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Export efficiency and determinants of Indonesian spices exports to major destination countries

Maya Aulia Ardini [a,1], Fahmi Salam Ahmad [a,2,*], Syarifah Amaliah [a,3]

[a] Department of Economics, IPB University, Indonesia
[1]mayaaulia3107@gmail.com; [2]fahmisalam@apps.ipb.ac.id*; [3]samaliah@apps.ipb.ac.id

* corresponding author

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ABSTRACT

Indonesian spice exports (HS 0904 to 0910) have been a major contributor to non-oil and gas exports. One issue related to spice exports is that their performance often fluctuates and does not truly reflect the "full potential" that can actually be achieved. Therefore, this study seeks to answer two questions: how efficient Indonesian spice exports are and what factors most determine their performance in eleven key destination markets from 2012 to 2023. The method used is the Stochastic Frontier Gravity Model (SFGM), which estimates the influence of economic factors and sources of inefficiency within a single framework. With this analytical method, export performance is not only assessed based on actual figures but also directly compared with their maximum potential. Based on the estimation results, Indonesia's real GDP, the real exchange rate, and economic distance are negatively related to spice exports. Conversely, partner country GDP and government effectiveness in destination countries have a positive and significant impact. The efficiency estimate shows a moderate figure, with an average of only 54.17%. Among the partner countries studied, India was the most efficient market (88.20%), while Japan ranked lowest (5.39%). The Covid-19 dummy factor did not prove statistically significant. Overall, these findings indicate wide differences in efficiency across destination countries. Therefore, future strategies should not simply focus on increasing export volumes but also focus on improving efficiency, strengthening logistics competitiveness, and expanding export destinations to maximize Indonesia's spice export performance.

1. Introduction

Non-oil and gas exports are one of the backbones of the Indonesian economy. This is due to Indonesia's strong natural resource base and diverse product range. Over the past ten years, the non-oil and gas sector has also appeared relatively more resilient to shocks than the oil and gas sector, which is heavily influenced by fluctuations in global commodity prices. In 2023, non-oil and gas exports contributed more than 90% of total national exports. This figure demonstrates the dominance of non-oil and gas in Indonesia's trade performance (BPS, 2024). Within the non-oil and gas sector, the agriculture and plantation sector remains one of the leading commodity sources. The contribution of agricultural and plantation exports is quite significant in generating foreign exchange and driving regional development. This pattern is also seen in several other countries, particularly developing ones. In Tunisia, for example, agricultural exports are closely linked to the movement of aggregate output through an export-led growth path (Trabelsi & Kachout, 2024).

For Indonesia, the plantation sector is a significant contributor to non-oil and gas exports, with key commodities such as palm oil, rubber, coffee, and spices. In 2022, the plantation sector's

contribution reached approximately 15% of total non-oil and gas exports (BPS, 2024). The impact extends beyond the trade balance. Not only for trade, but the plantation sector is directly linked to the livelihoods of rural communities. As of August 2023, the number of plantation workers was recorded at 12.22 million people, or approximately 8.74% of the total workforce (Ministry of Agriculture, 2023). This means that strengthening plantation exports is not merely an effort to diversify exports but also plays a role in supporting income and employment opportunities in villages.

Among Indonesia's plantation commodities, spices possess unique characteristics. Beyond their economic value, there are also inherent historical and cultural reasons. Indonesian spices are known for their aroma and natural character, and are widely used for various purposes, from culinary and pharmaceutical products to cosmetics and health (Ministry of Trade, 2021). In the global market, demand for spices tends to increase with the strengthening trend for natural and organic products. Evidence from India, the largest spice exporter, shows that expanding spice production and exports can be associated with increased added value and rural incomes, despite high volatility over time (Biswas et al., 2025). In other words, spices have the potential to leverage exports and regional development, but this effect can only be realized if managed properly.

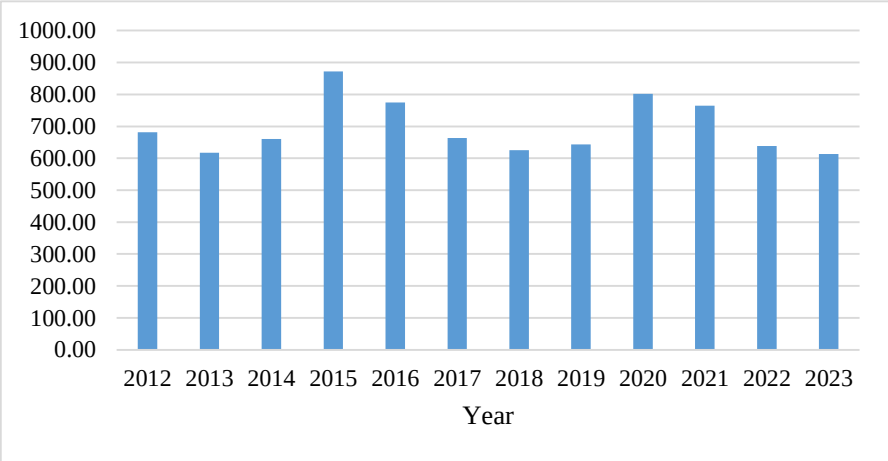

Figure 1. Export Value of Indonesian Spices (million US$) in 2012-2023

Figure 1 shows that Indonesian spice exports tended to fluctuate and fluctuate between 2012 and 2023. Export value increased until 2015, reaching a peak of around US$872.11 million (approximately 0.58% of total exports). However, after that, the general trend gradually weakened, reaching around US$613.78 million in 2023. This trend included episodes related to global shocks. In 2020, when the pandemic struck, Indonesian spice exports actually increased to around US$801.51 million. This is thought to be due to the pandemic shifting the demand structure, with demand for some food/agricultural products actually increasing, particularly herbal products and commodities associated with increased immunity (Ridley et al., 2023; Arita et al., 2022). However, when viewed more broadly over the entire decade, Indonesia's spice export performance appears more stagnant and inconsistent. The surges in 2015 and 2020 appear more episodic than evidence of stable competitiveness.

The stagnation of Indonesian spice exports over the past decade suggests untapped potential. Indonesia's spice markets remain concentrated in a handful of countries (e.g., China, the United States, India, Vietnam, and the Netherlands), increasing the risk of demand shocks or policy changes in destination countries (LPEI, 2023). Competitive pressures are also increasing as India, Vietnam, and several African countries actively strengthen product quality, encourage added value, and build brands (Biswas et al., 2025; Thomas et al., 2025). Other issues include increasing demands for quality standards, food safety, and traceability, particularly in high-income countries. India's experience shows that standard violations can lead to rejection and damage the exporter's reputation (Thomas et al., 2025; Pigłowski et al., 2025). Furthermore, logistics and infrastructure factors influence final costs through port efficiency and land connectivity. When logistics costs are high, price competitiveness is also under pressure. This aligns with findings that logistics performance is often a key factor in agricultural exports (Daryanto & Sahara, 2016; Mendes dos Reis et al., 2020; Kurniawan & A'yun, 2022; Nguyen & Vu, 2025). Furthermore, the OECD (2020) and the World

Bank (2020) identified complex border procedures, fragmented inter-agency coordination, and high transaction costs.

Based on these conditions, measuring the efficiency of Indonesian spice exports and identifying its determinants becomes relevant. It can be identified whether the main obstacles to spice exports stem predominantly from macro factors (e.g., income and exchange rates), geographic factors (distance), or "behind-the-border" constraints such as the quality of governance and logistics. Academically, spices are interesting because they are a high-value agricultural commodity that is sensitive to quality, standards, and institutional support, making them suitable for examining export efficiency issues more closely.

The gravity model is commonly used to explain bilateral trade flows through economic size, distance, and exchange rates (Anderson, 2011; Head & Mayer, 2014). However, this approach can be enhanced with a stochastic frontier gravity model (SFGM) to capture the fact that agricultural exports often fall below their potential due to both observable factors and subtle frictions (Nguyen, 2020; Abdullahi et al., 2022). Within this framework, economic distance is understood as a proxy for trade costs for agricultural and trade-sensitive products (Jiang et al., 2022). Furthermore, the real exchange rate has the potential to influence trade efficiency, particularly in developing countries (Muriu et al., 2024). Beyond standard gravity variables, institutional quality can also determine export performance. One relevant indicator is government effectiveness, which encompasses the quality of public services, the ability to formulate and implement policies, and the credibility of government commitments. This indicator is associated with export expansion through better regulation, reduced bureaucratic barriers, and more effective logistics coordination (Pertiwi et al., 2020; Nzama et al., 2023). Government effectiveness can be relevant for agricultural/food products that require institutional support in standards, certification, and trade facilitation at ports, customs, and inspection authorities.

In addition to these structural determinants, external shocks such as the Covid-19 pandemic also need to be examined. Empirical evidence suggests that agricultural trade tends to be more resilient than non-agricultural trade. However, the pandemic can still alter patterns and suppress trade flows in some product groups (Ridley et al., 2023; Engemann et al., 2022; Arita et al., 2022). For spices, the impact can be two-way: opportunities from increased demand for herbal products, or logistical disruptions and mobility restrictions. In Indonesia, mobility restrictions, port congestion, and supply chain disruptions during the pandemic have been shown to impact agricultural exports (Sari et al., 2022). Therefore, the net impact of Covid-19 on Indonesian spice exports needs to be empirically demonstrated.

While the agricultural trade literature continues to grow, there remains a gap in the case of Indonesian spices. Previous research has focused more on production, domestic value chains, or the demand side, while measuring export efficiency relative to potential is still rare. The novelty of this study lies in three aspects. First, the use of a frontier approach to generate country-specific efficiency scores. Second, incorporating the effectiveness of partner country governments as a determinant of institutional aspects. Third, focusing on 11 major importers during 2012-2023 to provide new evidence on the role of economic factors, institutions, and external shocks in an integrated analysis. With this framework, this study answers three questions: (1) how has Indonesia's spice exports developed in the main destination countries; (2) what factors determine these exports; and (3) how efficient are Indonesia's spice exports compared to their potential in each partner country.

2. Literature Review

2.1. Export and its Role in Economy

Exports are often viewed as one of the driving forces of economic development. In international trade theory, a country's entry into the global market provides access to a much broader market, opens up space for companies to utilize larger production scales, and encourages specialization based on comparative advantages (Krugman et al., 2012). In many empirical studies, increased exports often go hand in hand with increased productivity, increased foreign exchange reserves, and more stable macroeconomic conditions (Hausmann et al., 2007). For countries with a strong economic base in agriculture and natural resources, exports have important additional effects. A stable export base can provide a pathway to job creation in rural areas while strengthening value chains. When producers are

connected to international markets, there is an incentive to increase efficiency and increase added value, both through improved production processes and enhanced product quality (Celine et al., 2018).

In the context of Indonesia, as a commodity exporter, export performance is not only about overseas sales. Exports directly influence foreign exchange availability, balance of payments equilibrium, and even the direction of structural transformation of the economy. Sustained export growth tends to be positively correlated with long-term economic expansion, particularly when supported by increasingly efficient logistics systems, adequate institutional quality, and more diversified destination markets (UNCTAD, 2022; Yotov et al., 2024). This perspective serves as a reference for examining the factors shaping export performance and whether a commodity's export performance aligns with underlying economic fundamentals.

2.2. Export Efficiency

Export efficiency refers to the extent to which a country is able to approach its export potential. This potential is determined by economic characteristics, market size, distance, and institutional quality. Actual exports reflect the trade flows that actually occur, while potential exports represent the maximum level of trade that could be achieved when observable determinants are at their most favorable conditions (Noviyani et al., 2019). Kalirajan (1999) defines trade potential as the highest possible trade volume between two countries in the absence of policy distortions or trade frictions. Therefore, the gap between actual and potential exports can be interpreted as trade inefficiency. This measure is usually expressed as an efficiency ratio ranging from 0 to 1. A value close to 1 indicates that exports are very close to their potential, while a much lower value indicates obstacles, such as logistical issues, regulations, or product quality that does not meet the standards of the target market (Ravishankar & Stack, 2014). Mathematically, export efficiency can be expressed as follows:

$$Export\ Efficiency = \frac{actual\ export}{potential\ export} \quad (1)$$

The stochastic frontier gravity model (SFGM) is widely used to estimate potential exports directly through a gravity-based frontier. The advantage of this approach is its ability to distinguish between random deviations and systematic inefficiencies (Nguyen, 2020; Abdullahi et al., 2022). This concept is relevant for agricultural commodities because export gaps are often determined not only by economic size and distance, but also by applicable factors such as product quality, compliance with standards, and logistics performance. These factors ultimately determine how closely actual exports can catch up to potential exports.

3. Method

This study uses secondary data in a panel format. The time series dimension consists of annual data from 2012 to 2023. The cross-sectional dimension covers 11 major destination countries for Indonesian spice exports: China, the United States, India, Vietnam, Malaysia, the Netherlands, Singapore, Pakistan, Germany, Japan, and France. These eleven countries were selected because their export shares are quite dominant, representing approximately 82% of Indonesian spice exports in aggregate, and are therefore considered capable of depicting relevant key trade patterns. The commodities analyzed are the aggregate spice group in HS 0904 to 0910 (four digits). This group includes pepper (0904), vanilla (0905), cinnamon (0906), cloves (0907), nutmeg and cardamom (0908), anise/coriander/cumin seeds (0909), and ginger and other spices (0910). The export value variable is then defined as the total export value of all commodities within the HS 0904 to 0910 range.

Table 1. Definition of Variables

Variable	Unit	Source	Notation
Export Value	US$	WITS	X_{it}
Indonesia' Real GDP	US$	World Bank	GDP_{it}
Real GDP of Destination Country	US$	World Bank	GDP_{jt}
Real Exchange Rate	Rp/LCU	UNCTAD	RER_{ijt}
Economic Distance	Km/US$	CEPII	$EDIST_{ijt}$
Government Effectiveness	Index (-2,5 to 2,5)	WDI	GOV_{jt}
Dummy Covid-19	binary	-	dcovid

Source: multiple sources

Table 1 shows the Export value (X) refers to the total value of Indonesia's spice exports to major destination countries during 2012–2023, measured in million US$. Real GDP ($GDP_{it}$ and GDP_{jt}) represents the real GDP of Indonesia and its partner countries, reflecting annual economic growth at constant prices. Real exchange rate (RER) measures the relative price of goods between Indonesia and its trading partners, calculated as nominal exchange rate × (partner CPI/Indonesia CPI). Economic distance (EDIST) reflects trade-related transport costs, derived from geographical distance divided by the average GDP of the two countries. Government effectiveness (GOV) assesses the quality of public services, policy implementation, and government credibility, with values ranging from –2.5 to +2.5. The COVID-19 dummy equals 0 for non-pandemic years and 1 for the pandemic period (2020–2021).

Efficiency measurements are conducted using the Stochastic Frontier Gravity Model (SFGM). The stochastic frontier approach was initially introduced to measure technical efficiency (Aigner et al., 1977), and was later extended to the context of international trade by incorporating it into the gravity model (Drysdale et al., 2000). The key to this model lies in separating the error component into two parts: random error (v) and inefficiency (u). With this mechanism, the difference between actual and potential exports can be interpreted as trade inefficiency, rather than simply variation arising from chance factors. In general, the SFGM can be written as follows:

$$X_{ij} = f(T;\beta)\exp(v_{ij} - u_{ij}) \quad (2)$$

with v_{ij} representing random variation, while u_{ij} captures the trade inefficiency between country i and country j. Next, the trade efficiency (TRE) score is derived as:

$$TRE_{ijt} = \frac{\exp(lnX_{ijt})}{\exp[Inf(Y_{ijt};\beta)+V_{ijt}} = \frac{f(Y_{ijt};\beta)\exp(V_{ijt}-U_{ijt})}{f(Y_{ijt};\beta)\exp(V_{ijt})} = \exp(-U_{ijt}) \quad (3)$$

The TRE value ranges from 0 to 1. The closer it is to 1, the closer actual exports are to their potential frontier. The empirical model uses the value of Indonesian spice exports as the dependent variable. Explanatory variables included include Indonesia's real GDP, the real GDP of the destination country, the real exchange rate, economic distance, government effectiveness, and a COVID-19 dummy. The variable selection and specification form are based on model development from relevant previous studies, such as Noviyani et al (2019), Pertiwi et al (2020), Sari et al (2022), and Muriu et al (2024). The research model can be expressed through the following mathematical equation as follows:

$$lnX_{ijt} = \alpha_0 + \beta_1 lnGDP_{it} + \beta_2 lnGDP_{jt} + \beta_3 lnRER_{ijt} + \beta_4 lnEDIST_{ijt} + \beta_5 GOV_{jt} + \beta_6 dCOVID_t + V_{ijt} - U_{ijt} \quad (4)$$

Where X_{ijt} is the value of Indonesia's spice exports to partner country *j* in year *t* (Million USD); GDP_{it} is the real gross domestic product of Indonesia in year *t* (Million USD); GDP_{jt} is the real gross domestic product of partner country *j* in year *t* (Million USD); RER_{ijt} is the real exchange rate of Indonesia against partner country *j* in year *t* (Rp/LCU); $EDIST_{ijt}$ is the economic distance between Indonesia and partner country *j* (Km/USD); GOV_{jt} is the government effectiveness of partner country *j* in year *t* (index); $dCOVID_t$ the dummy variables as 1 = during COVID period (2020–2021), 0 = otherwise; V_{ijt} is the double-sided error term capturing omitted variables and measurement errors distributed randomly; U_{ijt} is the Error term distributed exponentially or half-normally, representing technical inefficiency; α_0 is the constanta; $\beta_1 - \beta_6$ is the coefficient of independent variables; ln is the natural logarithm and t is the period from 2012-2023.

The SFGM model controls for key macroeconomic and geographic factors, while the remaining unobserved heterogeneity is absorbed through a composite error term that separates random noise (v) from systematic inefficiency (u). This inefficiency element helps mitigate the influence of omitted variable bias and allows deviations from predicted exports to be interpreted as inefficiencies. Therefore, the advantage of the stochastic frontier gravity approach in this study is that it estimates the trade frontier while simultaneously generating efficiency scores. One risk in the gravity model is the potential for endogeneity, where GDP is simultaneously determined by trade flows. In this study, Indonesia's GDP and the GDP of its partner countries are treated as exogenous "mass" variables. This approach aligns with the structural gravity literature, which views economic size as a fundamental determinant of bilateral trade, rather than driven by the flow of a single commodity (Anderson, 2011; Head & Mayer, 2014). Given that spice exports constitute a very small share of total output, the potential for reverse causality from bilateral exports to GDP is expected to be minimal. This is commonly used in applications of the SFGM to agricultural exports (Nguyen, 2020; Abdullahi et al., 2022).

4. Results and Discussion

Figure 2 shows the fluctuations in Indonesian spice exports to 11 major markets from 2012 to 2023. The fluctuations are indicated by year-to-year fluctuations, with a downward trend in the latter half of the period. It's important to remember that these eleven countries account for approximately 82% of Indonesia's total spice exports, so the pattern shown here is fairly representative of the overall picture. In terms of market share, the United States holds the top spot with an average export value of around US$155.5 million annually. Vietnam follows closely behind (US$109.7 million), followed by India (US$77.5 million). Meanwhile, China has a somewhat different dynamic. From 2018 until the pandemic, demand from this country has tended to surge. One plausible explanation is the increasing consumption of herbal and natural products, along with the strengthening of the health agenda and support for traditional medicine and nutraceutical products (Fang et al., 2025). At the same time, many other destination markets have shown weakness. This is generally related to two factors: increased competition and stricter regulations. In the global spice market, Indonesia's main competitors are India and Vietnam.

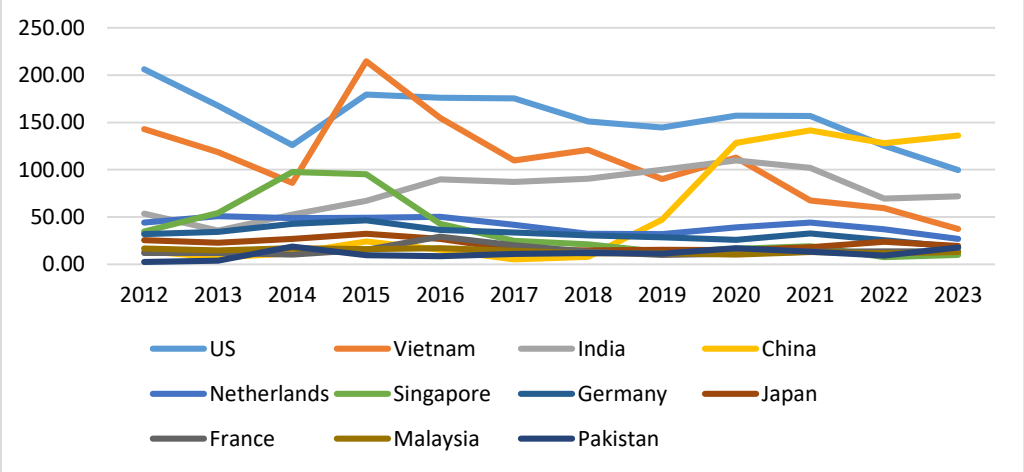

Figure 1. The development of Indonesia's spice export value to 11 main destination countries from 2012-2023

Based on commodity group or HS, pepper (HS 0904) was initially the mainstay. Its value peaked in 2015 at around US$520.9 million, after which it declined sharply to around US$99.9 million in 2023. The 2015 spike appears to have been a "single event", rather than a sustained trend. One trigger was a decline in Vietnamese production, prompting the country to increase imports for processing and re-export (Chusepepper, 2015). Prices also played a role. International prices reached US$11.33/kg, a three-year high at the time (Rosyita et al., 2023). During the same period, the structure of Indonesian spice exports began to shift. More stable commodities gradually gained importance. Cinnamon (HS 0906), for example, has seen growth since 2014. Nutmeg and cardamom (HS 0908) became the largest exporters in 2023, with a value reaching US$207.1 million. Other commodities, such as fennel/coriander/cumin (HS 0909), are still small, but tend to increase. Meanwhile, vanilla (HS 0905) and cloves (HS 0907) fluctuate more frequently. This shift demonstrates that the resilience of Indonesian spice exports cannot be supported by just one or two commodities. Diversification is becoming increasingly important, alongside consistent export trends. Furthermore, compliance with quality standards and global market regulations will increasingly determine who can survive and thrive.

The Stochastic Frontier Gravity Model (SFGM) estimation results for 2012-2023 are presented in Table 2. A gamma value of 0.988 indicates that approximately 98.8% of the residual variation stems from technical inefficiency rather than random error. Therefore, deviations from the potential export frontier are not simply statistical noise, but rather systematic factors that prevent exports from reaching their optimal capacity. Indonesia's real GDP has a negative and significant effect on spice exports (coefficient -0.979; $p = 0.008$). While this may seem counterintuitive, it makes sense from a domestic consumption perspective. As incomes increase, domestic consumption of food, beverages, herbal products, and spice derivatives tends to increase. Consequently, the surplus available for export can decrease. This pattern often occurs in agricultural commodities with a strong domestic consumption base (Celine et al., 2018).

Table 2. The Result of SFGM

Variables	Coefficient
GDP_{it}	-0.979*** (-2.65)
GDP_{jt}	0.187* (1.85)
RER_{ijt}	-0.216*** (-5.00)
$EDIST_{ijt}$	-0.536*** (-2.71)
GOV_{jt}	0.825*** (3.52)
$dCOVID_t$	0.155 (1.23)
C	23.415** (2.49)
Diagnostic Tools	
Sigma-squared	23.295 (217.525)
Gamma	0.988 (0.105)
LR-Test	44.28

Source: data processed

Data from the Ministry of Agriculture (2022) supports this pattern. Domestic clove consumption increased from 104,765 tons in 2020 to 127,559 tons in 2021 (a 21.7% increase). At the same time, exports actually decreased from 26,405 tons to 12,290 tons. This consistent pattern demonstrates that when purchasing power increases, the domestic market absorbs more. Sugiyanto (2017) also emphasized that rising GDP can boost domestic consumption. In contrast, the real GDP of partner countries is positive (coefficient 0.187; p = 0.065). This aligns with the gravity model's prediction that larger economies tend to import more due to increased purchasing power and more diverse consumption preferences (Head & Mayer, 2014; Yotov et al., 2024). In high-income countries, spice demand is typically linked to the processed food industry, nutraceutical products, and cross-cultural culinary habits. Several empirical studies also indicate a similar relationship (Ridley et al., 2023; Abdullahi et al., 2022).

The real exchange rate has a negative and significant effect (coefficient -0.216; p = 0.000). This means that changes in the RER leading to depreciation do not automatically increase the value of spice exports. One possible explanation is the relatively inelastic demand for spices. If demand is not highly responsive to price changes, depreciation could reduce export revenues more than increases in volume. This finding aligns with Muriu et al (2024). Furthermore, exchange rate stability is often more important for agricultural commodity exports than short-term price fluctuations (Ridley et al., 2023; Satriana et al., 2022). Economic distance is also negative and significant (coefficient -0.536; p = 0.007). This result is consistent with theory, where distance increases shipping costs, extends travel times, and complicates logistics coordination. For spices, handling and quality issues become even more sensitive. Recent gravity literature also confirms that distance remains a strong barrier despite advances in transportation technology (Jiang et al., 2022; Mayer & Steingress, 2020). Other evidence suggests that high logistics costs can indeed depress agricultural exports, especially when multimodal connectivity and cold chains are limited (Mendes dos Reis et al., 2020; Nguyen & Vu, 2025; Darsono et al., 2025).

The most prominent variable is government effectiveness in the partner country. Its coefficient is positive, large, and highly significant (0.825; p < 0.01). This coefficient is the largest among all variables. This confirms that governance in the destination country has a significant impact. Effective governance is typically accompanied by streamlined customs procedures, more efficient border management, more consistent regulations, and less procedural uncertainty. This combination lowers non-tariff costs and facilitates the flow of goods (Pertiwi et al., 2020; OECD, 2020). For quality-sensitive products like spices, the effect is even stronger (Nguyen, 2020; Abdullahi et al., 2022; Ridley et al., 2023). In general, these findings align with the literature on institutions and trade (Kaufmann et

al., 2010; Ahmad & Hall, 2017). The Covid-19 dummy is insignificant (p = 0.218). In other words, when viewed in aggregate, the pandemic has not had a consistent impact on the value of spice exports. The effects likely cancel each other out: in some countries demand increases due to the herbal product trend, while in others it decreases due to logistical disruptions. When all these effects are combined, the net effect is statistically insignificant.

Table 3. Average efficiency scores of Indonesia's spice exports to eleven major destination

Country	Average (%)
United States	81.37
Netherlands	86.84
China	27.57
India	88.20
Japan	5.39
Germany	42.93
Malaysia	18.96
Pakistan	56.10
France	26.85
Singapore	82.43
Vietnam	79.24
Average	54.17

Source: data processed

Table 3 shows the average efficiency of Indonesian spice exports from 2012 to 2023 was 54.17%. This means there is still a gap of approximately 45.83% from what could be considered "optimal." This suggests that existing export capacity is not yet fully utilized and there is significant room for improvement. Based on export destinations, India recorded the highest efficiency at 88.20%. Several factors support this finding, including the Indian market's large size, culturally ingrained spice consumption, relatively stable demand, and geographic proximity to Indonesia, which contributes to efficient logistics. After India, other countries with high efficiency include the Netherlands (86.84%), Singapore (82.43%), the United States (81.37%), and Vietnam (79.24%). These markets are generally supported by established trade networks and relatively mature logistics systems. The high efficiency in these countries has several significant implications. Indonesian products are more competitive due to lower logistics costs and shorter delivery times. This makes it easier to achieve increases in export volume and value, positively impacting foreign exchange earnings, smoother trade relations, and reducing logistical risks. In the medium term, these conditions have the potential to attract investment to strengthen supply chains and export-oriented processing industries. On the other hand, some destination countries have very low efficiency. Japan is the most extreme example, with a trade efficiency of only 5.39%. This figure indicates that Indonesia has not yet become a major spice supplier to the Japanese market. The Japanese market is notoriously selective, with stringent requirements regarding food safety, pesticide residue limits, and traceability systems (Japan External Trade Organization, 2021). Indonesia's spice production structure, heavily reliant on smallholder farmers, makes meeting these high standards challenging. As a result, market penetration is limited and efficiency declines.

Besides Japan, Indonesia's spice trade efficiency with Malaysia is also relatively low (18.96%), despite their proximity. This serves as a reminder that geographical proximity does not automatically guarantee efficiency. Despite its efficiency, Indonesia's export value to Malaysia is also relatively small compared to competing countries such as India and China. Malaysia tends to choose suppliers that offer a more competitive combination of quality, price, and distribution networks. Indonesia's spice trade efficiency to France stands at 26.85%. One factor that may explain this is Indonesia's small share in the market, but it faces high competition from other exporters. Furthermore, the European Union market is known for its stringent quality and sustainability standards. Without strong certification and compliance, Indonesia will struggle to compete efficiently. Another export destination with relatively low efficiency is China, with an efficiency of 27.57%. Despite its significant market potential, Indonesia's export value remains significantly lower than that of major suppliers to China, such as India, and Indonesia's export patterns to China are also quite volatile. Data shows that a sharp spike in Indonesian exports only emerged towards the end of the period. Therefore, the aggregate efficiency score remains low. This reinforces the important point that the consistency of exports to a market, not just market size, determines trade efficiency. Therefore, the aggregate

efficiency remains low. This finding reinforces an important point: the consistency and stability of exports to a particular market, rather than market size alone, are key factors in determining trade efficiency.

5. Conclusion

This study examines the determinants and efficiency of Indonesian spice exports to 11 major destination countries from 2012 to 2023, using the Stochastic Frontier Gravity Model (SFGM) approach. In general, spice export performance during the observation period appears unstable, fluctuating, and has tended to weaken in recent years. The estimation results show that the influence of each variable does not move in the same direction. Indonesia's real GDP is negatively related to exports, as is the real exchange rate. Conversely, partner country GDP drives export growth. Beyond standard gravity variables, government effectiveness in destination countries emerges as a very strong factor in increasing exports. Meanwhile, economic distance remains a significant and consistent barrier. Based on trade efficiency estimates, the average export efficiency is only 54.17%. This means that nearly half of the export potential remains unrealized. Furthermore, the efficiency gap between destination countries is quite wide, with some markets where Indonesian spice exports are approaching their potential, while others remain far below their potential. Academically, these findings confirm that export performance is determined not only by classical gravity variables such as economic size and distance, but also by institutional quality. The use of SFGM helps clarify the "distance" between actual and potential exports, making systematic barriers more easily discernible.

Several policy implications can be derived from the model results. First, the negative effect of domestic GDP indicates that export strengthening needs to be supported by higher productivity to maintain an export surplus. The focus covers the upstream-downstream value chain, including increasing farmer capacity, improving post-harvest handling, and strengthening the processing industry. Second, the positive effect of partner GDP and the strong role of effective partner country governments signal that export promotion strategies should prioritize relatively stable and well-governed markets, such as India, the United States, Vietnam, and the Netherlands. Third, the results related to exchange rates emphasize the importance of exchange rate stability and strengthening risk management for exporters. Fourth, the economic distance barrier needs to be addressed through logistical improvements, ranging from port efficiency and supporting infrastructure to simplifying trade procedures. For export destination markets with low efficiency, such as Japan, France, and Malaysia, approaches to improving export performance need to be more specific and cannot be generalized. The key points are adherence to quality standards, traceability, and certification. At the same time, promoting value-added products is crucial to ensure Indonesia continues to export raw materials. Overall, coordinated improvements to the supply chain, quality systems, and trade facilitation are key prerequisites for fully realizing Indonesia's spice export potential.

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