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Unlocking Export Potential: Technical Efficiency of Indonesia's Cocoa Butter Trade Using Stochastic Frontier Gravity Model

Andi Amran Sulaiman[1*], Muhammad Arsyad[1], Rio Akbar Rahmatullah[2], Abd Haris Bahrun[3], Ayu Anisa Amir[1] and Busige Nishantha[4]

[1]Agribusiness Study Program, Department of Agricultural Socioeconomics, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia; [2]Agricultural Economics Study Program, Department of Resources and Environmental Economics, Faculty of Economics and Management, IPB University, Bogor, Indonesia; [3]Agrotechnology Study Program, Faculty of Agriculture, Hasanuddin University, Makassar, Indonesia; [4]Department of Management and Organization Studies, Faculty of Management and Finance, University of Colombo, Colombo, Sri Lanka

[*]*Corresponding author:* aas@unhas.ac.id

Abstract

Indonesia is a major cocoa butter exporter that faces global market barriers and export inefficiencies, yet research on the technical efficiency of its trade remains limited. This study applies a Stochastic Frontier Gravity Model for the period 2015–2024 to examine the determinants and trade efficiency of Indonesia's cocoa butter exports. The analysis is conducted separately for developed and developing destination countries. The estimation results show that the exporter's gross domestic product (GDP) and the economic distance between the 2 countries have a statistically significant positive effect on the value of cocoa butter exports. Meanwhile, the importer's GDP has a statistically significant negative effect, consistent with the structural characteristics of an intermediate-goods market that is highly dependent on the presence of processing hubs. The real exchange rate of the Indonesian rupiah and the technical barriers to trade (TBT) coverage ratio are associated with lower trade inefficiency in both country groups. Among developed countries, the United States recorded the highest average technical efficiency over the past decade, while South Korea had the lowest. Among developing countries, India achieved the highest average efficiency, while other countries had substantially lower average technical-efficiency scores. These findings suggest that TBT measures may facilitate trade for exporters that comply with the relevant standards and that expansion strategies should prioritize countries with strong chocolate-processing industry clusters.

Keywords: cocoa butter; efficiency; gravity model; international trade

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INTRODUCTION

The plantation subsector contributes the largest share to Indonesia's agricultural gross domestic product (GDP), accounting for 43.77% in 2024 (Ministry of Agriculture, 2025; Rambe et al., 2025). Cocoa is one of the leading plantation commodities, representing 7.38% of national plantation exports (Ministry of Agriculture, 2025; Hutasoit and Supriana, 2026). Indonesia is also recognized as one of the world's largest cocoa bean producers (Arsyad et al., 2020). Moreover, cocoa is a key source of income for rural communities, as approximately 98.88%

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of cocoa plantations are owned by smallholders (Bemelmans and Maertens, 2025; Ministry of Agriculture, 2025).

Indonesia's cocoa exports have shifted from raw beans to processed products due to export duties introduced under Minister of Finance Regulation No. 67/PMK.011/2010, which aims to promote downstream processing (Ramadhani et al., 2023; Fatkurrohim et al., 2025; Hidayati and Prasada, 2025). In 2024, cocoa exports were valued at USD 2.62 billion, with cocoa butter contributing the most (64%) (Ministry of Trade, 2025). This downstream policy reflects an effort to move up the global value chain (GVC). The GVC framework focuses on how value is created and captured at different stages of production (Antràs, 2020). The upgrading of Indonesia's export composition from raw cocoa beans to cocoa butter suggests an improvement in Indonesia's position within the GVC (Marschner et al., 2025; Ministry of Trade, 2025).

In recent years, the global cocoa trade has faced significant challenges, particularly climate-related supply disruptions associated with El Niño and the need to adopt more sustainable farming practices. At the same time, the United States and European Union member states, as major importers, have raised their standards, including requirements for product traceability, safety, and guarantees of a deforestation-free supply chain (Partzsch, 2025; Solar et al., 2025). The European Union Deforestation Regulation (EUDR) requires that products entering the European Union not be derived from deforestation. This presents both a challenge and an opportunity for exporters supplying the European Union. However, the rewards for exporters that comply with these regulations include substantially improved market access, stronger buyer trust, and premium prices (Basri et al., 2023; Rasyidin et al., 2024).

Global cocoa trade patterns indicate that the availability of raw materials is not the primary factor determining export competitiveness. Ghana and Côte d'Ivoire supply 60% of the world's cocoa beans, yet they lack regulations governing sustainable cocoa processing (Gyan and Bajan, 2022; Dago and Pei, 2025). In contrast, Malaysia has become a leading processing hub, supported by duty-free imports and a strategic focus on cocoa-based products (Ahmad, 2015; Yudyanto and Hastiadi, 2019). According to gravity trade theory, GDP and geographical distance between countries influence bilateral trade flows (Anderson and Van Wincoop, 2003). Indonesia, with its extensive smallholder plantations and expanding processing capacity, could increase exports of processed cocoa products by addressing inefficiencies in its supply chain (Neilson et al., 2020; Widhiyoga and Wijayati, 2022).

The cocoa supply chain in Indonesia also faces efficiency constraints. Farmers often sell unfermented cocoa beans, which may limit the quality of the cocoa products (Hariyati, 2016; Servent et al., 2018; Andriani et al., 2020; Praseptiangga et al., 2020; Sari et al., 2023). In addition, high logistics costs, driven by limited transportation networks and infrastructure, weaken Indonesia's export competitiveness (Sandee, 2016). Certification requirements also pose challenges, as they entail cost and time commitments for farmers who require immediate cash (Henry and Pechevy, 2017; Ansah et al., 2020; Olutegbe and Sanni, 2021; Oladele et al., 2026). These issues suggest that Indonesia's cocoa butter exports may remain below their potential.

Analyses of exports do not rely solely on GDP, economic distance, or the market size of the destination country. While standard gravity models can identify the determinants of exports, they cannot measure the gap between actual export performance and maximum potential. Therefore, the Stochastic Frontier Gravity Model (SFGM) is an appropriate choice because it allows the estimation of trade potential while simultaneously identifying the inefficiencies that prevent exports from reaching optimal levels (Tandra and Suroso, 2023; Khaliqi et al., 2024). Building on standard gravity theory, the SFGM decomposes the composite error term into random noise and a one-sided inefficiency term (Battese and Coelli, 1995). In agricultural commodity trade studies, the SFGM has been used to examine associations between trade efficiency and factors such as infrastructure, economic openness, and trade barriers (Trakem and Fan, 2024; Cao et al., 2025). Additionally, the technical barriers to trade (TBT) coverage ratio, a trade-weighted indicator of the extent to which imports are subject to this category of non-tariff measure (NTM), has seldom been examined within the SFGM.

Several studies have examined the competitiveness of Indonesian cocoa butter using revealed comparative advantage (RCA) and export product dynamics (EPD) (Ginting et al., 2021; Rahmanta and Lindawati, 2025) and have analyzed trade policies such as ASEAN+6 (ASEAN, Australia, China, India, Japan, Korea, and New Zealand) in relation to cocoa butter

exports (Danendra et al., 2025). However, research that specifically analyzes cocoa butter remains limited. In addition, existing studies generally do not measure the technical efficiency of Indonesia's cocoa butter trade, particularly in a way that differentiates between the market characteristics of developed and developing countries. These country groups have different demand structures, technical standards, processing capacities, and levels of supply-chain integration. A further research gap is the limited use of the TBT coverage ratio as an explanatory variable in trade-inefficiency models.

Based on these gaps, this study analyzes the determinants and technical efficiency of Indonesia's cocoa butter exports during 2015–2024. It aims to measure technical efficiency and trade inefficiency in the cocoa butter trade with both developed and developing countries. By differentiating the analysis by destination country groups, the study provides a more context-specific basis for formulating strategies to increase the export value of Indonesia's cocoa butter. The remainder of this paper is organized as follows. The Materials and Method section presents the data sources, variable construction, and SFGM specification. The Results and Discussion section reports and interprets the empirical results, including the determinants of trade, inefficiency factors, and technical efficiency scores. The Conclusion summarizes the principal findings and policy recommendations.

MATERIALS AND METHOD

Data

This study uses the value of Indonesia's cocoa butter exports (HS 1804) as the dependent variable. The independent variables include the constant-price GDP of the exporter (Indonesia), the constant-price GDP of the importing country, economic distance, the real exchange rate, and the coverage ratio for TBT, a category of non-tariff measure (NTM). The data sources are presented in Table 1. Economic distance is defined as the geographical distance between Indonesia and a partner country weighted by the partner country's share of world GDP. It is calculated by multiplying the geographical distance by the ratio of the importing country's GDP to total world GDP. TBT coverage ratio is calculated using Equation 1.

Methodology

This study estimates the determinants, inefficiency, and technical efficiency of Indonesia's cocoa butter exports in the international market over the period 2015–2024. The analysis is divided into 2 country groups: developed and developing trading partners. The developed-country group comprises the Netherlands, Germany, the United States, France, China, Estonia, Australia, Canada, Japan, South Korea, New Zealand, and Singapore. In contrast, the developing-country group comprises India, Malaysia, Pakistan, the Philippines, Saudi Arabia, and South Africa. These countries are selected because they are the only importers that have maintained continuous cocoa butter trade with Indonesia throughout 2015–2024. Because the log-linear SFGM specification cannot accommodate zero trade values directly, the sample was restricted to partners with positive cocoa butter trade in every year from 2015 to 2024. The empirical equations in this study are based on the gravity model and stochastic frontier approaches (Asodina et al., 2021; Lanamana and Supardi, 2021; Nugroho, 2024), which together

$$CR_{ijk} = \frac{\sum D_{ijk} \times V_{ij}}{\sum V_{ij}} \quad (1)$$

Where, CR_{ijk} = the level of TBT regulatory coverage applied by country *i* to country *k* in year *j*, D_{ijk} = TBT dummy variable if product from country *k* in country *i* in year *j* is subject to TBT regulations, V_{ij} = import value of cocoa butter in country *i* year *j*.

Table 1. Sources of data

Data	Source
Cocoa butter export and import value	https://www.trademap.org/ and https://comtradeplus.un.org/
GDP of Indonesia and partner countries	https://data.worldbank.org/
Geographical distance	https://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele.asp
Real exchange rate	https://fx.sauder.ubc.ca/fxdata.php
TBT coverage ratio	https://trainsonline.unctad.org/home

$$\ln Y = \beta_0+\beta_1 \ln GDP_{it}+\beta_2 \ln GDP_{jt}+\beta_3 \ln Dist_{ij}+(v_{ijt}-u_{ijt}) \quad (2)$$

Where, Y_{ijt} = value of Indonesia's cocoa butter exports to destination country *j* in year *t*, β_0 = constant, β_1, β_2, β_3 = coefficient, GDP_{it} = Indonesia's constant-price GDP in year *t*, GDP_{jt} = constant-price GDP of destination country *j* in year *t*, $Dist_{ij}$ = economic distance between Indonesia and the destination country *j*, v_{ijt} = random error term, u_{ijt} = inefficiency component.

$$u_{ijt} = \delta_0+\delta_1 Z_{1ijt}+\delta_2 Z_{2ijt}+w_{ijt} \quad (3)$$

Where, δ_0 = constant, δ_1, δ_2 = coefficient, Z_{1ijt} = Indonesia's real exchange rate against destination country *j* in year *t* (IDR/LCU), Z_{2ijt} = TBT coverage ratio for destination country *j* in year *t*, w_{ijt} = random error for inefficiency.

$$\ln Y_{ijt} = \beta_0+\beta_1 \ln GDP_{it}+\beta_2 \ln GDP_{jt}+\beta_3 \ln Dist_{ij}-\delta_0-\delta_1 Z_{1ijt}-\delta_2 Z_{2ijt}-w_{ijt}+v_{ijt} \quad (4)$$

$$Y^*_{ijt} = Y_{ijt}/TE_{ijt} \quad (5)$$

Where, Y_{ijt} = actual export value, Y^*_{ijt} = potential (frontier) export value, TE_{ijt} = technical efficiency value.

$$\text{Export Gap} = Y_{ijt}-Y^*_{ijt} \quad (6)$$

generate a composite error term with 2 components. The SFGM applied here is modified from previous studies (Tandra and Suroso, 2023; Khaliqi et al., 2024) and is specified as Equation 2, which presents the gravity model function in natural logarithmic form. The corresponding inefficiency-effects model (u_{ijt}) is specified as Equation 3.

The *Z* variables are included as potential determinants of trade inefficiency. The real exchange rate is calculated as the nominal exchange rate (IDR/LCU) multiplied by the importer's consumer price index (CPI) and divided by the exporter's CPI. The TBT coverage ratio is calculated by dividing the value of cocoa butter imports covered by TBT measures by the total value of cocoa butter imports from all countries included in the model for that year and multiplying the resulting ratio by 100. These 2 variables are then incorporated into the SFGM to obtain the following more complete mathematical specification, which is presented in Equation 4.

Export potential is then calculated from the estimated technical-efficiency scores. In the SFGM framework, technical efficiency is defined as the ratio of actual export value to frontier export value. Accordingly, potential export value is calculated using Equation 5. Next, the export gap is calculated using Equation 6.

The SFGM was estimated by maximum likelihood estimation (MLE) using the one-step procedure proposed by Battese and Coelli (1995). This procedure simultaneously estimates the parameters of the frontier function and the inefficiency-effects model. The 2 error components are assumed to be independently distributed. The random-error term, v_{ijt}, captures statistical noise and exogenous shocks and follows a normal distribution $N(0,\sigma^2_v)$. The inefficiency term, $u_{ijt,}$ follows a normal distribution with mean δZ_{ijt} and variance σ^2_u, truncated at zero to ensure non-negative inefficiency. Excel was used for data preparation and variable calculation, and Frontier 4.1 was used to obtain the MLE estimates and technical-efficiency scores.

To assess whether the SFGM was appropriate relative to the conventional pooled OLS model, 2 model diagnostics were examined. First, a likelihood-ratio (LR) test was used to test the null hypothesis that the model contained no trade-inefficiency effect (H_0: $\gamma = \delta_0 = \delta_1 = \delta_2 = 0$). The statistic was calculated as $LR = -2[\ln L(OLS) - \ln L(SFGM)]$. Under the applicable mixed chi-square distribution, a statistically significant LR statistic leads to rejection of the null hypothesis. Second, the gamma parameter, $\gamma = \sigma^2_u/(\sigma^2_u + \sigma^2_v)$, was evaluated. Gamma measures the proportion of the composite error variance attributable to trade inefficiency rather than to random shocks.

RESULTS AND DISCUSSION

Determinants of Indonesia's cocoa butter trade

The results of the analysis of the determinants of cocoa butter exports to developed (Table 2) and developing (Table 3) countries show broadly similar estimated coefficients and significance levels. Exporter GDP (Indonesia) and economic distance are positively and significantly associated with the value of Indonesia's cocoa butter exports. In contrast, importer GDP has a significant negative effect on cocoa butter export value. The variables associated with trade

inefficiency also yield similar results for the 2 country groups. Both the real exchange rate and the TBT coverage ratio have negative and significant effects on cocoa butter trade inefficiency, indicating that higher values of these variables are associated with lower inefficiency. The high gamma values for the developed- and developing-country groups (0.95 and 0.84, respectively) indicate that most of the variance in the composite error term is attributable to inefficiency rather than random noise.

Indonesia's GDP has a positive and statistically significant effect on cocoa butter export values to both developed and developing countries. The estimated coefficients for developed countries (1.98) and developing countries (1.22) indicate that a 1% increase in Indonesia's GDP is associated with increases of 1.98% and 1.22% in cocoa butter export values, respectively. These results are consistent with Darhyati et al. (2017), who reported that Indonesia's GDP per capita significantly affects Indonesia's cocoa exports. Similarly, Sansi (2022) found that the GDP per capita of exporting countries has a positive and significant effect on the value of cocoa powder exports from Sub-Saharan African countries. This pattern is plausible because GDP reflects the total economic activity in a national economy. An increase in GDP indicates higher production capacity and greater purchasing power, enabling firms to invest in expanding production.

The GDP coefficients for importing countries in Tables 2 and 3 are negative and statistically significant, with reductions of −0.68 and −0.84, respectively. This implies that a 1% increase in the GDP of importing countries is associated with a reduction of 0.68% and 0.84%, respectively, in the value of Indonesia's cocoa butter exports. These results contradict several previous studies. For example, Danendra et al. (2025) reported that the real GDP of partner countries (ASEAN+6) has a significant positive effect on Indonesia's cocoa butter trade. For cocoa products more broadly, Darhyati et al. (2017) found that the GDP per capita of importing countries has a significant positive effect on the value of Indonesia's cocoa exports. Similarly, an analysis of the determinants of agricultural trade between Indonesia and India showed that India's GDP has a positive effect on

Table 2. Maximum likelihood estimates of the SFGM for developed countries

Variable	Coefficient	Standard error	t-ratio
Frontier intercept	−21.3	1.72	−12.39
Exporter GDP	1.98***	0.10	19.02
Importer GDP	−0.68***	0.12	−5.58
Economic distance	0.75***	0.10	7.52
Inefficiency intercept	4.79	0.54	8.72
Real exchange rate	−0.28***	0.07	−3.90
TBT coverage ratio	−0.23***	0.01	−13.99
Sigma-squared	1.64	0.31	5.18
Gamma	0.95	0.02	44.24
LR test of the one-sided error	132.42		
Number of restrictions	4		

Note: *** $p < 0.01$

Table 3. Maximum likelihood estimates of the SFGM for developing countries

Variable	Coefficient	Standard error	t-ratio
Frontier intercept	4.71	2.03	2.31
Exporter GDP	1.22***	0.38	3.23
Importer GDP	−0.84**	0.34	−2.45
Economic distance	0.44***	0.14	3.10
Inefficiency intercept	7.21	0.64	11.14
Real exchange rate	−0.31***	0.04	−6.80
TBT coverage ratio	−0.18***	0.007	−24.97
Sigma-squared	2.07	0.38	5.41
Gamma	0.84	0.01	47.59
LR test of the one-sided error	54.24		
Number of restrictions	4		

Note: *** $p < 0.01$, ** $p < 0.05$

the value of Indonesia's agricultural exports (Rosyidi et al., 2021).

Emmanuel-Rabiu et al. (2025) also obtained results that differ from this study, indicating that Nigeria's GDP and the GDP of its trading partners are positively related to cocoa exports. Sansi (2022) likewise found that the GDP per capita of importing countries has a positive and significant effect on cocoa powder export values, although the estimated coefficient is very small (0.0014). The only result that is consistent with the present findings is that of Abdullahi et al. (2021), who reported that Nigeria's GDP per capita and that of its cocoa-importing partners have significant negative coefficients. At first glance, these findings appear to contradict the common assumption that higher importing-country GDP, which signals rising consumer purchasing power or increased investment by processing companies, will tend to increase trade volumes (Abbas and Waheed, 2015; Maciejewski and Wach, 2019; Mwangi, 2021).

One possible explanation for this pattern is the structure of the cocoa butter trade. Import decisions depend not only on the importing country's GDP but also on the presence of a chocolate-processing industry. Although higher GDP can enable importing countries to invest in processing plants and thereby increase imports, this does not always occur because other commodities may be prioritized (Gopinath and Echeverria, 2004). Countries with very large GDPs, such as the United States, China, and Japan, are therefore not necessarily the main markets for Indonesian cocoa butter. By contrast, countries with smaller GDPs than the United States and China, such as the Netherlands and Estonia, import more and function as hubs for processing and re-exporting chocolate products (Jambor et al., 2017; İzgi and Kavacık, 2025).

These findings challenge the conventional assumption that larger import markets are always more attractive to exporters. For intermediate goods such as cocoa butter, the economic structure of the destination country, particularly its role in downstream processing, is more important than the size of its GDP (Mattoo et al., 2013; Baldwin and Taglioni, 2014). This implies that Indonesia's export-promotion policies could consider not only the size of destination economies but also their roles as processing hubs, such as those of the Netherlands and Estonia. Within the GVC framework, market potential for upstream suppliers may therefore be better understood by considering the presence and capacity of processing industries alongside GDP.

Economic distance also has a significant positive effect on the value of Indonesia's cocoa butter exports to both groups of countries. This result contrasts with the findings of Darhyati et al. (2017), who reported that economic distance has a significant negative effect on the value of Indonesia's cocoa exports. Emmanuel-Rabiu et al. (2025) also found that geographic distance has a negative, although statistically insignificant, coefficient for Nigeria's cocoa trade. The standard gravity model assumes proportional distance costs (Baier et al., 2018). However, for semi-finished products with geographically concentrated markets, distance is no longer a proxy for cost but rather for proximity to downstream industrial clusters. In the case of processed chocolate, major processing centers are located in Europe, which is geographically farther from Indonesia than Malaysia, Singapore, or Japan, yet Indonesia still records substantial exports to these destinations.

There are at least 2 implications for Indonesia regarding distance and trade relations. First, this suggests that export competitiveness is less related to geographic proximity and more related to integration into processing clusters (Porter, 2000). Second, from a policy perspective, international market-access strategies should focus on aligning regulations and certifications to enter processing hubs, rather than simply targeting the nearest markets.

Regarding the determinants of inefficiency, the real exchange rate had a statistically significant negative effect in both country groups. The estimated coefficients of −0.28 (developed countries) and −0.31 (developing countries) for developed and developing countries, respectively, indicate that a 1% increase in the exchange rate reduces inefficiency (i.e., increases technical efficiency) by approximately 0.28% and 0.31%, respectively. This result is consistent with the theory that a real depreciation of the rupiah is associated with lower inefficiency or higher trade efficiency (Kang and Dagli, 2018). Nevertheless, Siregar and Rajan (2004) and Heriqbaldi et al. (2023) emphasize that this relationship is highly dependent on the context, direction, and magnitude of depreciation.

These findings are also consistent with Anggoro and Widyastutik (2016), who reported that the exchange rate has a significant positive effect on Indonesia's cocoa exports. Similarly, Emmanuel-Rabiu et al. (2025) showed that the nominal exchange rate has a positive and

significant effect on the value of cocoa exports. In the same vein, Danendra et al. (2025) found that the exchange rate has a significant positive effect on Indonesian cocoa butter prices because it enhances price competitiveness in the international market, thereby stimulating demand.

Although real depreciation reduces trade inefficiency by improving price competitiveness, it is important to recognize its limitations. Depreciation is a macroeconomic condition that cannot be targeted specifically to the cocoa sector. The implication for policymakers is that relying solely on exchange rate movements is insufficient. Indonesia needs to simultaneously invest in non-price competitiveness, such as quality improvement and sustainability certification, to build resilience against exchange-rate volatility.

The TBT coverage ratio has a statistically significant negative association with trade inefficiency in both country groups. The estimated coefficients are −0.23 for developed countries and −0.18 for developing countries. These results suggest that greater TBT coverage is associated with lower estimated trade inefficiency. NTMs, which were expected to act as barriers, in practice functioned as drivers of increases in the value of Indonesia's cocoa butter exports. This finding contrasts with Darhyati et al. (2017), who reported that Sanitary and Phytosanitary (SPS) NTM policies led to a decline in the value of Indonesia's cocoa exports. In that study, TBT measures had no statistically significant effect. SPS measures are generally applied to cocoa beans, whereas TBTs are more commonly applied to processed cocoa products.

In this study, NTMs operate as catalysts in both developed and developing countries with tightly regulated markets. NTMs may restrict market access for non-compliant competitors, thereby benefiting compliant exporters (Ghodsi et al., 2017). Conversely, Ghodsi et al. (2017) explain that the effect of TBTs on firms is not significant, implying that for firms that are already exporting, TBTs do not necessarily constitute a barrier to maintaining or increasing export volumes.

These findings suggest that NTMs, particularly TBT measures, may have both beneficial and adverse effects. Although these measures increase compliance costs, they may also provide a competitive advantage to exporters capable of meeting the relevant standards by restricting market access for non-compliant competitors. Indonesia could therefore support exporters' compliance through technical assistance, certification financing, and capacity-building programs.

Indonesia's cocoa butter trade efficiency and export potential

The results of the stochastic frontier analysis also reveal the average technical efficiency of Indonesia's cocoa butter exports to developed countries (Figure 1), illustrating export performance relative to major importing partners. The analysis shows that Indonesia's cocoa butter exports have not yet reached the optimal frontier (100% efficiency) with any importing partner in the sample. Nevertheless, in 2024, Indonesia achieved a technical efficiency above 75% with 4 importing partners: the Netherlands, the United States, Estonia, and Australia. On average over the study period, the highest efficiency rates were recorded for exports to the United States, Australia, and Estonia. The United States had an average efficiency of 0.86, while the average efficiencies of all other importing countries were below 60%. The lowest average efficiency levels were found for exports to South Korea, New Zealand, and France, each with an average efficiency below 10%. Overall, these results suggest that there remains substantial scope to improve the technical efficiency of Indonesia's cocoa butter exports to developed trading partners.

Estimations of export potential (frontier values) and export gaps reveal substantial heterogeneity among developed-country markets (Table 4). The United States recorded the highest trade efficiency (0.90) and a small relative gap of USD 43.55 million, which may reflect deep market integration and strong demand from major chocolate processors. The United States benefits from Indonesia's status as a World Trade Organization (WTO) member, which grants it Most-Favored-Nation (MFN) treatment and a 0% tariff rate (Grassnick and Brümmer, 2021; Nattasya, 2026). In addition, the United States hosts major chocolate manufacturers such as Cargill, Hershey, Mars, Mondelez, and Blommer, which generate consistent demand for cocoa butter as an intermediate input (Austin, 2025).

Estonia, the Netherlands, and Australia also exhibit relatively small export gaps, indicating that strategic logistics hubs and stable regulatory environments facilitate efficient market access. Although Estonia and the Netherlands reportedly apply an MFN tariff of 7.7% and a GSP tariff of 4.2% to Indonesian cocoa butter imports (ITC,

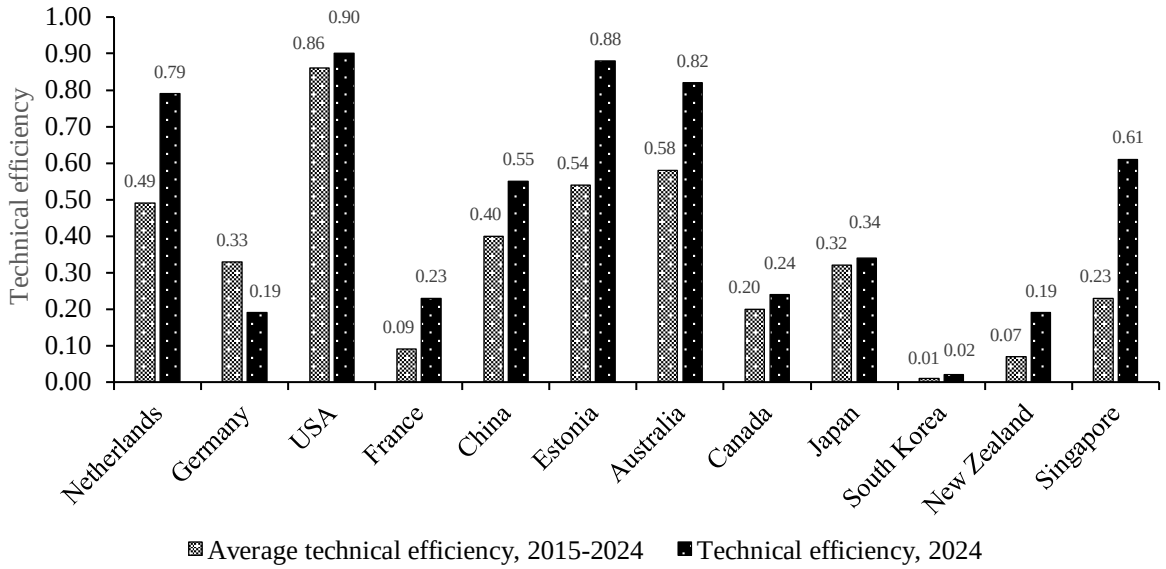

Figure 1. Average technical efficiency of Indonesia's cocoa butter exports to selected developed countries

Table 4. Export potential for Indonesia's cocoa butter in selected developed countries

Country	Technical efficiency	Actual export value (USD)	Potential export value (USD)	Export gap (USD)
Netherlands	0.79	183,787,888.42	232,642,896.73	48,855,008.31
Germany	0.19	38,587,602.73	203,092,645.95	164,505,043.22
United States	0.90	391,959,000.00	435,510,000.00	43,551,000.00
France	0.23	45,262,512.29	196,793,531.68	151,531,019.40
China	0.55	74,638,941.92	135,707,167.13	61,068,225.21
Estonia	0.88	195,328,366.54	221,964,052.89	26,635,686.35
Australia	0.82	117,349,376.42	143,108,995.63	25,759,619.21
Canada	0.24	58,206,615.60	242,527,565.00	184,320,949.40
Japan	0.34	45,576,026.31	134,047,136.21	88,471,109.90
South Korea	0.02	1,859,790.00	92,989,500.00	91,129,710.00
New Zealand	0.19	25,296,299.04	133,138,416.00	107,842,116.96
Singapore	0.61	17,299,646.19	28,360,075.73	11,060,429.53

Note: Technical-efficiency scores and export values are for 2024. USD = United States dollars

2026), both countries function as gateways to the broader European market. This role is illustrated by the presence of Steinweg Amsterdam in the Netherlands, which serves as a cocoa hub in the European Union, and Katoen Natie Eesti AS in Estonia, a major importer of Indonesian cocoa that collaborates with PT Asia Cocoa Indonesia (Weide and Paauw, 2025; Market Inside, 2026). Australia's high efficiency is associated with rising demand from its chocolate industry and trade cooperation under the Indonesia–Australia Comprehensive Economic Partnership Agreement (IA-CEPA) (Husaini, 2026).

China and Singapore have moderate trade efficiency scores, with export gaps of USD 61 million and USD 11 million, respectively. In terms of Indonesia's export ranking relative to other supplying countries, Indonesia ranks first among cocoa butter suppliers to China and second among suppliers to Singapore. These rankings indicate strong market positions for Indonesia in both countries. Nevertheless, the model estimates suggest that further export potential remains.

The low efficiency observed for Germany, France, Canada, Japan, South Korea, and New Zealand may partly reflect Indonesia's concentration of exports in other priority markets (ITC, 2025). For Germany and France, Indonesia exports more cocoa butter to the Netherlands and Estonia, both of which are members of the European Union. In the authors' assessment, this low efficiency does not necessarily indicate an inability to comply with food-safety and technical requirements, as Indonesia has already

entered the German and French markets with substantial export values. In 2024, Indonesia ranked fifth among cocoa butter suppliers to Germany, with an export value of USD 38 million, which is far below the export values of the Netherlands (USD 992 million), Côte d'Ivoire (USD 252 million), France (USD 207 million), and Nigeria (USD 161 million). This pattern indicates that Germany sources substantially more cocoa butter from other European Union members and West African suppliers.

A similar pattern is observed in France, where Indonesia ranked sixth in 2024 with an export value of USD 45 million, trailing the Netherlands (USD 229 million), Côte d'Ivoire (USD 122 million), Germany (USD 73 million), Malaysia (USD 55 million), and Spain (USD 47 million). This pattern indicates that France's cocoa butter imports are concentrated among European and West African suppliers. In Canada, however, Indonesia's cocoa butter exports have performed relatively well: Indonesia ranked third in 2024 with exports valued at USD 58 million, behind the United States (USD 214 million) and Malaysia (USD 101 million). The United States is the dominant supplier, which may reflect geographical proximity and market integration under the United States–Mexico–Canada Agreement (USMCA) (Reuters, 2025).

Japan, South Korea, and New Zealand display a different pattern. Indonesia ranks among the top 3 cocoa butter suppliers in each market: second in Japan, third in South Korea, and first in New Zealand, despite relatively low trade efficiency scores. This may reflect that the cocoa butter processing industries and markets in these countries are still developing and are relatively small compared with those in the European Union and North America. This is consistent with their estimated potential export values being lower than those for the European Union and North American markets.

Table 5 reports the average technical efficiency of cocoa butter exports to developing countries. The analysis indicates that Indonesia's cocoa butter exports to these markets are characterized by very low efficiency for all importing partners except India. Only India recorded a relatively high average efficiency (75%). Malaysia has the second-highest average efficiency at 22%, although this value remains very low. The lowest average efficiencies are observed for the Philippines, Pakistan, Saudi Arabia, and South Africa, each with an average efficiency below 10%. These results suggest that Indonesia's cocoa butter trade with developing countries is highly inefficient, except for India. A comparison of the 2 efficiency tables shows that India's efficiency exceeds that of many developed countries. India's high average efficiency may be associated with relatively favorable market access (Harilal and Dhanya, 2015). In addition, strong business ties between India and Indonesia appear to support higher transaction volumes (Veeramani and Saini, 2011; Kustiari, 2017).

An analysis of export potential (Table 6) for developing countries reveals a marked contrast between India and the other markets. India

Table 5. Average technical efficiency of Indonesia's cocoa butter exports to selected developing countries

Country	Average technical efficiency, 2015–2024	Technical efficiency, 2024
India	0.75	0.91
Malaysia	0.22	0.13
Pakistan	0.02	0.02
Philippines	0.002	0.001
Saudi Arabia	0.01	0.01
South Africa	0.05	0.05

Table 6. Export potential for Indonesia's cocoa butter in selected developing countries

Country	Technical efficiency	Actual export value (USD)	Potential export value (USD)	Export gap (USD)
India	0.91	289,242,515.22	317,848,917.82	28,606,402.60
Malaysia	0.13	16,651,339.51	128,087,227.01	111,435,887.50
Pakistan	0.02	3,949,114.61	197,455,730.50	193,506,615.89
Philippines	0.001	107,162.53	107,162,530.00	107,055,367.47
Saudi Arabia	0.01	2,020,263.30	202,026,330.00	200,006,066.70
South Africa	0.05	14,981,597.44	299,631,948.80	284,650,351.36

Note: Technical-efficiency scores and export values are for 2024. USD = United States dollars

exhibits a relatively small export gap of USD 28 million. This high level of efficiency is closely associated with the ASEAN–India Free Trade Agreement (AIFTA), which eliminates or substantially reduces tariffs on cocoa butter (Danendra et al., 2025). India's large food-processing sector also generates sustained demand for cocoa butter as an intermediate input (Fulara, 2026). In addition, Indonesia and India have long-standing diplomatic and business ties; for example, Indonesia was India's second-largest trading partner in the ASEAN region during the 2023–2024 fiscal year (Confederation of Indian Industry, 2025).

Apart from India, all developing countries in the sample record low trade efficiency scores. This pattern is consistent with the findings for several developed countries that also exhibit low efficiency scores. Indonesia has not yet fully realized its export potential in any developed market, and this gap is even more pronounced in developing countries, where industrial capacity and demand are generally lower than in developed countries. Nevertheless, in terms of export rankings for 2024, Indonesia has recorded a strong actual export performance, ranking first in South Africa and Malaysia, second in Pakistan, and third in the Philippines. Overall, Indonesia continues to demonstrate solid trade performance despite its substantial untapped export potential.

Policy implications

The empirical results of this study yield 3 main policy implications. First, policymakers should prioritize markets with large industrial bases and established processing centers. The significant negative coefficient on the importing country's GDP variable suggests that, for cocoa butter exports, Indonesia should consider countries' roles as processing hubs rather than focusing solely on the size of their economies. The government and exporters could therefore prioritize efforts to realize the estimated export potential in markets such as the United States, the Netherlands, Estonia, Australia, and India.

Second, the government should strengthen support and assistance for compliance with global trade regulations. The findings indicate that greater TBT coverage is associated with lower trade inefficiency, suggesting that compliance with these measures may provide Indonesian exporters with a competitive advantage. The government can further reinforce this advantage by providing technical assistance and certification subsidies to farmers. Such support could encourage more sustainable practices, facilitate compliance with traceability requirements, and help ensure that Indonesia's cocoa industry is prepared for the implementation of the EUDR.

Third, policy should focus on increasing production capacity and downstream processing. Estimates of potential export value indicate substantial room for further growth, despite Indonesia's strong supplier rankings in several markets. The government could encourage investment in 2 areas. First, it could promote investment in cocoa-plantation intensification to raise productivity, increase national production, and meet the needs of the processing industry more reliably. Second, it could support the establishment of processing facilities by domestic and international firms to expand processing capacity and, where feasible, increase the production of finished products such as chocolate confectionery, which offer higher value-added.

CONCLUSIONS

The study finds substantial variation in the technical efficiency of Indonesia's cocoa butter exports over 2015–2024. Among developed countries, the United States exhibits the highest average efficiency (0.86). Among the developing countries, India shows a high average efficiency (0.75). This indicates that efficiency depends not on income level but on the presence of chocolate-processing hubs. This suggests that for Indonesian exporters who comply with these measures can generate competitive advantages and access to premium markets. The study recommends the government prioritize trade diplomacy with efficient markets, facilitate compliance with NTMs, and strengthen supply chain quality to enhance export competitiveness.

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