, 2016–2019. Source: USDA [6].

Based on several past studies, among the factors contributing to the low level of exports is the problem of technical inefficiency in exporting certain goods [11–13]. This is also expected to happen in palm oil exports. However, discussions on the level of technical inefficiency for palm oil exports still need to be expanded due to a lack of clarity, which has raised a question about the level of technical efficiency for Malaysian and Indonesian palm oil exports. Information on the level of palm oil technical efficiency can guide policymakers in expanding their market shares. Thus, given this background, the main objective of this study is to determine the level of technical efficiency and then analyse the export potential of Malaysia and Indonesia palm oil. We choose these two countries as together they represent around 85% of world palm oil export shares [5].

In general, empirical studies have used export efficiency to calculate the export potential and export gap in analysing the efficiency of exports. Export efficiency is defined as the export performance of a firm or country that aims to make products using minimum inputs to increase profits [14]. Through this export efficiency analysis, the export potential, which is defined as the maximum value of exports that can be achieved when there is no resistance in trade factors, can be calculated. This export potential provides a clear picture of the performance of a firm or country conducting its trading activities in the international market. Meanwhile, the export gap shows the differences between current export and potential export. This is pivotal for the exporting countries to estimate how much they can tap the market to further increase palm oil market shares.

The motivation of this study in determining the level of technical efficiency and export potential of world palm oil can be explained by two crucial reasons. First, given the role of the palm oil industry as a major agricultural industry in both countries, the evaluation of the level of export efficiency is essential for further understanding how the explanatory variables affect the efficiencies of palm oil export. For instance, higher trade barriers may distort the bilateral trade flows and cause the countries to be unable to export at their full potential. Moreover, the industry's negative allegations and discrimination also seem to add to the difficulty of the exporting countries to penetrate the market at their full capacity. Second, information on the export potential may provide an insight into which importing countries could form a new target market to expand palm oil export. The new target market information can also motivate the exporting countries to investigate the key elements that can help palm oil exports grow in those potential countries.

Owing to the essential role of the palm oil industry in Malaysia and Indonesia, this paper may thus contribute to two dimensions. First, this study is beneficial to policymakers in both exporting countries. By knowing the level of export efficiency and its potential, they can implement extensive policy reforms to increase the export level, enhance the promotion of palm oil benefits and create a stable political relationship to attract the importing countries to increase their demand for palm oil. Second, this study extends the palm oil industry literature by focusing on technical export efficiency and export potential. Numerous studies have discussed the technical efficiency concerning palm oil production [15–17], while in terms of technical export efficiency, past studies focus on other goods [11–13]. However, new studies by Devadason and Mubarik [7] have discussed technical export efficiency of palm oil, but their studies are only limited to Southeast Asia and Latin America regions and also consider the tariff factor only. Therefore, this present study will extend the literature by providing evidence of the palm oil market opportunities that can be explored more in the future for 59 major importing countries that accounted for 89 per cent of the world's total palm oil imports and also take into account the new trade policy factors that highly affected international trade which is non-tariff measures.

This article is organised into five sections. Section 2 reviews the relevant theoretical and empirical literature, describes the source of data and the baseline empirical model using a stochastic frontier analysis estimation. Section 3 summarises the main empirical findings, and finally, Section 4 concludes and provides some policy implications of the study.

2. Materials and Methods

The measurement of economic efficiency has been closely linked to frontier functions. Both of these fields begin with a study by Farrell [18]. His study was strongly influenced by Koopmans [19] and Debreu ([20], in which he introduced a method for decomposing the overall efficiency of a production unit into technical and allocation components. Farrell says that productive units can become inefficient either by obtaining less than the maximum available output from a specified group of inputs (technically inefficient) or by not buying the best input package with marginal price and productivity (inefficient allocation). However, his studies are discussed in the context of input-oriented only. Then, further studies have improved the concept of efficiency measures in terms of output-oriented. For instance, Fare et al. [21,22] and Lovell [23] have discussed allocation efficiency analysis in terms of output by maximising revenue. On the other hand, studies by Kumbhakar [24], Fare et al. [22] and Fare et al. [25] performed an allocation efficiency analysis based on profit maximisation, where both minimise the cost (input-oriented model) and maximise the revenue (output-oriented model) were assumed in their analysis.

From the theory discussed, modern researchers have used the same concept to measure technical efficiency in terms of exports at the firm or country level. Nevertheless, some past researchers have focused on levels of efficiency in production or productivity [26–29]. The findings of past studies show that endowment factors such as labour improve productivity and thus lead to the increment of technical efficiency [29,30]. Moreover, agricultural land size [27,28,31,32] has also proven to play a significant role in determining the level of technical efficiency of production. Then, past researchers also found evidence of the use of mechanisation and technological innovation to increase the productivity of farm activities and further increase its efficiency [33,34].

As for the case of palm oil, technical efficiency analysis is still poor and limited. Most of the past studies have focused on the context of productivity efficiency. For instance, a preliminary study by Soekartawi [35] said that most palm oil producers are usually unable to achieve optimal production levels. This is because the use of inputs for production is still not at the maximum level, and in turn, causes the production not to reach the set target. This finding is also supported by Utami [36] and Azzuhdan et al. [15], who argued that palm oil production is still inefficient due to several factors, such as a lack of fresh fruit bunches and lack of manpower. Nevertheless, Ismiasih's [16] study proves that the level of efficiency of palm oil production can be improved if the quality of the trees and the type of fertiliser used are good. In addition, studies by Nordin et al. [17] shows that the efficiency of palm oil production in the case of smallholders in Malaysia has not yet reached the optimum level. The level of production efficiency of these smallholders also depends on the quality of fertiliser used, the level of soil fertility and current weather conditions.

In this regard, many previous researchers also used the same concept to analyse the level of technical efficiency of exports. Ravishankar and Stack [11] studied the impact of the implementation of trade integration of Eastern and Western European countries on trade potential. Their results showed that all the countries studied achieved two-thirds of the overall efficiency scores. Their results also prove that the countries are trading at a good level. Then, a study by Atif et al. [12] examines the determinants and export potential of the agricultural sector for Pakistan. The results show that Pakistan has not yet traded optimally with its trading partner countries, especially in the Middle Eastern and European countries. Similar results were obtained for the export of Pakistani chemical products [13]. In terms of palm oil export efficiency, new studies by Devadason and Mubarik [7] compare intraregional export potentials for palm oil in two regions: Southeast Asia and Latin America. Their findings suggest that intraregional exports of palm oil and palm-based products have low efficiency and have a great potential to be tapped.

2.1. Source of Data

The data used for the analysis are from a yearly time series data set spanning from 2009 to 2019. The data are for Malaysia and Indonesia, which represent the world-leading palm oil export countries, while the major importers of palm oil include 59 countries (see Appendix A). The selection of the importing country is based on the percentage of the total palm oil imported by them and also the availability of data related to the importing country. All 59 countries selected in this study accounted for 89 per cent of the world's total palm oil imports.

The world palm oil export data used in this study are taken from the UN Comtrade database, which is based on the Harmonized System classification at the four-digit level, which is HS-1511 for palm oil. Data on the trade restrictiveness index for palm oil are obtained from Hamidi [37]. Next, this study uses trade agreement (TA) variables related to the agriculture or palm oil sector that are still in force to date (see Appendix A). This variable is a dummy variable where a value of 1 represents the year the TA was first implemented between the importing country Malaysia and Indonesia. A value of 0 indicates that there is no trade agreement between the countries. Information on this TA was obtained from the Macmap [38] database provided by the International Trade Center (ITC). For the gravity model variable, this study gathered data from the World Bank for Gross Domestic Product (GDP), population and exchange rates. The data on distance are collected from the CEPII database [39]. Table 1 shows the overall variable description and data sources.

Table 1. Variable Description & Data Sources.

Variables	Description	Data Sources
X	Bilateral palm oil export values (HS1511) in USD	Comtrade [5]
GDP	Gross Domestic Product for importing and exporting countries in USD	World Bank [40]
POP	The total population for importing and exporting countries	World Bank [40]
$DIST$	Bilateral distances between importing and exporting countries in kilometres	CEPII [39]
TRI	Trade restrictiveness index imposed by importing countries	Hamidi [37]
ER	The bilateral exchange rate between importing and exporting countries	World Bank [40]
TA	Trade agreement dummy between importing and exporting countries	Macmap [38]

2.2. Methodology

This study utilises the Stochastic Frontier Model (SFM) that was first developed by Aigner et al. [41] and Meeusen and van den Broeck [42]. Since the conception of this idea, this methodology has widely been used to assess firm performance. Typically, the SFM postulates production possibility frontiers representing the optimal level of production obtained from the fixed available inputs. The efficient firms operate on production possibility boundaries, whereas technically inefficient firms operate inside the given frontier level, also representing the production loss equal to the difference between the actual and potential output. Hence, it implies that the latter can further expand its output from a given level of inputs. Thus, stating in the context, the firm operating below the optimal level of production commits technical inefficiency.

Accordingly, production boundaries have been adopted to explain the trade performance or export potential [11–13]. In the context of exports, a country that achieves its export potential or trades at the border level is said to trade efficiently. On the other hand, inefficient trading refers to the condition in which actual trade is below the maximum level of trade boundaries. Since this study analyses at the national level, SFM is seen as more appropriate than the Stochastic Meta Frontier (SMF) analysis focused on analysis at the firm's level with various technology levels. In addition, given that Malaysia and Indonesia are the two major producers of palm oil in the world, this study assumes the homogenous export technology for both countries.

Following Ravishankar and Stack [11], this study used the augmented gravity model to obtain the technical efficiency values as follows:

$$\begin{aligned} \ln X_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln DIST_{ij} \\ + \beta_6 \ln TRI_{jt} + \beta_7 \ln ER_{ijt} + \beta_8 TA_{ijt} + v_{ijt} - u_{ijt} \end{aligned} \quad (1)$$

where X_{ijt} are the bilateral palm oil export values from country i to country j at time t, GDP_{it} are the income for country i at time t, GDP_{jt} are the income for country j at time t, POP_{it} are the population for country i at time t, POP_{jt} are the population for country j at time t, $DIST_{ij}$ are the bilateral distance between country i and country j, TRI_{jt} are trade restrictiveness index for country j at time t, ER_{ijt} are the bilateral exchange rate between country i and country j at time t, and TA_{ijt} are trade agreements between country i and country j at time t. Following Atif et al. [12], v_{ijt} are denoted as double-sided error terms that assume $N(0 \sim \sigma_v^2)$ that explains statistical noise caused by estimation errors and u_{ijt} are single-side error terms that are supposed to be normally distributed, $N(\mu \sim \sigma_u^2)$ that measure technical inefficiency. We use u_{ijt} to identify the extent to which the actual trade level deviates from the maximum possible trade. The TRI is calculated by incorporating tariffs and non-tariff measures, and it serves to represent trade barriers. TRI calculation shows the overall degree of trade restrictions imposed by importing countries to restrict trade. Higher TRI values mean a higher degree of trade restrictions imposed on imported goods. We hypothesise that trade restrictiveness distorts bilateral trade flows and thus might cause lower export efficiencies.

Based on the estimated parameters, this study calculates the technical efficiency by using the equation that was introduced by Battese and Coelli [43] as follows:

$$E\left[\exp(-u_{ijt})\,|v_{ijt}+u_{ijt}\right] = \left[\frac{1-\Phi[\sigma_\alpha + \gamma(v_{ijt}+u_{ijt})/\sigma_\alpha}{1-\Phi\gamma(v_{ijt}+u_{ijt})/\sigma_\alpha}\right] \times \exp\left[\gamma(v_{ijt}+u_{ijt}) + \frac{\sigma_\alpha^2}{2}\right] \tag{2}$$

where $\Phi(.)$ is a density function for a common random variable. If γ is equal to 0, there is no deviation due to inefficiency. If γ is equal to 1, there is no deviation in the export variance in v. Technical efficiency can be estimated for each importing country between 0 and 1. The technical efficiency value that is equal to 1 indicates that the actual trade and full potential are the same, while a value approaching 0 indicates that the actual trade is below the potential level of trade, and this creates opportunities for exporters to increase trade. After estimating technical efficiency, this study uses each coefficient value from the estimation to find the value of export potential and the export gap between countries.

To ensure the robustness of our estimations, two of the most common gravity models estimation, which are the Poisson Pseudo Maximum Likelihood (PPML) and the Fixed Effect (FE) methods, are employed [44]. These two estimations take into consideration unobservable heterogeneity and trade resistance within the gravity model [45]. Moreover, PPML is usually prefered in gravity model analysis as it can deal with zero trade bias and heteroskedasticity issues [46–48]. On the other hand, the FE approach does not take into consideration time-invariant variables of the gravity equation. This causes the models to drop these variables during estimation. The FE approach will also lead to selection bias due to zero trade issues. The PPML equation is similar to Equation (1); it only differs for the dependent variables as in PPML, we do not log the export values as follows:

$$\begin{aligned} X_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln DIST_{ij} \\ +\beta_6 \ln TRI_{jt} + \beta_7 \ln ER_{ijt} + \beta_8 TA_{ijt} + \varsigma_{ijt} \end{aligned} \tag{3}$$

where ς_{ijt} is the error term and the description for all other variables is similar to Equation (1). Meanwhile, the FE equation is as follows:

$$\begin{aligned} \ln X_{ijt} = \beta_0 + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln POP_{it} + \beta_4 \ln POP_{jt} + \beta_5 \ln DIST_{ij} \\ +\beta_6 \ln TRI_{jt} + \beta_7 \ln ER_{ijt} + \beta_8 TA_{ijt} + \varepsilon_{ijt} \end{aligned} \tag{4}$$

where ε_{ijt} is the error term and the description for all other variables is similar to Equation (1).

3. Results and Discussion

Before discussing the estimation results, this study provides descriptive statistics for all variables used in the model to have an overall understanding of the nature of the data. Based on Table 2, it can be seen that all variables have low standard deviations, which show low variation in each variable.

Table 3 shows the results of stochastic frontier analysis for world palm oil exports (Malaysia and Indonesia). Based on these results, it can be seen that the variables that determine the appropriateness of the stochastic frontier model (SFM) in measuring the performance of world palm oil exports are significant. A high and significant gamma (γ) value of 0.7159 indicates that the estimated model is good. Then, a significant value of μ proves the existence of inefficiencies in world exports of palm oil. σ^2, the value which is also significant at a 5 per cent significance level, measures the overall mean of variation over a while. This study also conducts PPML and FE estimation to ensure the robustness of the SFM estimation results, as reported in Table 3. Overall, it can be seen that the signs and values for all estimations are similar. Hence, for the interpretation of the results, this study focus on the SFM results.

Table 2. Descriptive Statistics.

Indicators	$\ln X_{ijt}$	$\ln GDP_{it}$	$\ln GDP_{jt}$	$\ln POP_{it}$	$\ln POP_{jt}$	$\ln Dist_{ij}$	$\ln TRI_{jt}$	$\ln ER_{ijt}$	TA_{ijt}
Mean	16.951	26.929	26.247	18.270	17.066	8.940	0.188	−2.758	0.201
Median	17.236	26.780	26.311	18.272	16.991	9.149	0.140	−2.079	0.000
Maximum	22.372	27.646	30.601	19.394	21.050	9.892	0.883	8.816	1.000
Minimum	1.099	26.033	21.937	17.138	13.985	5.754	0.000	−10.703	0.000
Std. Dev.	2.513	0.559	1.833	1.074	1.475	0.661	0.162	4.912	0.401

Table 3. Estimation Results for World Palm Oil Export.

Variables	SFM		PPML		FE	
	Coefficients	Standard Deviations	Coefficients	Standard Deviations	Coefficients	Standard Deviations
$\ln GDP_{it}$	1.789 ***	0.348	1.597 ***	0.238	1.865 ***	0.397
$\ln GDP_{jt}$	−0.002	0.130	−0.350 **	0.145	0.512	0.339
$\ln POP_{it}$	−2.306 ***	0.383	−6.232 ***	1.251	−4.261 **	2.090
$\ln POP_{jt}$	0.986 ***	0.168	2.774 **	1.075	1.010	1.101
$\ln Dist_{ij}$	−0.503 *	0.265	−2.217 **	1.116		
$\ln TRI_{jt}$	−0.553	0.424	−0.031	0.031	−0.617	0.443
$\ln ER_{ijt}$	−0.297 ***	0.063	−0.213 **	0.087	−0.524 ***	0.117
TA_{ijt}	0.255	0.280	0.537 **	0.216	0.394	0.302
Constant	0.654	7.491	2.724 ***	0.613	2.408	4.868
γ	0.716 ***	0.059				
μ	2.451 ***	0.728				
η	0.002	0.007				
σ^2	5.445 **	1.119				
Observation	1159		1159		1159	
Log-likelihood	−1866.086 ***					
Hausman test					14.63 **	
R^2			0.950		0.330	

Notes: *, ** and *** denotes significant level at 10%, 5% and 1%, respectively. Country and time-fixed effects have been included in the model.

The regression result shows that the gravity variable has a significant relationship and is consistent with the theory. Palm oil exports are positively influenced by the income of exporting countries, as a higher exporter's income increases the production capacity, thus leading to higher export. The exporter's and importers' populations also show a significant impact in influencing palm oil exports. A high population in the exporting country will cause domestic demand to increase, which will affect exports. In contrast, an increment in the importers' population increases the demand for palm oil to meet the needs of the food supply in the country.

In terms of transportation cost, which is measured by the bilateral distance variable, the negative and significant relationship indicates that the further the distance between exporting nations to importing nations, the higher the cost to be borne by the importing country, and thus have lower export. The exchange rate has also negatively and significantly affected world palm oil exports. Rising exchange rates cause the prices of export goods to become relatively more expensive, affecting bilateral exports. This study also found that trade restrictiveness indices and TA have no significant impact. From a positive perspective, this means that higher trade restrictions do not affect established palm oil trade between nations as there are trade agreements imposed, but theoretically, it can still distort the chances for exporting countries to enter a new market.

Next, this study proceeds to calculate the technical efficiency (TE) based on the stochastic frontier model (SFM) for palm oil exports with trading partners and presented in Tables 4 and 5 for Malaysia and Indonesia, respectively. The reported TE are the average values for the entire sample from 2009 to 2019. Overall, it can be seen that neither Malaysia nor Indonesia has 100 per cent technical efficiency. This indicates that Malaysia and Indonesia have yet to export with the selected trading partners at the maximum capacity with the chosen determinants in the stochastic frontier gravity model. This may be due to the multilateral trade resistance (MTR) that is usually unobservable or tough to compute, and it can lead to inefficiency in export performance [49].

Table 4. Malaysia Palm Oil Export Technical Efficiency (%).

Importing Country	TE (%)	Importing Country	TE (%)
Benin	73.3	Colombia	7.1
Netherland	71.6	Belgium	6.5
Vietnam	67.8	Canada	6.4
South Korea	48.8	Jordan	6.3
Lebanon	37.2	Spain	6.2
United Arab Emirates	36.2	China	5.5
Pakistan	27.8	Russia	4.8
Denmark	24.6	Germany	4.7
Sri Lanka	24.2	Greece	4.5
Cameroon	23.7	Switzerland	4.0
Ireland	22.2	Algeria	4.0
Singapore	22.2	Kazakhstan	3.8
Japan	22.1	Hong Kong	3.7
Togo	19.9	Cote d'Ivoire	3.2
Senegal	18.4	Morocco	3.2
Niger	16.5	Qatar	2.9
Mauritius	15.8	United Kingdom	2.8
Sweden	15.7	Nigeria	2.1
Saudi Arabia	12.6	Nepal	1.8
Ethiopia	11.5	Tunisia	1.8
Turkey	11.0	France	1.7
Oman	10.4	Israel	1.2
New Zealand	10.2	Chile	1.1
Ghana	10.1	Myanmar	0.9
Italy	9.6	Mexico	0.8
India	8.5	Peru	0.7
Australia	8.4	Philippines	0.6
Kuwait	8.4	Brazil	0.3
Bahrain	8.0	Thailand	0.1
United States	7.8		

For Malaysia, only three trading partners with TE exceed 50 per cent, namely Benin (73.3 per cent), Netherlands (71.6 per cent) and Vietnam (67.8 per cent). This can be explained by the high palm oil consumption in these countries. On the other hand, there are five countries with TE of less than 1 per cent, namely Myanmar, Mexico, Peru, Philippines and Brazil. For these countries, palm oil consumption shares are still relatively low. This shows that there is higher export potential in these countries. Meanwhile, in the case of Indonesia, Netherlands (85 per cent), United Arab Emirates (68.5 per cent), Vietnam (55.6 per cent), Italy (55.1 per cent) and Spain (54.0 per cent) are trading partners with TE more than 50 per cent, while Thailand, Bahrain and Kuwait are among the countries with low TE values. Similarly, the estimated results for Indonesia also show opportunities and potentials that can be explored further to increase exports to these countries.

In addition, this study found that Malaysia and Indonesia have huge differences in the technical efficiency of each trading partner, except the Netherlands, where palm oil exports from Malaysia and Indonesia account for 71 per cent and 85 per cent, respectively.

On the other hand, Indonesia has a high TE in Spain (54 per cent) and Italy (55.1 per cent), while Malaysia's TE in the same country only recorded 6.2 per cent and 9.6 per cent. Hence, the huge gap proves that Malaysia's ability to export palm oil is still behind its main competitor, Indonesia.

Table 5. Indonesia Palm Oil Export Technical Efficiency (%).

Importing Country	TE (%)	Importing Country	TE (%)
Netherland	85.0	Jordan	7.0
United Arab Emirates	68.5	Togo	6.7
Vietnam	55.6	Japan	6.0
Italy	55.1	Sweden	5.7
Spain	54.0	Brazil	5.5
Oman	49.1	France	4.9
India	43.6	Myanmar	4.7
Russia	41.5	United Kingdom	4.6
Pakistan	40.7	Lebanon	4.6
Denmark	38.8	Israel	4.4
Algeria	28.3	United States	4.0
Senegal	27.8	Colombia	3.9
Saudi Arabia	27.3	Morocco	3.6
Tunisia	27.3	Niger	2.8
Nepal	23.0	Peru	1.9
Greece	19.1	Philippines	1.8
Singapore	18.8	Kazakhstan	1.6
South Korea	18.1	Switzerland	1.4
Mauritius	17.7	Canada	0.7
Benin	16.5	Hong Kong	0.6
Cote d'Ivoire	15.8	Ireland	0.6
Germany	15.3	New Zealand	0.4
Ethiopia	12.5	Australia	0.2
Cameroon	11.7	Chile	0.2
Belgium	9.9	Qatar	0.2
China	9.9	Thailand	0.2
Turkey	9.3	Bahrain	0.1
Ghana	8.4	Kuwait	0.1
Sri Lanka	7.5	Mexico	0.1
Nigeria	7.4		

The explanations provided earlier can also be supported by Figure 2, where on average, the value of TE for Indonesia is higher than in Malaysia throughout the year. However, it can be seen that TE for Malaysia has a growing trend. On the other hand, Indonesia has had a declining trend since 2015. This indicates that the existing measures and policies taken by policymakers in Malaysia positively impact palm oil exports. However, it is still not sufficient, as the TE gap between Malaysia and Indonesia is still huge. This highlights the need for policy interventions to ensure that exporters in Malaysia can compete in the international market and further increase their market shares.

The estimated export potential and export gap based on the stochastic frontier gravity model are reported in Table 6 for Malaysia and Table 7 for Indonesia. The export gap is the difference between potential exports and actual exports. The results presented in the table are the average values for the years 2009 to 2019. Overall, both tables show that there is still considerable potential for palm oil exports. From Table 6, we can see that among the countries with large export gaps are China, India, Thailand, America and the Philippines. Their high populations and incomes most likely contribute to this as it is among the factors that affect the demand for palm oil. In addition, the high consumption of substitute oils such as soybean oil (America, China, Thailand), mustard seed oil (India) and coconut oil (Philippines) in some countries resulted in a higher export gap. Thus, Malaysia has the opportunity to increase its market share by exporting more palm oil to these countries.

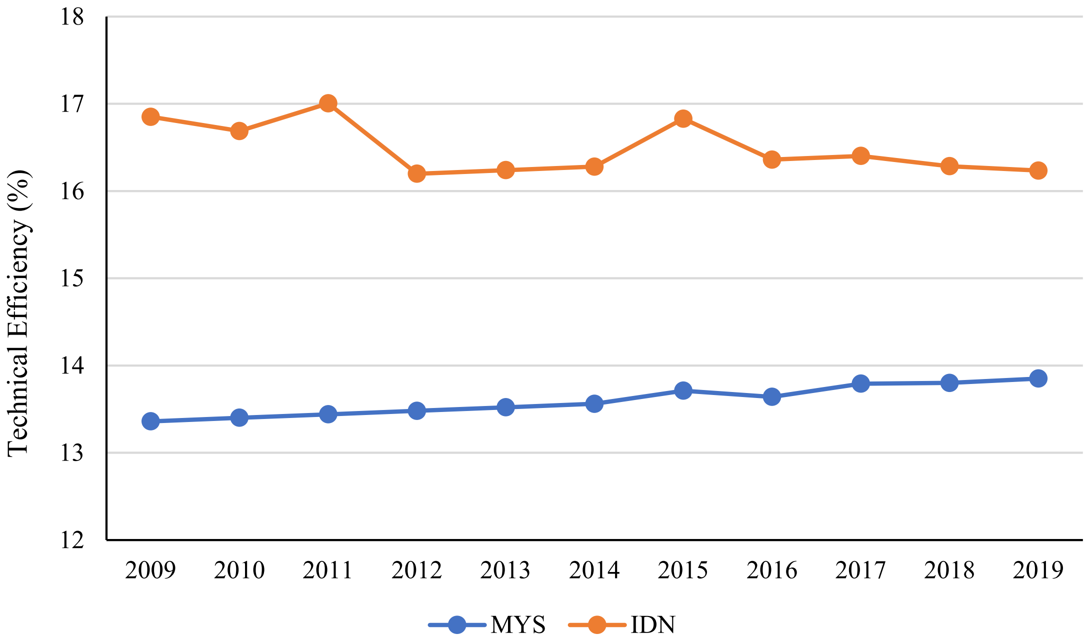

Figure 2. Average Technical Efficiency for Malaysia and Indonesia.

Table 6. Malaysia Palm Oil Export Potential and Export Gap, average million USD (2009–2019).

Importing Country	Current Export	Export Potential	Export Gap	Importing Country	Current Export	Export Potential	Export Gap
China	2500.8	45,469.5	−42,968.6	Cote d'Ivoire	12.1	378.8	−366.6
India	1731.9	20,375.4	−18,643.5	Oman	41.9	402.5	−360.6
Thailand	10.0	9960.0	−9950.0	Algeria	15.0	374.8	−359.8
United States	698.8	8959.1	−8260.3	Israel	4.3	361.7	−357.3
Philippines	27.5	4583.3	−4555.8	Jordan	23.7	376.0	−352.3
Nigeria	96.0	4569.1	−4473.1	Sweden	61.8	393.6	−331.8
Brazil	10.9	3620.0	−3609.1	Netherland	714.8	998.3	−283.5
Myanmar	28.1	3116.7	−3088.6	Switzerland	11.2	279.5	−268.3
Germany	134.4	2858.7	−2724.4	Hong Kong	10.2	275.4	−265.2
Pakistan	996.4	3584.1	−2587.8	South Korea	224.2	459.4	−235.2
France	40.3	2371.8	−2331.4	Sri Lanka	74.4	307.5	−233.1
United Kingdom	61.2	2186.1	−2124.9	United Arab Emirates	124.2	343.0	−218.8
Turkey	259.8	2362.0	−2102.2	Kuwait	18.0	213.7	−195.7
Russia	104.7	2180.8	−2076.2	Kazakhstan	7.6	200.3	−192.7
Italy	219.5	2286.5	−2067.0	Vietnam	397.7	586.5	−188.9
Mexico	14.2	1775.0	−1760.8	New Zealand	20.1	196.8	−176.7
Spain	111.1	1791.3	−1680.2	Colombia	13.2	185.5	−172.3
Japan	460.7	2084.6	−1623.9	Denmark	55.5	225.8	−170.2
Ethiopia	169.1	1470.2	−1301.1	Ireland	40.2	181.0	−140.8
Australia	95.1	1131.8	−1036.7	Chile	1.6	141.8	−140.3
Singapore	292.2	1316.0	−1023.9	Cameroon	34.6	146.2	−111.5
Canada	61.4	959.4	−898.0	Niger	16.6	100.8	−84.2
Peru	6.3	902.9	−896.5	Bahrain	6.3	78.3	−72.0
Saudi Arabia	128.1	1016.8	−888.6	Qatar	2.1	72.4	−70.3
Ghana	78.2	774.7	−696.4	Senegal	12.9	70.2	−57.3
Tunisia	9.7	536.7	−527.0	Togo	8.6	43.2	−34.6
Morocco	16.9	528.4	−511.5	Benin	56.5	77.1	−20.6
Greece	22.0	488.4	−466.5	Mauritius	3.5	22.3	−18.8
Nepal	8.1	452.2	−444.1	Lebanon	10.8	29.0	−18.2
Belgium	28.3	434.9	−406.7				

Table 7 shows Indonesia's potential and export gap, where China, Mexico, Thailand, the United States, and India have the highest export gap. Similar to Malaysia, the high gap in these trading partners may be influenced by population factors, national income and high consumption of substitute oils. If comparing Malaysia and Indonesia, it can be observed that the export gap for Malaysia is three times larger than for Indonesia. The country that contributed to the significant difference in this export gap was India, where the export gap for Malaysia was USD 18.6 billion, while Indonesia was USD 5.4 billion. This is also supported by a report released by MPOC [50], where the reduction in the total intake of Malaysian palm oil by India is because they take higher palm oil from Indonesia.

Table 7. Indonesia Palm Oil Export Potential and Export Gap, average million USD (2009–2019).

Importing Country	Current Export	Export Potential	Export Gap	Importing Country	Current Export	Export Potential	Export Gap
China	2087.4	21,084.9	−18,997.5	Belgium	25.0	252.6	−227.6
Mexico	13.9	13,870.0	−13,856.1	Sri Lanka	17.8	236.8	−219.0
Thailand	15.8	7900.0	−7884.2	Sweden	13.0	227.9	−214.9
United States	268.2	6705.8	−6437.5	Jordan	14.4	205.9	−191.5
India	4193.1	9617.2	−5424.1	Greece	43.2	225.9	−182.8
Brazil	120.1	2183.8	−2063.7	Switzerland	2.5	181.4	−178.9
Canada	11.9	1701.4	−1689.5	Kuwait	0.2	170.0	−169.8
Turkey	150.9	1622.4	−1471.5	Cote d'Ivoire	30.2	191.1	−160.9
Philippines	26.8	1489.4	−1462.6	Nepal	44.9	195.2	−150.3
Germany	257.0	1679.8	−1422.8	Netherland	745.1	876.5	−131.5
Myanmar	62.6	1332.8	−1270.1	Hong Kong	0.8	128.3	−127.6
Pakistan	840.7	2065.6	−1224.9	Algeria	50.0	176.7	−126.7
Ethiopia	166.8	1334.7	−1167.9	Tunisia	44.2	162.0	−117.8
United Kingdom	54.7	1189.4	−1134.6	Togo	8.4	125.2	−116.8
Japan	71.4	1189.2	−1117.8	Israel	4.9	110.2	−105.4
France	57.4	1172.0	−1114.6	Kazakhstan	1.6	102.5	−100.9
Nigeria	67.4	911.4	−843.9	Oman	93.5	190.4	−96.9
Peru	12.6	665.3	−652.6	Vietnam	119.6	215.0	−95.5
Australia	1.3	635.0	−633.7	New Zealand	0.3	82.5	−82.2
Russia	439.7	1059.5	−619.8	Denmark	45.5	117.2	−71.7
Italy	732.2	1328.8	−596.6	Cameroon	7.9	67.5	−59.6
Singapore	135.0	717.9	−582.9	United Arab Emirates	129.2	188.6	−59.4
Chile	1.0	510.0	−509.0	Niger	1.5	54.3	−52.8
Spain	555.7	1029.0	−473.3	Benin	7.9	48.1	−40.1
Ghana	40.3	479.3	−439.0	Bahrain	0.0	30.0	−30.0
Saudi Arabia	146.9	538.2	−391.3	Senegal	10.2	36.7	−26.5
South Korea	69.8	385.4	−315.7	Lebanon	1.3	27.6	−26.3
Ireland	1.9	315.0	−313.1	Qatar	0.1	25.0	−25.0
Colombia	11.2	287.7	−276.5	Mauritius	2.6	14.4	−11.9
Morocco	9.7	269.4	−259.7				

4. Conclusions

This study identifies the level of export technical efficiency and analyses world palm oil export potential. The domestic consumption in the ten major importing countries is still low for palm oil, especially in countries with large populations, such as China, India and European Union countries. One of the reasons for the low consumption is the problem of technical inefficiency in exporting certain goods [11–13]. If this problem can be overcome, the potential for world palm oil exports will be enhanced. Therefore, using panel data for 59 major palm oil importing countries from 2009 to 2019, this study uses a stochastic frontier model (SFM) to determine the technical efficiency and export potential for palm oil.

The main findings from the study can be summarised as follows. First, this study proves the existence of inefficiencies in world palm oil exports. This is also supported by the technical efficiency (TE) values calculated through this SFM model. Overall, it can be seen that no country shows 100 per cent technical efficiency. This indicates that Malaysia and Indonesia have yet to export to the maximum level with their trading partners with the determinants or factors set in the stochastic frontier gravity model. The results also indicate that there are opportunities and potential that can be explored to increase trade with these countries. These findings are consistent with those of Devadason and Mubarik [7] as they found low palm oil export efficiency for Southeast Asia and Latin America Regions. Second, it can be seen that Malaysia and Indonesia dominate different markets from each other, except in the Netherlands. For Malaysia, the three main countries with high TE values are Benin, the Netherlands and Vietnam. Meanwhile, the top three countries are the Netherlands, the United Arab Emirates, and Vietnam, for Indonesia. Third, the study also found a very large gap between Malaysia and Indonesia because the average TE value for Indonesia is higher than for Malaysia throughout the year. This proves that Malaysia's ability to export palm oil is still behind its main competitor, Indonesia. Lastly, Malaysia and Indonesia have great potential to expand their palm oil export to China, India, Thailand and the United States.

This study had a few limitations that can be considered for improvement in future studies. First, the analysis of technical efficiency in this study uses only gravity and TRI model factors. Other variables can be taken into account to determine the level of export efficiencies, such as the price and use of other vegetable oils. Future research that evaluates palm oil export efficiency should try to consider the current domestic consumption of vegetable oil. Although it is not doable at the moment due to data limitations, with a better dataset in the future, the values for export potential obtained and policy targets will be clearer if it is based on domestic consumption. In addition, the export efficiency value calculated in this study is also an average value because the value variation cannot be determined. After all, it only uses annual data for 11 years (2009–2018). If the data span can be extended, the variation of efficiency values can be analysed more deeply and can be compared before and after the crisis faced by the sample of selected countries.

Several policy implications can emerge from this study. First, policymakers from both countries should set up a new combined strategy to maximise the palm oil export to its trading partners. Low values of TE in several importing countries show the market potential that can be explored further. Second, although our findings show that exchange rate depreciation can lead to higher exports, policymakers need to intervene in exchange rate variation so that the cost of imported inputs for the palm oil industry can be stabilised. Lastly, this study also shows that Malaysia and Indonesia have the potential to expand their palm oil exports in the same market, namely China, India and the United States. This market has great potential because it has a high population that can benefit palm oil exports. Therefore, the two major exporters of palm oil in the world need to further promote the use of palm oil among consumers in those countries. In addition, policymakers also need to improve existing policies with the country so that good and stable political relations can be maintained to help palm oil exports capture those markets.

Author Contributions: H.N.A.H. carried out the experiment and wrote and revised the manuscript with support from N.K., Z.A.K. and M.R.K.V.Z. The central idea of this research is given by Z.A.K. and H.N.A.H. and the earliest manuscript is verified by N.K. and M.R.K.V.Z., N.K., Z.A.K. and M.R.K.V.Z. have also verified the analytical method and the interpretation of the results of this article. The revised version of this article is supervised by Z.A.K. as a correspondence author. All authors have contributed significantly from the earlier draft until the final stage of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: The authors thankfully acknowledge the financial support from the MPOB-UKM Endowment Chair research grant (Project Code: MPOB-UKM-2021-013) for the research project entitled 'Competitiveness and Export Potential of Palm Oil in Malaysia and Indonesia'.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on the UN Comtrade online database, World Bank online database, Hamidi (2022), and Macmap (2020).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of Importing Countries.

Country	ISO3	Country	ISO3
Algeria	DZA	Mexico	MEX
Australia	AUS	Morocco	MAR
Bahrain	BHR	Myanmar	MMR
Belgium	BEL	Nepal	NPL
Benin	BEN	Netherland	NLD
Brazil	BRA	New Zealand	NZL
Cameroon	CMR	Niger	NER
Canada	CAN	Nigeria	NGA
Chile	CHL	Oman	OMN
China	CHN	Pakistan	PAK
Colombia	COL	Peru	PER
Cote d'Ivoire	CIV	Philippines	PHL
Denmark	DNK	Qatar	QAT
Ethiopia	ETH	Russia	RUS
France	FRA	Saudi Arabia	SAU
Germany	DEU	Senegal	SEN
Ghana	GHA	Singapore	SGP
Greece	GRC	Spain	ESP
Hong Kong	HKG	Sri Lanka	LKA
India	IND	Sweden	SWE
Ireland	IRL	Switzerland	CHE
Israel	ISR	Thailand	THA
Italy	ITA	Togo	TGO
Japan	JPN	Tunisia	TUN
Jordan	JOR	Turkey	TUR
Kazakhstan	KAZ	United Arab Emirates	ARE
South Korea	KOR	United Kingdom	GBR
Kuwait	KWT	United States	USA
Lebanon	LBN	Vietnam	VNM
Mauritius	MUS		

Table A2. Trade Agreements for Malaysia.

Agreement	Starting Year
AANZFTA	2010
Armenia for Developing Countries	2015
Belarus (EAEU) for Developing Countries	2016
CECA, ASEAN–Korea	2007
CECA, India–Malaysia	2011
CEPA, Malaysia–Pakistan	2008
EPA, ASEAN–Japan	2009
EPA, Japan–Malaysia	2006
FTA, ASEAN–China	2005
FTA, ASEAN–Hong Kong	2019
FTA, ASEAN–India	2010
FTA, Australia–Malaysia	2013
FTA, Chile–Malaysia	2012
FTA, Malaysia–New Zealand (MNZFTA)	2010
FTA, Malaysia–Turkey (MTFTA)	2015
Group of Eight (D8)	2016
Kazakhstan (EAEU) for Developing Countries	2016
Kyrgyzstan for Developing Countries	2015
Russian Federation (EAEU) for Developing Countries	2016

Sourcer: Macmap (2020).

Table A3. Trade Agreements for Indonesia.

Agreement	Starting Year
AANZFTA	2012
Armenia for Developing Countries	2015
Belarus (EAEU) for Developing Countries	2016
CECA, ASEAN–Korea	2007
EPA, ASEAN–Japan	2018
EPA, Indonesia–Japan	2008
FTA, ASEAN–China	2005
FTA, ASEAN–India	2010
FTA, Chile–Indonesia	2019
Group of Eight (D8)	2016
GSTP	2004
Kazakhstan (EAEU) for Developing Countries	2016
Kyrgyzstan for Developing Countries	2015
PTA, Indonesia–Pakistan	2013
Russian Federation (EAEU) for Developing Countries	2016
Turkey for GSP countries	2002

Source: Macmap (2020).

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