Southeast Asian Journal of Economics Vol.12(3), December 2024: 151-180
Received: August 22, 2023
Revision: October 16, 2023
Accepted: January 22, 2024

Measuring determinants and potential exports of Indonesian agricultural commodities to ASEAN[1]

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Abstract

This study was conducted to evaluate the efficiency, determining factors and exports opportunities of Indonesian agricultural commodities to ASEAN (Association of Southeast Asian Nations) for the 1997-2021 period using Stochastic Frontier Gravity Model (SFGM), followed with the Fixed Effect (FE) and Pseudo Poisson Maximum Likelihood (PPML) models to confirm the robustness of our model. The findings of this study showed that the GDP of Indonesia, as well as the GDP and population of importer countries, were

[1] Acknowledgements: We would like to thank the editor and anonymous reviewers for their suggestions and constructive input on an earlier version of this article.

stimulating factors in Indonesia's agricultural exports to other ASEAN countries. Geographical distance and shared borders between Indonesia and importer countries have a negative impact on Indonesian exports. Other findings of this study showed that Indonesia's agricultural commodities exports to the other 9 ASEAN member countries were inefficient, with an average TE value of 29.59%. The negative value of export potential indicates the unoptimized export performance of Indonesia's agricultural commodities to other ASEAN countries. In the end, this study contributed to enriching the literature by evaluating efficiency and export potential, which were not widely studied in international trade economic studies As part of this study, policy recommendations for increasing Indonesia's agricultural exports to other ASEAN countries were provided as well.

Keywords: Agricultural trade, exports efficiency, exports potential, panel data, SFGM

1. Introduction

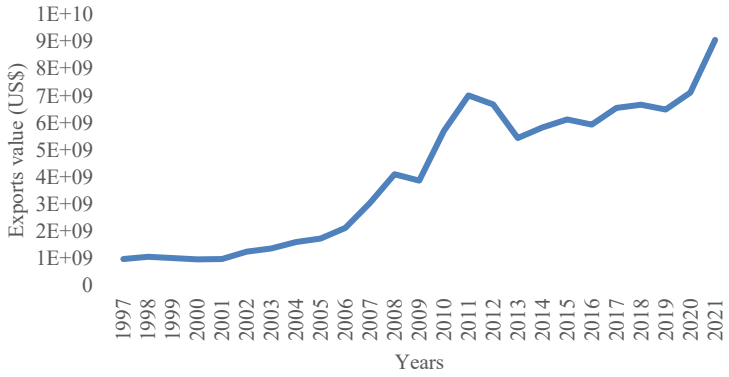
Agricultural sector is crucial to Indonesia's economic development (Bashir et al., 2019). The significance of the sector is demonstrated by its 12.62% contribution to Gross Domestic Product (GDP) in 2021 (Badan Pusat Statistik, 2022). Furthermore, agricultural sector plays a role as a provider of employment opportunities, industrial raw materials, alleviating poverty, and increasing the income of the population, specifically in rural communities (Ervani, 2013; Khairiyakh et al., 2016). The strategic importance is also seen from the contribution of agricultural commodities exports to Indonesia's total exports which reached 4.62% in 2021(World Bank, 2023). Even though exports contribution is relatively small, the export value of Indonesian agricultural commodities has increased significantly in the last few decades.

Exports are the main composition in the integration and growth of the economy (Abdullahi, Aluko, et al., 2021; Dooranov et al., 2023; Hermawan et al., 2023), including exports of agricultural commodities. The inclusion of various countries in international trade contributes positively to economic improvement and achieves other development, such as poverty reduction, job creation, food security, and gender inclusivity (Sohail et al., 2021). In particular, exports of agricultural commodities play an important role in the economic success of developing countries (Hoang, 2018; Xu et al., 2023), including Indonesia (Arifah & Kim, 2022). Arifah & Kim (2022) added that increased exports of agricultural commodities contribute positively to Indonesia's economic growth. As one of the key sectors in the Indonesian economy, the export pattern of Indonesian agricultural commodities also influences the pattern of Indonesian exports as a whole. Indonesia's export value of agricultural commodities has increased significantly in the last 20 years, with value in 2022 of US$ 347 billion (Trade Map, 2023). The increase in the export

value of agricultural commodities is expected to contribute to the Indonesian economy.

One of the largest exports market for Indonesian agricultural commodities are ASEAN (Association of Southeast Asian Nations), with a contribution of 17.92% of Indonesia's total agricultural exports in 2021 (UN Comtrade, 2023). ASEAN is a regional integration organization consisting of 10 countries (Rasyid & Ghee-thean, 2023) that aims to strengthen international trade relations in the Southeast Asia region. In addition, it is a solid economic region with a relatively high share of agriculture in GDP and is a growing market for agricultural products (Mizik et al., 2020). This market is also a leading pioneer in economic integration in the Eastern Region of the Asian continent and plays a central role in regional cooperation (Ishikawa, 2021). As potential economic region, in 2021 ASEAN will have a collective population of around 673 million people or 8.48% of the total world population and a combined GDP of US 3.1 trillion (World Bank, 2023). Therefore, ASEAN is considered a very large economic entity and ranked in the top 3 in Asia and the top 10 in the world (Hoang, 2018; Noureen & Mahmood, 2021). ASEAN is projected to become the fourth-largest economy in the world in 2030 (Liu et al., 2019). The economy continues to increase with average population growth and GDP of 1.37% and 4.90% for the 1997-2021 period (World Bank, 2023), which strengthens the position as potential economic region for international trade, including agricultural products.

Figure 1. Exports value (USD) of Indonesian agricultural commodities to ASEAN



Source: (UN Comtrade, 2023)

Indonesia's exports of agricultural products to ASEAN in the last 25 years have fluctuated with a tendency to increase (Figure 1). The value in 1997 was US$ 987 million, which increased significantly to US$ 9 billion in 2021 (UN Comtrade, 2023). Fluctuations in Indonesian agricultural commodities exports to ASEAN are influenced by many factors in terms of demand, supply, and other factors (Abafita & Tadesse, 2021; Abula & Abula, 2021; Malau, Ulya, et al., 2022; Tandra & Suroso, 2023). The exchange rate also influences fluctuations in Indonesian exports to ASEAN (Hadi & Mardianto, 2004). Competition with other exporting countries and the similarity of Indonesian agricultural products also influence exports fluctuations (Hoang, 2018). Other factors such as free trade agreements, the economic crisis, changes in consumer tastes, trade costs, and the Covid-19 pandemic contribute to Indonesian export fluctuations. As one of the largest markets for Indonesian agricultural products, fluctuations in Indonesia's exports to ASEAN are important to analyze due to the economic impact. Given the important role of agricultural commodity exports to the Indonesian economy, it would be useful to investigate agricultural commodities exports through an evaluation of the determinants of trade flow.

Export determinants have been the focus of extensive research over the past several decades, with the majority of these studies employing the gravity

model as their theoretical framework.Analogous to the gravity law of Newton, a bilateral trade stream between two countries is directly corresponds to the size of the economy (GDP) and inversely comparable to the distance (Ayuda et al., 2022). Other characteristics of importing and exporting countries, such as population, language similarity, colonialism relations, national borders, and various other factors, were also added by previous researchers to the gravity model (Balogh & Aguiar, 2022; Balogh & Leitão, 2019; Hassan Khayat, 2019; Renjini et al., 2017).

Besides the strategic function of agricultural field, only a few studies have discussed agricultural exports as a whole. In this context, the comprehensive analysis of agricultural product trade at the ASEAN level is rarely found in international literature (Mizik, 2021). Several researchers have discussed Indonesia's main agricultural sector commodities exports, such as coffee, cocoa, and CPO (Anggoro & Widyastutik, 2016; Darhyati et al., 2017; Nugroho, 2014; Ridwannulloh & Sunaryati, 2018). However, research on agricultural commodity exports to ASEAN is still limited. Therefore, this study evaluates determinants of Indonesia's exports of agricultural products to ASEAN. This information is useful as recommendations for policy improvement in increasing agricultural exports which leads to increasing national income.

As a comprehensive analysis, this study also measured the potential and efficiency of Indonesia's exports for agricultural products to ASEAN. Efficiency of export is the proportion between the quantity of actual exports and opportunities (Noviyani et al., 2019). This was measured by using Stochastic Frontier Gravity Model (SFGM) and the result can assist in the process of evaluating Indonesia's exports performance. The use of SFGM is offered by Kalirajan (2008) because the gravity model has limitations in measuring export

efficiency. It is hoped that establishing exports opportunities of agricultural materials to any ASEAN country will provide important information regarding the target market (Xu et al., 2023). This study contributes to addressing the study gap related to exports of agricultural products to ASEAN and the relatively limited use of SFGM in international trade literature.

2. Literature Review

International trade practices are increasingly developing with liberalization and economic globalization (Abdullahi et al., 2022). The concept is increasingly complex (Chen, 2022) since the theory is developed through various approaches. Studies on international trade often use gravity models which try to understanding trade between countries using Newton's gravity theory (Masood et al., 2022). Tinbergen introduced this method with the assumption that the main factors driving trade flows are the size of the economy and the distance (Joki & Haque, 2022). Even though gravity model is not found in economic theory, the concept is considered feasible in explaining trade flow between countries (Natale et al., 2015). This is driven by the ease of implementation with real data (Sinaga et al., 2019) and its flexibility for various measures outside of economic elements such as language, population, colonial relations, and geographical conditions (see (Renjini et al., 2017; Morland et al., 2020; Masood et al., 2022; Noviyani et al., 2019).

The use of gravity models in previous studies shows that trade between countries is positively influenced by exporter GDP (Khati & Kim, 2023), importer GDP (Hendy & Zaki, 2021; Yu et al., 2020), population (Manu, 2020), colonial relations (Hendy & Zaki, 2021; Renjini et al., 2017), contiguity (Yao et al., 2021), and the existence of the FTA (Manu, 2020; Masood et al., 2022). However, international trade can also be negatively influenced by several

factors including distance (Stavytskyy et al., 2019; Yao et al., 2021; Yu et al., 2020) and exchange rates (Abidin et al., 2013; Effendi, 2014; Shahriar et al., 2019). In subsequent developments, economists are starting to find weaknesses in the gravity model. This is because the concept only explains the average value of trade flows, and not the optimum value that can be achieved by the countries involved in it (Abdullahi, Aluko, et al., 2021; Atif et al., 2017). The optimum potential is important information for exporting countries to increase the value of exports. The gravity model is unable to measure "behind the border" factors, causing a hole between actual and potential exports (Nguyen, 2022).

To overcome these weaknesses, the model was developed with stochastic frontier approach, namely Stochastic Frontier Gravity Model (SFGM), which allows to determine the maximum trading level that can be achieved (Ebaidalla & Ali, 2023). The model assumes that all trade barriers that cannot be measured in the gravity model are the same trade inefficiencies as inefficiencies that occur in the production process in the conventional stochastic frontier model (Amstrong, 2007). In SFGM model, this inefficiency is shown as an error term so this model has two error terms, namely error which indicates trading inefficiency which has a value between 0 to 1 and error in the form of statistical interference in the model estimation (Abdullahi, Aluko, et al., 2021). The model also has the advantage of evaluating the statistical problem of economic distance bias causing heteroscedasticity and non-normality (Abdullahi et al., 2022).

Study using SFGM in analyzing international trade in various sectors has been reported (see (Abdullahi, Aluko, et al., 2021; Abdullahi, Huo, et al., 2021; Ebaidalla & Ali, 2023; Nguyen, 2022). The model is more reliable because SFGM can also measure information on efficiency and exports potential.

However, previous studies have used SFGM to analyze trade in certain commodities from a country, such as exports of rice and coffee from Vietnam (Nguyen, 2022), Nigerian agri-food commodities (Abdullahi, Aluko, et al., 2021), and Indonesian palm oil products (Tandra & Suroso, 2023). Study measuring the efficiency of exports of agricultural products is limited, specifically in the case of Indonesia. Previously, similar studies have been conducted in the cases of Pakistan (Atif et al., 2017) and China (Abdullahi et al., 2022), while for the case of Indonesia, previous research using SFGM analysis only measured the efficiency of Indonesian exports in general (Noviyani et al., 2019), and the effect of AFTA on exports (Effendi, 2014). This study would add to the literature related to the use of SFGM in measuring exports efficiency and potential, specifically in the case of Indonesian trade in the ASEAN.

3. Material and Methods

3.1 Model and Methodology

This research endeavors to assess the factors, effectiveness, and prospects of Indonesia's agricultural products exports to ASEAN by employing the gravity model.. It assumes that geographical proximity and economic size are crucial in bilateral exports between countries (Shobande, 2019). In general, GDP and distance play a role as a proxy for the size of the economy and transportation costs. According to the model, bilateral trade flows are determined negatively by distance and positively by GDP (Natale et al., 2015). The primary linear formula of the model is written as follows:

$$EXP_{ij} = \beta_0 + \beta_1 GDP_i + \beta_2 GDP_j + \beta_3 DIST_{ij} + \varepsilon_{ij} \quad (1)$$

where, EXP_{ij} is exports value from the country of origin (i) to the export

destination country (j), GDP_i is the GDP value of exporting country (i), GDP_j is the GDP value of the importing country (j), $DIST_{ij}$ is a geographical distance of exporting country (i) and the importing country (j), β is a coefficient, and ε is an error term.

Several factors also determine bilateral exports between countries, such as exchange rates, population, and land borders (Abdullahi, Kea, et al., 2019; Malau, Anjani, et al., 2022; Rahman et al., 2019; Aluko, et al., 2021). In line with this, the variables added influenced Indonesia's agricultural commodities exports to ASEAN. As a cross-border trading activity, the exchange rate plays a crucial role in international trade due to differences in currencies. The importer population also determines trade flows, where an increase in the importer population will increase trade flows. This study also used a dummy variable in the form of a common border. Therefore, the development of the model used is written as below formula:

$$\ln \mathrm{EXP}_{ijt} = \beta_0 + \beta_1 \ln \mathrm{GDP}_{it} + \beta_2 \ln \mathrm{GDP}_{jt} + \beta_3 \mathrm{DIST}_{\mathrm{ijt}} + \beta_4 \mathrm{EXC}_{\mathrm{ijt}} + \beta_5 \mathrm{POP}_{\mathrm{jt}} + \gamma_6 \mathrm{CNTG}_{\mathrm{jt}} + \varepsilon_{\mathrm{ijt}} \quad (2)$$

where EXP_{ijt} is the value of exports for Indonesian agricultural commodities towards country j in year t; GDP_{it} is the GDP of Indonesia in year t; GDP_{jt} is the GDP of the importer in year t; $DIST_{ijt}$ is the geographical distance of Indonesia and importer in year t; EXC_{ijt} is a rupiah exchange rate towards LCU in year t; POP_{jt} is an importer's population in year t; $CNTG_{jt}$ is a dummy of Indonesia's land border and importer (1 = land border and 0 = no land border); Ln is the natural logarithm, β, and γ are the coefficients, t is the year of analysis (1997-2021), and ε_{ijt} is an error term.

However, the use of the model is considered inappropriate to describe exports potential (Noviyani et al., 2019), because gravity model with OLS

produces a value that is centralized or the middle value of the existing data set, which does not describe an upper bound value. To overcome the inherent bias in conventional gravity models, Kalirajan, (2008) offered SFGM as a combination of Stochastic Frontier Production Function and gravity model, allowing estimation of exports efficiency (Abdullahi, Aluko, et al., 2021). The use is more acceptable and suitable for considering trade constraints or barriers that cannot be observed by ordinary gravity models (Amstrong, 2007). SFGM also corrects the term economic distance bias causing heteroscedasticity and non-normality, isolating the concept into a statistical error term. In contrast to the gravity model, SFGM has two error terms, namely an error indicating trade inefficiency and an error arising due to other factors not expected in the model (Xu et al., 2023). The basic SFGM equation is written as follows (Miankhel et al., 2014):

$$\ln \mathrm{X}_{ij} = \ln f\left(\mathrm{T}_{ij}\,;\beta\right) exp^{(v_{ijt} - u_{ijt})} \tag{3}$$

where, f (T; β) is a function for determinants of potential exports (T_{ijt}), X_{ij} is an actual value of exports from country i to country j, β is the estimated parameter, u_{ijt} is the error caused by economic distance bias, v_{ijt} is the error caused by the influence of "behind the border measures".

Therefore, the model used in this study is formulated as below:

$$\begin{aligned}\ln \mathrm{EXP}_{ijt} = {} & \beta_0 + \beta_1 \ln \mathrm{GDP}_{it} + \beta_2 \ln \mathrm{GDP}_{jt} + \beta_3 \mathrm{DIST}_{\mathrm{ijt}} + \beta_4 \mathrm{EXC}_{\mathrm{ijt}} + \\ & \beta_5 \mathrm{POP}_{\mathrm{jt}} + \gamma_6 \mathrm{CNTG}_{\mathrm{jt}} + \mathrm{u}_{\mathrm{ijt}} + \mathrm{v}_{\mathrm{ijt}}\end{aligned} \tag{4}$$

Equations (2) and (4) have differences in the error components. Meanwhile, the error component in equation (4) is divided into two, namely the single side error (u_{ijt}) from the combination effect over the border constraints and behind the

border constraints of country trade i to j generating a distinction between potential and actual exports values, and double side error (v_{ijt}) which is an error due to measurement errors and omitted variables that are randomly distributed.

The calculation of exports efficiency of Indonesian agricultural commodities to ASEAN is as follows (Xu et al., 2023):

$$Export\ efficiency_{ij,t} = \frac{Actual\ export_{ij,t}}{Potential\ export_{ij,t}} = \frac{Exp(X_{ij,t}\beta + v_{ij,t} - u_{ij,t}}{Exp(X_{ij,t}\beta + v_{ij,t})} = Exp\left(-u_{ij,t}\right) \quad (5)$$

Exports efficiency ranges from 0-1 (Xu et al., 2023), and a score of 0 shows inefficiency where opportunities increase exports, while 1 indicates that actual exports match potential exports (Abdullahi, Aluko, et al., 2021). Potential exports value is calculated based on the efficiency value, so that Indonesia's export potential for Indonesian agricultural products is known in each trading partner country. Potential exports are calculated using the following equation (Xu et al., 2023):

$$Potential\ export_{ij,t} = \frac{Actual\ export_{ij,t}}{Export\ Efficiency_{ij,t}} \quad (6)$$

Apart from SFGM, testing the relationship of the variables also used other estimation methods in the form of Poisson pseudo maximum likelihood (PPML) model and panel data regression. These three estimation methods were used to investigate the robustness of the model. The use of PPML aimed to mitigate the issue of selection bias that arises from the presence of zero trades and heteroscedasticity (Abafita & Tadesse, 2021; Balogh & Aguiar, 2022) as well as multicollinearity (Abdullahi et al. 2021). Panel data regression produces three models, namely Common Effect, Fixed Effect, and Random Effect (Juanda, 2009). The Chow test selected Common Effect or Fixed Effect, the

Hausman test determined Fixed Effect or Random Effect, while the LM test was used to select Random Effect or Common Effect.

3.2 Data and Variables

A comprehensive dataset encompassing Indonesian agricultural exports to ASEAN countries over a period of 25 years (1997-2021) was collated to address the research objectives of the study.. The objects of this study were Thailand, Singapore, Malaysia, Philippines, Myanmar, Cambodia, Lao PDR, Vietnam, and Brunei Darussalam. Agricultural commodities consisted of HS 01-24 collected from UN Comtrade. Variables playing the role of economic indicators were population and GDP from the World Bank, while the exchange rate was from UNCTAD. Other variables, namely landlocked, contiguity, and distance were collected from CEPII. The variables used the natural logarithm (Ln), except for dummy and those using percentage units. Sources of data and units of measurement of the variables are shown in Table 1.

Table 1. The description and source of variables

Variable	Description	Unit	Source
EXP_{ijt}	Exports value of Indonesian agricultural commodities (HS 01-24) to ASEAN	USD	UNComtrade
GDP_{it}	GDP of Indonesia (in constant 2015)	USD	World Bank
GDP_{jt}	GDP of impoter(s) (ASEAN) (in constant 2015)	USD	World Bank
EXC_{ijt}	Exchange rate	IDR/LCU	UNCTAD
$DIST_{ijt}$	The geographical distance of Indonesia to the importing country	Km	CEPII
$CNTG_{jt}$	Dummy variable for direct land borders	Binary (0,1)	CEPII
POP_{it}	Population of importer(s)	Person(s)	World Bank

Source: Author's compilation

Based on the descriptive statistics in Table 2, most of the variables had a small standard deviation which showed a little variation. EXC_{ijt} and GDP_{it} were the variables with the highest and lowest standard deviations, namely 3.5457 and 0.3521. The relatively large range of maximum and minimum observations for EXP_{ijt} showed the very diverse exports value of Indonesian agricultural

commodities. EXC_{ijt} and EXP_{ijt} also showed a large observation range, where ASEAN countries had a lot of differences in several aspects.

Table 2. Descriptive statistics

Variable	Obs	Mean	Maximum	Minimum	Std. Dev
EXP_{ijt}	224	18.218	22.005	6.976	2.945
GDP_{it}	225	27.165	27.694	26.646	0.352
GDP_{jt}	225	24.931	26.855	22.163	1.471
EXC_{ijt}	225	4.445	9.273	-0.849	3.546
$DIST_{ijt}$	225	7.5918	8.014	6.787	0.413
$CNTG_{jt}$	225	0.111	1	0	0.315
POP_{it}	225	16.647	18.551	12.654	1.699

Source: Author's calculations

4. Results and Discussion

4.1 Determinants of Indonesia's Agricultural Commodities Exports to ASEAN

A total of three estimation methods in the form of SFGM, PPML, and panel data regression were used to evaluate determinants of Indonesia's exports of agricultural commodities to ASEAN (Table 3). The best panel data regression model was selected using the Chow, Hausman, and LM tests. The Chow test showed a probability of 0.0000 or smaller than the real level of 5%, hence FE was better than Common Effect. Hausman test showed a probability of 0.0137 or smaller than the real level of 5%, therefore FE was better than Random Effect. Based on these two tests, Fixed Effect was selected as the model that represents panel data regression. To accommodate the Ordinary Least Square assumption, the selected model was estimated using Fixed Effect Robust. FE was used by eliminating time-invariant variables such as geographic distance and contiguity (Rahman et al., 2019; Tandra & Suroso, 2023).

The three estimation methods showed relatively the same value, direction, and significance to support the robustness of the model. The gamma (γ) value of 0.9878 showed that SFGM was feasible to use. Gamma (γ) close to

1 showed that SFGM was appropriate in explaining variations in Indonesia's plantation commodities exports (Atif et al., 2019; Vinh & Phuong, 2022). A large γ value also reported that "behind the border" obstacles in the form of socio-political-institutional factors were responsible for the average variation in Indonesian agricultural exports to ASEAN (Ebaidalla & Ali, 2023; Miankhel et al., 2014). The use of PPML and FE was supported by R-square values of 0.6967 and 0.6499. The R-Square was 0.6967 in PPML, which means that exports of Indonesian agricultural commodities to ASEAN could be explained by 69.67% of independent variables while the rest was explained by other variables not included in the model. The R-Square in FE showed that the independent variable could explain 64.99% of Indonesia's agricultural commodities exports to ASEAN, while the rest was explained by other variables that are not included in the model.

The variables showed the desired value and direction, which was consistent with the fundamentals of gravity model theory. The GDP of Indonesia and importers had a positive and significant effect on SFGM, but Indonesia's GDP only had a significant effect on PPML and FE. GDP of Indonesia referring to supply capacity while importer's GDP describes demand capacities (Atif et al., 2017). The positive coefficients of Indonesia's GDP and its exporters showed that countries with larger economies were expected to engage more in bilateral trade. As a proxy of trade flows, a higher GDP for exporter indicated a higher capacity to produce or supply, which can result in increasing exports. Therefore, an increase in GDP of Indonesia would increase agricultural commodities exports for Indonesia to ASEAN. This is in agreement with prior study in several countries, namely Latin America and Caribbean (Balogh & Aguiar, 2022), India (Renjini et al., 2017), and Vietnam (Xu et al., 2023).

The importer's GDP with a positive effect showed that an income increase of trading partner countries would have a cause on improving exports of Indonesian agricultural materials. This is because an increase in the GDP for importers indicated that the country required more goods and services than usual. To meet the demand, the importing country would carry out special imports of goods. Other studies also established empirical evidence of the positive effect of importer's GDP on exports in other countries, such as Nigeria (Abdullahi, Aluko, et al., 2021) and Pakistan (Atif et al., 2017).

Table 3. Determinants of Indonesia's agricultural commodities exports to ASEAN

Independent variables	SFGM		PPML		FE	
	Coefficient	St.Dev	Coefficient	St.Dev	Coefficient	St.Dev
$Ln(GDP_{it})$	2.6361**	0.2945	0.1009**	0.0163	2.8444**	0.5390
$Ln(GDP_{jt})$	0.7260**	0.2010	0.0037	0.0102	0.3891	0.2849
$Ln(DIST_{ijt})$	-8.3694**	1.4664	-0.2607**	-0.0283	-	-
$Ln(EXC_{ijt})$	-0.2142*	0.1280	0.0122**	0.0039	-1.1109**	0.4110
$Ln(POP_{jt})$	0.5797**	0.2570	0.0862**	0.0120	-1.3611	1.5227
$CNTG_{jt}$	-1.4100	1.1728	-0.0908**	0.0184	-	-
Constant	-14.0583	11.6112	0.5535	0.4235	-41.1435**	16.5455
γ	0.9878	82.3080				
R^2			0.6967		0.6499	
Chow test					0.0000**	
Hausman test					0.0137*	

Note: ** significant at 5% level, * significant at 10% level
Source: Author's calculations

The other variable for the gravity model was geographic distance which acted as a proxy for transportation costs (Irandu, 2019). The farther the area between countries, the higher the transportation costs, resulting in a decrease in the quantity demanded by importing countries. Therefore, an increase in geographical distance would reduce Indonesia's agricultural commodities exports in SFGM and PPML. These results are consistent with the projections and basic theory of the model (Natale et al., 2015). Transportation costs would cause additional operational expenses for exporters and importers, leading to increased prices for consumers in importing countries. Comparable study conducted in various countries obtained analogous results, consistent with the

results observed in Pakistan (Atif et al., 2017), China (Abula & Abula, 2021), and Albania (Braha et al., 2017).

In addition to the fundamentals of the model, this study examined the influence of various variables such as exchange rates, importer population, and contiguity. The analysis showed that the importer population positively affected Indonesia's agricultural commodities exports in SFGM and PPML. The addition of the importer population affected increasing consumption in the country which would increase exports of Indonesian agricultural commodities. ASEAN's position dominated by developing countries is a huge market potential due to positive population growth. The countries with the highest growth in the 1997-2021 period were Malaysia (1.93%), the Philippines (1.89%) and Cambodia (1.56%) (World Bank, 2023). The positive effect of population on agricultural exports has also been reported in previous studies in the European Union (Balogh & Leitão, 2019) and Albania (Braha et al., 2017).

As an activity of exchanging goods and services between countries, exports are closely related to the exchange rate due to different currencies. Based on SFGM and FE, the exchange rate negatively had an important effect on Indonesian exports of agricultural commodities. This result showed that an increase in the exchange rate would reduce exports. Previous studies on exports of agricultural commodities by Abdullahi, Aluko, et al., (2021) and Barma, (2017) also provided empirical evidence regarding the negative influence of the exchange rate towards exports activities. According to the results, the appreciation of the Rupiah against the importer's currency reduces Indonesia's agricultural exports because it will make the prices of Indonesian agricultural commodities more expensive for importing countries. However, PPML estimate showed that the exchange rate positively had an important effect, which was consistent with previous studies on agricultural commodities exports

from Atif et al., (2017) and Braha et al., (2017).

The differences in the influence of the exchange rate in these three models increasingly show that empirically the influence of the exchange rate on international trade is still uncertain and debated. According to (Zhu et al., 2022), exchange rate depreciation caused domestic product prices to fall and encouraged increased exports, but trading partner countries did not necessarily adjust their purchasing power. This condition occurred in exports of Indonesian agricultural products, specifically in PPML model. Even though there was an appreciation in the Rupiah exchange rate, demand for Indonesian products continued to increase because trading partners could not respond by looking for substitutes for Indonesian products.

The $CNTG_{jt}$ dummy negatively influenced Indonesia's agricultural commodities exports at PPML. $CNTG_{jt}$ coefficient of -0.0908 showed that there was a difference in exports value of Indonesia's agricultural commodity towards countries with direct land borders compared to countries that did not have direct land borders with Indonesia, with a coefficient value of 0.0908. This result was not consistent with the desired initial expectations, even though the land border dummy variable was relatively small. The negative influence occurred because the majority of goods were carried out through sea transportation, and the borders did not have a direct effect on increasing exports. Other previous studies also reported that the possession of a direct land border did not contribute significantly to increasing bilateral trade (Atif et al., 2019; Gul & Yasin, 2011). Concerning the implication was that a country bordering Indonesia (Malaysia) did not have a significant effect on increasing exports. This condition existed because the land border was limited to the areas of Kalimantan and East Malaysia, while most of the trade, production, and exports ports were on the island of Java.

4.2 Efficiency and Potential Indonesia's Agricultural Commodities Exports to ASEAN

Exports efficiency shows a condition in which a country cannot exports additional goods. Conversely, inefficient exports shows a hole between the observed and maximum level of exports (Abdullahi et al., 2022). Estimation of the technical efficiency of agricultural commodities exports to ASEAN countries is presented in Table 4, with an average value of 29.59%. The TE value of 29.59% showed that Indonesia had potential of 61.41% to increase its agricultural commodities exports to the ASEAN market. The technical efficiency of exports to ASEAN has attracted attention with a very large range, namely 0.29% - 83.45%. An empirical study from Xu et al. (2023) also reported a very large range of exports efficiency for Vietnam's agricultural commodities (5.6% - 84.8%) to APEC. In line with the low average technical efficiency, no country has shown 100% technical efficiency, hence Indonesia still has the potential to increase exports to its trading partners.

A low technical efficiency of 29.59% showed that the performance of Indonesia's agricultural commodities exports to ASEAN was not optimal. For example, Singapore, Lao PDR, and Malaysia were the 3 most inefficient countries with TEs of 0.29, 0.46, and 4.06 respectively. The TE value implied that Indonesia had potential to increase untapped exports to Singapore, Lao PDR, and Malaysia at 99.71%, 99.54%, and 95.94%, respectively. Conversely, trading partner countries with the highest technical efficiency were Myanmar (83.45%), the Philippines (82.475%), and Vietnam (50.20%).

The low TE in these three countries can be caused by several factors, such as the geographical condition of Lao PDR as the only landlocked country in the ASEAN region. This landlocked condition has a negative effect on international trade (Masood et al., 2022; Shahriar et al., 2019), because

transportation costs from Indonesia to Lao PDR will increase so it will be more profitable if Lao PDR imports products from countries that directly border it. Malaysia's TE is low because the geographical conditions are relatively similar to Indonesia so Malaysia can produce similar agricultural products such as palm oil, cocoa, rubber and other products, so it does not require a lot of imports from Indonesia. According to (Hoang, 2018), Indonesia-Malaysia exhibits the most comparable agricultural product export patterns among ASEAN nations. Meanwhile, Singapore is most concerned about product quality (Le et al., 2022), which causes TE exports to be low because the quality of Indonesian products is not good enough (Mulyono et al., 2022). The inability to meet product quality standards means that Indonesia can only control 6% of the share of fruit and vegetable products in Singapore, even though its position is very close and directly borders Indonesia (Perdana & Kusnandar, 2012).

Table 4. Efficiency and exports potential of Indonesian agricultural commodities to ASEAN

No	Country	Technical efficiency (TE) (%)	Actual exports (USD)	Potential exports (USD)	Gap (USD)
1	Thailand	16.76	346,375,340	2,066,641,744	- 1,720,266,405
2	Singapore	0.29	881,313,605	303,758,790,857	- 302,877,477,251
3	Malaysia	4.06	1,508,750,695	37,128,315,761	- 35,619,565,067
4	Philippines	82.47	505,870,249	613,419,565	- 107,549,316
5	Myanmar	83.45	225,866,933	270,654,950	- 44,788,017
6	Cambodia	19.20	155,408,650	809,330,538	- 653,921,888
7	Lao PDR	0.46	211,739	45,634,388	- 45,422,648
8	Vietnam	50.20	478,874,863	954,002,968	- 475,128,105
9	Brunei Darussalam	9.44	12,173,548	128,994,910	- 116,821,362

Source: Author's calculations

It is interesting to note that the relatively low TEs were occupied by Indonesia and ASEAN countries with high GDP such as Singapore, Malaysia, and Thailand. Undeniably, forging robust trade connections with economically significant nations could facilitate the expansion of Indonesian agricultural product exports by harnessing their considerable export potential.. Low TE value were also occupied by Indonesia and countries which have close

geographical distances, such as Singapore and Malaysia. Efforts to increase exports of Indonesian and neighboring countries' agricultural commodities were carried out by increasing trade relations, joining trade agreements, and reducing political disputes (Atif et al., 2019).

Table 4 also shows exports potential and gap in exports of Indonesian agricultural commodities. The negative exports gap value for all trading partner countries showed that Indonesia's agricultural commodities exports were not optimal. Improved trade policies should lead to increased exports of Indonesian agricultural products to ASEAN, which would subsequently result in increased state revenues.

Indonesia's average exports for agricultural products to ASEAN had untapped potential (gap), which was 37.9 billion USD per year. Efforts to increase exports of Indonesian agricultural commodities should focus on countries with large export potential, such as Singapore (303.7 billion USD), Malaysia (37.1 billion USD), and Thailand (2.1 billion USD). The large exports potential was in line with the economic size of the importing country. In addition, these three countries were relatively close to Indonesia compared to others and had potential to increase exports of agricultural commodities. Exports efficiency to Lao PDR was relatively small, namely 0.46% due to geographical conditions of Lao PDR, which was landlocked, so that transportation costs were higher because it went by land and air.

5. Conclusion

ASEAN presents a promising market for Indonesia's agricultural commodity exports, backed by the GDP and population growth in its member countries.. In this context, Indonesia's exports of agricultural products to ASEAN in the last 25 years (1997-2021) fluctuated with a tendency to elevate

with an average growth of 10,825% per year. Therefore, this study used a gravity model method to analyze potential, determining factors, and efficiency of Indonesia's exports of agricultural products to ASEAN. Panel data from 9 ASEAN countries for the period 1997-2021 was used to answer study objectives using three estimation methods supporting the robustness of the model, namely SFGM, PPML, and FE.

The estimation results for exports determinant were as follows: first, the economy size proxied by Indonesia's GDP and its importing countries encouraged larger flows of agricultural commodities exports. Second, the geographical distance between Indonesia and trading partner countries was proven to affect trade flows negatively. Third, the exchange rate had an ambiguous impact on Indonesia's agricultural commodities exports. Fourth, the positive impact of importer populations was also reported. Fifth, different from the expected sign, the shared border affected Indonesia's agricultural commodities exports negatively.

Exports efficiency evaluation showed that exports to ASEAN had not been efficient, as showed by the TE value of 29.59%. In addition, no country reported a TE value of 100%, hence Indonesia still had potential to increase exports. Some countries with TE below the average were Thailand (16.76%), Singapore (0.29%), Malaysia (4.06%), Cambodia (19.20%), Lao PDR (0.46%), and Brunei Darussalam (9.44%). Based on TE and actual exports value, the calculation shows that Indonesia's agricultural commodities exports performance is not optimal. Therefore, better trade policies were expected to encourage increased trade flows of Indonesian agricultural commodities to ASEAN.

Several recommendations were put forward to optimize prospects for boosting Indonesian agricultural exports to ASEAN.First, economic size was

proven to have an effect, hence Indonesia must pay special attention to countries with large GDP. From exporter GDP perspective, Indonesia's agricultural exports to ASEAN could be stimulated by formulating and implementing macroeconomic policies aimed at increasing the size of the economy. Second, the negative effect of geographical distance showed that more attention should be given to the closest neighbors in increasing exports. Third, the positive effect on the importer's population showed a focus on trade relations by countries with larger populations. Fourth, trading partner countries with low TE could also increase exports in line with large potential. Fifth, Indonesia must maintain a stable exchange rate to stimulate increased exports. Sixth, trade relations with ASEAN member countries must be strengthened. Seventh, in connection with "behind the border" obstacles, policymakers were expected to pay special attention to socio-political-institutional factors related to bilateral trade. These recommendations showed that Indonesia had a big opportunity to increase agricultural exports.

Finally, this study offered novelty through the evaluation of exports potential and efficiency which was limited in international trade studies. Previous results were only focused on determinants of exports but this study conducted a comprehensive analysis of determinants, efficiency, and potency. Besides the functional role of agricultural sector, there was another novelty in the analysis (HS 01-24), which was not limited to the main commodities. The recommendation for further study was conducted by examining the influence of other relevant variables, such as free trade agreements and infrastructure, or analyzing the efficiency of agricultural product exports to trading partner countries outside ASEAN.

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