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Determinants of Malaysian palm oil export efficiency: A gravity stochastic frontier model

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Abstract

Palm oil export is one of the significant contributors to the Malaysian economy. The country's palm oil export is affected by international market uncertainties. This study examines the determinants of Malaysian palm oil export efficiency from 2000 to 2020. The Gravity Stochastic Frontier Model (GSFM) findings show that importing countries' GDP and foreign exchange rates positively affect Malaysian palm oil export. In contrast, distance has a negative impact on palm oil export. The study also found that technical efficiency increased from 2000 to 2020. Meanwhile, the average export efficiency score was high except for the US. This study enriches the agricultural literature, especially concerning palm oil export in Malaysia. Thus, the findings enlighten the industry and policymakers in formulating policies that can improve palm oil export and its competitiveness at the global level.

Keywords: Efficiency, exchange rate, export, Gravity Stochastic Frontier Model, Malaysia, palm oil

Introduction

Palm oil is known for its advantages, such as high oil production yield, lower cost, and stability at high temperatures (Zamri et al., 2018), and requires a smaller land area than other vegetable oil cultivation (MPOC, 2022). Palm oil production can reach about 3.35 tons per hectare compared to sesame oil (0.76), rapeseed oil (0.74), and soybean oil (0.45) (MPOC, 2022). In addition, palm oil has multi-purposes, such as food products, biodiesel, cosmetics and pharmaceuticals (MPOC, 2022). In Malaysia, palm oil is the highest-producing commodity and is one of the major contributing sectors to the national economy (DSOM, 2021). The palm oil industry has dominated the country’s agricultural sector trade with 25.8% to production and 34.3% to world palm oil export by 2020 (DOSM, 2021). The country’s major palm oil export destinations are India, China, Pakistan, the Netherlands, and the US (DOSM, 2021). The industry is expected to remain relevant, given the global demand for oils and fats (MPOC, 2020).

The palm oil industry faces the challenges of global market volatility. For example, export trade politics between China and the US could cause influence the demand for soybean oil and palm oil. Moreover, the increased supply of rapeseed vegetable oil in India and domestic commodity protection policies in other countries, such as grape seed oil and sunflower oil, could affect palm oil export (Devadason & Mubarik, 2021). Meanwhile, global palm oil demand was also affected by the European Union’s palm oil boycott campaign and sustainable development issues related to environmental damage, such as deforestation, greenhouse gas emissions and wastewater pollution (Norhidayu et al., 2017). Recently, the contagion implications of COVID-19 infection have also restricted global palm oil export, partly due to fewer working hours and a downward trend in global demand (MPOB, 2020). Based on MPOB data for the first half of 2020, Malaysia has recorded a decline in production of 5.8%.

The trade theory argues that national diversification and market uncertainties such as national income, foreign exchange rates, prices of substitute goods, distance and competition can cause inefficiencies in realising export potential (Abdullahi et al., 2021; Atif et al., 2017). There is demand (external factors from importing countries) and supply factors (internal factors from exporting countries) that have a deterrent effect on a country's export potential (Funke & Holly, 1992; Guloglu & Pay, 2016). Thus, the palm oil industry needs to improve export efficiency to increase its competitiveness and trade potential at the international level. Export efficiency is a comparative advantage and a critical component of risk management in ensuring sustainable growth in the long run. Increased efficiency will result in improved cost management, output quality, technology, human resources, and capital, ultimately increasing productivity (Ismail et al., 2017).

Previous palm oil studies focused on Southeast Asian countries such as Indonesia, Malaysia, and Thailand. Palm oil performance trends are primarily documented (Ezechi & Young, 2019; Kushairi et al., 2017; Norhidayu et al., 2017; Zamri et al., 2018), but research on efficiency is minimal. Existing studies focused on technical efficiency (TE) (Azman et al., 2014; Ismiasih, 2018; Juyjaeng et al., 2018; Puruhito, 2019; Riffin, 2017) and total frontier production (TFP) (Ismail et al., 2017; Afzal et al., 2018; Jelita et al., 2020) to measure the productivity of farmers and manufacturers. Meanwhile, studies on export determinants were documented in different sectors, such as textiles (Dhiman et al., 2020; Fahmy-Abdullah et al., 2018; Ho et al., 2020; Rahman et al., 2019), manufacturing (Basarac Sertić et al., 2015; Pay et al., 2015), energy (Bashir et al., 2020; Hu & Xu, 2022; Kazemzadeh et al., 2022), chemicals (Atif et al., 2019), environment (Wang et al., 2020; Yang & Li, 2019), and livestock (Tikhomirov & Fomin, 2018). In comparison, the study of agricultural export is related to cocoa (Abdullahi et al., 2021), rice (Kea et al., 2019), rubber (Mohamad & Zainuddin, 2021), and the aggregate agricultural sector (Meyers al., 2018; Atif et al., 2017). However, studies related to palm oil export are limited.

Closest to this study, Devadason and Mubarik (2021) compared the integration of palm oil export and palm-based products between Southeast Asia and Latin America. While Lugo Arias et al. (2020) analysed the long-run cointegration relationship between palm oil export, palm oil prices, and foreign exchange rates for 26 countries. However, they did not examine palm oil export from the aspect of efficiency and its determinants. Thus, this study aims to identify the determinants of Malaysian palm oil export efficiency from 2000 to 2020. Furthermore, it focuses on Malaysian palm oil export to major trading partners, namely China, Pakistan, India, the Netherlands, and the US. The findings will contribute to the literature related to agriculture in the context of Malaysia using the GSFM model. The gravity model is an increasingly adopted analytical technique in trade-related research because of its advantages in predicting trade flows between countries (Westerlund & Wilhelmsson, 2011). In addition, applying stochastic frontier parametric techniques also has the advantage of producing unbiased estimates in the presence of measurement errors and stochastic disturbances (Ruggiero, 2007). The findings will provide relevant information to policymakers and address the need to promote the efficiency and productivity of the industry in realising the long-term growth of the palm oil sector in Malaysia.

Literature review

The trade literature examining the factors influencing export can be viewed from the perspective of demand and supply. Senhadji and Montenegro (1999) found that demand factors such as income and price influence export for 53 industries in developing countries. Meanwhile, supply factors such as labour, production, subsidies and taxes at the industrial and aggregate levels were also found to significantly influence export (Togan, 1993; Rodriguez & Samy, 2003; Edwards & Golub, 2004). Thus, Funke and Holly (1992) concluded that a robust export determinant model needs to consider both demand and supply factors. It is vital to avoid the problem of missing relevant variables (Guloglu & Pay, 2016). Accordingly, many studies incorporate demand and supply factors in their export determinants model in textiles (Dhiman et al., 2020; Fahmy-Abdullah et al., 2018; Ho et al., 2020; Rahman et al., 2019), manufacturing (Basarac Sertić et al., 2015; Pay et al., 2015), energy (Bashir et al., 2020; Hu & Xu, 2022; Kazemzadeh et al., 2022), chemicals (Atif et al., 2019), environment (Wang et al., 2020; Yang & Li, 2019), and livestock (Tikhomirov & Fomin, 2018).

Specifically for the agricultural and plantation industries, Atif et al. (2017) used GSFM to identify determinants of Pakistan's agricultural export to 63 major trading partners (1995-2014). The findings show that Pakistan's GDP and importing countries, foreign exchange rates, regional trade agreements, and shared borders positively impact Pakistan's agricultural export. In contrast, geographical distance and tariff have a negative impact. However, the similarity of communication languages did not affect Pakistan's agricultural export. Abdullahi et al. (2021) found that Nigeria's cocoa export are positively influenced by GDP, foreign exchange policy, World Trade Organization (WTO), European Union, and common colonial countries. In comparison, it is negatively influenced by GDP per capita, distance, landlocked countries, Australia, and the Economic Community of West Africa countries (ECOWAS).

Kea et al. (2019) showed that Cambodian rice export positively correlate with the inter-country relations history, foreign exchange policy, and land area. Mohamad and Zainuddin (2021) show that bilateral export of natural rubber to Thailand, Indonesia, Vietnam, and Malaysia have a positive relationship with non-tariff restrictions. Export of natural rubber increased after implementing the "Belt and Road Initiatives" (BRI). In Ukraine, Meyers al. (2018) evidenced that the inefficiency of agricultural export is due to the high dependence on main export commodities and foreign markets volatility. They suggested that Ukraine could diversify the export markets structure such as milk and dairy products, eggs, meat, vegetables and fruits.

Most palm oil efficiency research have focused on the productivity aspects of farmers and manufacturers. In Indonesia, Euler et al. (2016) found that important factors of smallholder palm oil production in Sumatra are fertiliser cost, harvest interval period and plant damage. Rifin (2017) found that domestic vs export-oriented ownership, location and business are essential variables to explain efficiency. In particular, palm oil mills owned by national private companies are the most efficient, followed by foreign and government-owned companies. Palm oil mills in Kalimantan are more efficient than in other islands, and locally-oriented mills are more efficient than export-oriented ones. Similarly, Jelita et al. (2020) found that although most large palm oil mills are located in Sumatra, more efficient palm oil mills are found in Kalimantan. The foreign-owned private sector was more efficient than the privately-owned and state-owned factories. Also, it shows that TFP growth is negative and minimally influenced by technological change.

Ismiasih (2018) evidenced that TE farmers in West Kalimantan are influenced by the number of productive trees, tree age, fertiliser, labour and artificial pesticides. The causes of inefficiency are a percentage of own capital, cooperative membership, and contract farm membership. In the case of the North Mamuju District case, Puruhito et al. (2019) found that soil, fertiliser use, non-family labour, tree age, and farm distance to the river positively affected TE, while farm sanitation frequency decreased TE. In contrast, the causes of inefficiency are experience, household income, age and differences in plasma patterns. Apriyanti (2019) found that the productivity of producers and producers in Sumatra, Indonesia, is influenced by the maturity age of palm oil trees, labour, fertiliser and farm area.

In comparison, the productivity function of palm oil in the Jambi district produces low technical efficiency (Saidin et al., 2019). It also shows that technical efficiency is highly responsive to soil area, the number of trees, and urea fertiliser. Juyjaeng et al. (2018) studied TE and the factors influencing TE of palm oil production between the member and non-member farmers under the Large Agricultural Plot Scheme (LAPS) in Bang Saphan Noi district, Thailand. The findings indicate that LAPS member farmers have higher TE than non-members. It also shows that farmers ’experience and age positively correlate with TE.

Azman (2014) evaluated TE for large and small palm oil mills in Malaysia and compared TE between integrated and non -integrated mills in the country. He found that large factories with a production capacity of more than 20t/h were more efficient than small factories, and integrated factories were more efficient than non -integrated factories. Norhidayu et al. (2017) analysed crude palm oil (CPO) production in Malaysia based on Cobb Douglass's theory. The findings show that increased labour, capital and consumption rates lead to higher CPO production. Ismail et al. (2017) studied the impact of TFP growth on the output growth of the palm oil industry in Malaysia from 2000 to 2012. They used the Malmquist index based on the DEA procedure to measure TFP. The findings show that TFP growth has a positive relationship with output growth, and its impact is higher in non-food-based industries compared to food-based industries. Next, Foong et al. (2018) analysed the operating performance of palm oil mills through an input-output optimisation model. They performed a feasible operating range analysis (FORA) to explore the usability and feasibility of the process and found that capital costs were reduced by 37% and economic performance increased by 49%. The plant consumption index increased from 0.48 to 0.76 during the peak season.

However, to the author's knowledge, there are still no studies that attempt to explore the determinants and performance of palm oil export efficiency, particularly in Malaysia. Devadason and Mubarik (2021) compared the export efficiency of palm oil and palm-based products between the integration of Southeast Asian and Latin American countries. The findings evidenced that the level of trade efficiency is relatively low. Lugo Arias et al. (2020) found that the foreign exchange rate has a positive relationship with the competitiveness of palm oil export and a negative association with palm oil prices for 26 selected countries. Thus, this study is conducted to fill the gap of previous studies by offering empirical evidence on the determinants of palm oil export and the efficiency of palm oil export in Malaysia.

Data and methodology

Analysis approach

The study applied the Gravity Stochastic Frontier Model (GSFM) introduced by Kalirajan (2000) to address the inherent bias in the conventional gravity model of trade and estimate the performance (efficiency) of trade flows. The gravity model is a widely adopted estimation model for studying the determinants of trade between countries. However, there are weaknesses in the approximate gravity model. Export or import values are usually taken as sample averages rather than optimal values feasible for trading countries. It might be problematic in approximate gravity models involving the presence of highly divergent sample values (Ravishankar & Stack, 2014). Therefore, the SFA method stands better in estimating the gravity model. Kalirajan (2007) introduced the stochastic frontier method in the gravity equation proposed by Aigner, Lovell, and Schmidt (1977) to describe variations in trade between trading partners. The trade boundary estimated through this approach gives freedom in taking the optimal level of trade between countries in the analysis. The model's positive or negative error terms affect these bilateral trade limits. It allows the randomly generated trading frontier to vary according to the specific part that determines the gravity model. Then the observed magnitude of trade can be compared with the forecast value of the border of trading partner countries to analyze the maximum trade capacity. The equation of the GSFM model is as follows;

$$lnX_{ijt} = lnf(Y_{ijt}, \beta)exp^{(V_{ijt}-U_{ijt})} \quad (1)$$

where X_{ijt} represents actual export from the country (i) to importing country (j). $f(Y_{ijt}, \beta)$ is the export determining function (Y_{ijt}), and β is a vector of unknown parameters. The error term U_{ijt} is the economic distance caused by the influence of trade restrictions of the importing country (Anderson, 1979). Economic distance is the difference between actual and potential export between two countries. The value of U_{ijt} ranges from 0 to 1, and U_{ijt} is assumed to be semi-normally distributed.

Measuring export performance (efficiency) is the same as measuring the firm's production performance. A firm is at its best when operating on the optimal production frontier. This situation shows that the firm achieves economic efficiency, known as technical efficiency (Kalirajan & Shand, 1999). Similarly, a country is said to achieve optimal export potential when it operates on the most efficient border. It means that export potential is achieved when there is less resistance to trade (Drysdale et al., 2000; Kalirajan, 2000; Armstrong & Kalirajan, 2008). This situation means the maximum possible export value can be achieved using the most open (most efficient) trade policy. Therefore, the determination of export performance (achieved economic export efficiency) with the ratio of actual export to export potential as the following equation;

$$TEX = \frac{f(Y_{ijt,}\beta)\ \exp(v_{ijt}-u_{ijt})}{f(T;\beta)\exp(v_{ijt)}} = \exp^{(-u_{ijt})} \quad (2)$$

The advantages of the GSFM analysis estimation method are as follows: First, the method can estimate factors affecting export and, at the same time, estimate export efficiency. Second, this method has two errors: sampling and inefficiency. The inefficiency error describes the gap between the optimal and actual export. It shows the extent to which export can be achieved due to the effects of trade constraints.

Data sources

This study uses annual panel data of five bilateral trading partners of Malaysian palm oil export from 2000 to 2020. The list of selected trading partner countries is based on their relative importance to Malaysian palm oil export. They are China, India, Pakistan, the Netherlands and the US. Aggregate data on palm oil export was taken from the Department of Statistics Malaysia (DOSM). Data on Malaysian Gross Domestic Product (GDP) and importing countries were from the World Bank. Indonesian export data and tariffs were obtained from the Datastream database. The country's two-way foreign exchange rate data was collected from Bank Negara Malaysia, while the distance data was from Globefeed's distance calculator.

This study adopted the function proposed by Drysdale et al. (2000) and Kalirajan and Finley (2005), GSFM, which can be rewritten as:

$$lnX_{mjt} = \beta_0 + \beta_1 lnGDP_{Mt} + \beta_2 lnGDP_{ji} + \beta_3 lnX_{\ Indon} + \beta_4 lnCPO_{\ Mal} + \beta_5 lnSoy + \beta_6 lnDis_j + \beta_7 lnTax_7 + \beta_8 lnXR_{\ j} + V_{ijt} - U_{ijt} \quad (3)$$

where X_{ijt} is the amount of Malaysian palm oil export (m) to trading partners (j) as the dependent variable. GDP_{Mt} is Malaysian GDP, and GDP_{ji} is the GDP of trading partners (j) as a proxy for a country's market size. Malaysian GDP reflects producer/exporter capacity, while importer GDP refers to foreign market earning capacity and demand for palm oil export. Abdullahi et al. (2021) and Atif et al. (2017) have included domestic and foreign economic size variables to distinguish supply and demand effects. It expects a positive relationship between the size of the economy and export.

X_{Indon} is CPO export from Indonesia as a proxy for competition. Malaysian CPO export are expected to have a negative relationship with Indonesian CPO export. The intense competition in international markets will reduce demand and export of local palm oil (Opoku et al., 2020) and indirectly cause local manufacturers to focus on the local market instead of looking for opportunities in overseas markets (Fung et al., 2008). $CPO_{\ Mal}$ is the Malaysian CPO price and is expected to have a negative relationship with export. Cost increases cause a decrease in demand. *Soy* is the price of soybean oil and is a proxy for substitute goods. The increase in soybean prices is expected to increase demand for palm oil because, relatively, the price of palm oil becomes cheaper. *Dis* is a distance that refers to transportation costs and is expected to be negatively related to export (Abdullahi et al., 2021; Atif et al., 2017). The longer the distance, the higher the cost, causing export to decrease. *Tax* is a tariff that also shows the cost of export, where the higher the tariff rate, the lower the export (Atif et al., 2017). *XR* refers to the bilateral foreign exchange rate between Ringgit Malaysia and the importing country. It is a proxy for international trade prices. Depreciation in the Malaysian Ringgit lowers the price of domestic goods in the international market, and it is expected to generate more export revenue due to increased demand (Abdullahi et al., 2021; Atif et al., 2017; Kea et al., 2019).

Results and discussion

Table 1 details the statistical summary of the model variables. Based on the average Malaysian palm oil export over the past 20 years, China has imported the most palm oil, followed by India, Pakistan, the Netherlands and the US. The relatively large standard deviation values for export to Malaysian five main trading partners indicate that global palm oil demand was volatile during the observation period. Likewise, the standard deviation for most other variables such as Malaysian GDP, GDP of importing countries (India and Pakistan), Indonesian palm oil export, CPO prices, soybean oil prices and bilateral foreign exchange of Malaysian Ringgit and Pakistani Rupee. It shows the high uncertainty in the global market, which has the potential to impact Malaysian palm oil demand.

Table 1. Descriptive statistics

Variables	Unit	Country	Mean	S.Dev	Minimum	Maximum
Malaysian CPO export	USD1000	China	1,452,051	963,183	276,813	3,572,871
		India	1,099,555	736,101	146,167	2,364,524
		Netherland	628,988	330,388	90,221	1,300,297
		Pakistan	731,834	493,256	266,285	1,988,864
		US	304,558	240,056	23,599	791,080
Malaysian GDP	USD	Malaysia	2.36e+11	9.55e+10	9.28e+10	3.65e+11
Importer's GDP	USD	China	6.94e+12	4.78e+12	1.21e+12	1.47e+13

		India	1.56e+12	8.04e+11	4.68e+11	2.87e+12
		Netherland	7.67e+11	1.66e+11	4.16e+11	9.48e+11
		Pakistan	1.90e+11	7.91e+10	7.95e+10	3.15e+11
		US	1.55e+13	3.49e+12	1.03e+13	2.14e+13
Indonesian CPO export	USD	Global	1.66e+07	8221799	4110027	2.89e+07
CPO price	USD per tan	Global	759.87	293.85	287.46	1367
Soybean oil price	USD per tan	Global	798.66	268.53	338.14	1297.66
Distance	KM	China	4348.05	0.00	4348.05	4348.05
		India	3839.16	0.00	3839.16	3839.16
		Netherland	8839.61	0.00	8839.61	8839.61
		Pakistan	4513.94	0.00	4513.94	4513.94
		US	15337.93	0.00	15337.93	15337.93
Tariff	%	Global	19.55	13.49	0.00	30.00
Exchange rate	MYR/CNY	China	0.52	0.07	0.45	0.66
	MYR /INR	India	15.39	3.21	10.87	20.54
	MYR/ANG	Netherland	4.48	0.47	3.37	5.17294
	MYR/PKPR	Pakistan	35.02	11.12	17.70	58.84
	MYR/USD	US	3.71	0.41	3.06	4.49

Table 2 shows the factors that affect Malaysian palm oil export efficiency using the GSFM model. The validity test of the model shows that the Wald chi-square value is 131.95, the Log-likelihood is -69.404279, and the P-value is 0.0000. Those values show that the model fits the existing data. Whereas the value of gamma (γ) is 0.203, the value of mu (μ) is not significant at 1%, which confirms that there is no inefficiency variable. The eta (η) value is statistically significant at the 1% level and has a positive coefficient. It explains the increase in export efficiency throughout the study.

The findings show that palm oil export efficiency is positively determined by the demand of trading partners (importer's GDP). A 1% increase in the income of importing countries leads to a 0.098% increase in palm oil export. The positive relationship between the GDP of importing countries and Malaysian palm oil export is in line with Atif et al. (2017). They claimed that the higher the demand, the higher the amount of merchandise exported. However, the study could not support Atif et al. (2017) and Abdullahi et al. (2021), which show the importance of supply factors. Malaysian GDP (supply capacity) was found to have no significant impact on palm oil export. It shows that the Malaysian palm oil industry is always relevant to continuously meet the global demand for palm oil without being affected by the domestic economy.

Distance shows a negative relationship with palm oil export efficiency. A 1% increase in the distance reduces palm oil export by 1.234%. This finding is in line with the hypothesis of the gravity model, which is that Malaysian palm oil export is inversely related to the distance between trading partners. It is also consistent with the findings of previous studies (Abdullahi et al., 2021; Atif et al., 2017), which show that the greater the distance between countries, the lower the export due to increased transport costs proportional to the distance (per km).

The exchange rate has a positive effect on palm oil export efficiency. The positive coefficient value should be read with caution as this study uses currency exchange terms from the Malaysian Ringgit to the importing country's currency. It shows that a 1% increase in the foreign exchange rate causes a 0.122% increase in palm oil export revenue. In other words, when the Ringgit is relatively weak, it causes export costs to become cheaper, which leads to an increase in palm oil export. It proves that Malaysian palm oil export demand is elastic, and the Ringgit's depreciation positively affects palm oil export results. This finding is in line with Abdullahi et al. (2021), Atif et al. (2017), and Kea et al. (2019).

Soybean oil prices, CPO prices, Indonesian export, and tariff do not affect Malaysian palm oil export efficiency. Fluctuations in alternative vegetable oil prices, such as soy, have not affected the global demand for Malaysian palm oil. This finding can be attributed to the advantages of palm oil compared to soybean oil, such as lower cost and stability at high temperatures (Zamri et al., 2018). Likewise, competition from the world's leading palm oil exporter (Indonesian CPO export) does not affect Malaysian palm oil demand. Perhaps regional trade agreements and good trade relations between Malaysia and its trading partners have supported the country's palm oil export growth. The uncertainty of CPO prices also has no implications for palm export, considering that Malaysia is the world's second-largest producer of palm oil (MPOC, 2022). This finding is also in line with the findings that prove that import tariff trade restrictions that cause an increase in CPO export prices have no impact on global palm oil demand.

Table 2. GSFM estimation for Malaysian palm oil export

Variable	Coefficient	Standard error	Z-value	P-value	[95% confidence level]	
GDP Malaysia	0.603	0.693	0.87	0.384	-0.755	1.961
GDP importer	0.098**	0.040	2.44	0.015	0.019	0.177
Distance	-1.234***	0.283	-4.36	0.000	-1.788	-0.679
Soybean oil price	0.867	0.655	1.32	0.186	-0.417	2.151
Indonesia export	-0.577	0.410	-1.41	0.160	-1.380	0.227
CPO	0.413	0.638	0.65	0.517	-0.837	1.664
Tariff	0.034	0.084	0.41	0.685	-0.131	0.199
Exchange rate	0.122*	0.066	1.85	0.064	-0.007	0.251
Constant	6.730	11.089	0.61	0.544	-15.005	28.464
mu	-3.893	21.511	-0.18	0.856	-46.054	38.268
eta	0.191	0.104	1.84	0.066	-0.013	0.394
lnsigma2	-1.372	1.193	-1.15	0.250	-3.710	0.965
ilgtgamma	-1.366	5.860	-0.23	0.816	-12.853	10.120
sigma2	0.254	0.302			0.024	2.626
gamma	0.203	0.949			0.000	1.000
sigma_u2	0.052	0.302			-0.540	0.643
sigma_v2	0.202	0.028			0.146	0.258
Wald chi-square			131.95			
Log-likelihood			-69.404279			
P-value			0.0000			

Notes: ***, ** refers to significance level at 1% and 5%, respectively

Table 3 shows the estimated technical efficiency (TE) of palm oil export for Malaysian main trading partners obtained from the GSFM model. TE scores were divided annually for trend comparison. Estimated TE scores prove that no country shows 100% technical efficiency. Malaysian palm oil export has more than 95% potential with its five main trading partners. On average, China has the highest TE, followed by Pakistan, the Netherlands, India, and the US. It shows that the country's palm oil industry has the potential to continue increasing export to those countries. The most notable example is palm oil export to the US, which has increased yearly export growth. The US has a significant trade potential for Malaysian palm oil export, which is 95.8% in 2020. Likewise, the TE of export to all major importing countries also shows improvement over time, and inefficiency in most countries is less than 1% to 5 % in 2020.

Table 3. Technical efficiency (TE) score of Malaysian palm oil export to importing countries

Year/ Country	China	India	Netherland	Pakistan	US
2000	0.859	0.733	0.773	0.792	0.147
2001	0.881	0.771	0.807	0.823	0.204
2002	0.900	0.805	0.836	0.850	0.268

2003	0.916	0.835	0.862	0.873	0.336
2004	0.930	0.861	0.883	0.894	0.406
2005	0.941	0.883	0.902	0.911	0.474
2006	0.951	0.902	0.918	0.925	0.539
2007	0.959	0.918	0.932	0.938	0.600
2008	0.966	0.931	0.943	0.948	0.655
2009	0.972	0.943	0.953	0.957	0.705
2010	0.977	0.952	0.961	0.964	0.749
2011	0.981	0.961	0.967	0.970	0.788
2012	0.984	0.967	0.973	0.975	0.821
2013	0.987	0.973	0.977	0.979	0.849
2014	0.989	0.977	0.981	0.983	0.874
2015	0.991	0.981	0.985	0.986	0.894
2016	0.992	0.985	0.987	0.988	0.912
2017	0.994	0.987	0.989	0.990	0.927
2018	0.995	0.989	0.991	0.992	0.939
2019	0.996	0.991	0.993	0.993	0.949
2020	0.996	0.993	0.994	0.995	0.958
Mean	0.960	0.921	0.934	0.939	0.667

Conclusion

Malaysia aims to increase the country's palm oil export as one of the 12 National Key Economic Areas (NKEA) to support the country's economic growth. In this regard, this study determines factors that influence Malaysian palm oil export efficiency from 2000 to 2020 using the GSFM approach. This study focuses on the main trading partners of Malaysian palm oil export: China, Pakistan, India, the Netherlands and the US. The findings show that palm oil export is positively affected by the importing country's GDP and foreign exchange rate and negatively by the distance factor. In contrast, Malaysian GDP, Indonesian CPO export, soybean prices, CPO prices and tariffs were found not to affect the country's palm oil export. The GSFM technique also measures export potential by estimating technical efficiency. It shows that the technical efficiency (TE) score of palm oil export to the five main importing countries increased from 2000 to 2020, with the average TE ranging from 67% to 96%. The highest technical efficiency is in China, followed by Pakistan, the Netherlands, India, and the US. It shows that Malaysia still has the potential to increase export to leading importing countries and take advantage of its vast market. In addition, the average efficiency value shows that Malaysia had lost the potential of palm oil export by 33% to the US. However, export efficiency to the US has improved, with 95.8% in 2020, suggesting an export potential of 4.2%.

Understanding export efficiency and influencing factors is essential to achieve full export potential. It provides an overview of the country's palm oil export performance and insights into the necessary policy reforms. For example, the national bank can project a depreciation of the Malaysian Ringgit against the currency of the country's leading palm oil importers to reduce the price of a foreign export, encourage the export of palm oil-based products and increase competitiveness. The government can also reduce the impact of existing trade restriction measures through bilateral and regional trade agreements to realize export capacity. Strategic efforts such as improving institutions, infrastructure, and other support can also improve the country's export performance. The increase in export is a positive factor for the Malaysian economy, which can reduce the trade deficit and increase the country's capital inflow.

However, the scope of this study is limited in the Malaysian context. Future studies can expand the scope of the study by comparing export between Malaysia and Indonesia to obtain more comprehensive study findings, especially from the aspect of efficiency performance. A comparison of efficiency performance between the leading and second global palm oil producers can provide empirical evidence for the full exploitation of palm oil export potential.

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