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Indonesian Exports to ASEAN: A Gravity Model Analysis of Primary and Manufactured Goods

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Abstrak

Penelitian ini bertujuan untuk menguji hubungan antara ekspor produk primer dan manufaktur Indonesia ke negara-negara anggota ASEAN dengan ukuran ekonomi dan jarak geografis, serta untuk mengeksplorasi sejauh mana model gravitasi standar dan model gravitasi yang diperluas dapat menjelaskan arus perdagangan ini dan apakah hubungan tersebut berbeda antara kedua kategori produk tersebut. Menggunakan data panel ekspor Indonesia ke anggota ASEAN dari tahun 2013 hingga 2022, hasil penelitian menunjukkan bahwa ukuran ekonomi mitra dagang memiliki hubungan positif dan signifikan terhadap ekspor Indonesia, sedangkan jarak geografis berhubungan negatif dan signifikan. Status sebagai negara terkurung daratan (*landlocked*) berdampak negatif pada ekspor kedua kelompok produk, sementara perbatasan langsung (*contiguity*) menunjukkan hasil yang beragam: berhubungan positif dengan ekspor produk primer tetapi negatif terhadap ekspor barang manufaktur. Temuan ini mengonfirmasi model gravitasi, di mana ukuran ekonomi mendorong ekspor Indonesia, sementara jarak geografis dan status terkurung daratan menghambat perdagangan, dengan perbatasan langsung menguntungkan ekspor produk primer tetapi membatasi ekspor barang manufaktur. Temuan ini dapat memberikan implikasi kebijakan, di mana upaya untuk mengurangi biaya transportasi dan logistik dapat berkontribusi pada peningkatan ekspor Indonesia ke negara-negara ASEAN, terutama ke negara-negara dengan pendapatan relatif tinggi seperti Singapura, Malaysia, dan Thailand, yang merupakan pasar utama bagi ekspor Indonesia di ASEAN. Selain itu, Indonesia perlu meningkatkan logistik, meningkatkan efisiensi administrasi bea cukai dan perdagangan untuk mengurangi hambatan perdagangan, dan meningkatkan aksesibilitas, terutama untuk anggota ASEAN yang terkurung daratan. Mengingat dampak negatif perbatasan langsung terhadap ekspor produk manufaktur, Indonesia dapat meningkatkan daya saing industrinya melalui adopsi teknologi, diversifikasi ke produk dengan kandungan teknologi lebih tinggi, serta memperkuat partisipasi dalam rantai pasok regional agar lebih selaras dengan struktur permintaan industri di ASEAN.

Kata kunci: Ekspor, Komoditas Primer, Produk Manufaktur, Model Gravitasi, Pseudo Poisson Maximum Likelihood

Abstract

This study aims to examine the relationship between Indonesian primary and manufactured exports to ASEAN member states and economic size and geographical distance and to explore the extent to which the standard and augmented gravity models explain these trade flows and whether the relationship differs between the two product categories. Using panel data on Indonesian exports to ASEAN members from 2013 to 2022, the results reveal a positive and significant relationship between the economic size of trade partners and Indonesian exports of primary and manufactured products, while geographical distance exhibits a negative and significant relationship. Landlocked status is negatively associated with exports of both product groups,

whereas contiguity yields mixed results: positively related to primary exports but negatively attributed to manufactured goods exports. The findings corroborate the gravity model, confirming that economic size boosts Indonesian exports, while distance and landlocked status hinder trade, with contiguity benefiting primary exports but restricting manufactured goods trade. These results might pose policy implications, such that efforts to reduce transportation and logistic costs might contribute to a further increase in Indonesian exports to ASEAN members, particularly with relatively high income, such as Singapore, Malaysia, and Thailand, which are key markets in ASEAN for Indonesian exports. Moreover, Indonesia might need to improve logistics, enhance customs and trade administration efficiencies to reduce trade barriers**,** and improve accessibility, particularly for landlocked ASEAN members. Considering the adverse role of contiguity on manufactured product exports, Indonesia might benefit from enhanced industrial competitiveness through technological adoption, diversification into higher-technology products, and strengthening regional supply chain participation to align with ASEAN's industrial demand structure.

Keywords: Exports, Primary commodities, Manufactured products, Gravity model, Pseudo Poisson Maximum Likelihood

INTRODUCTION

The Association of Southeast Asian Nations (ASEAN) members have been important trade partners for Indonesia. For Indonesian exports, the Philippines, Malaysia, Singapore, Vietnam and Thailand are among the top destination countries in the last decade. According to the gravity model of bilateral trade, economic and geographical proximity are several factors contributing to the intensive trade between the two trading parties (Chaney, 2018). ASEAN is a crucial export market for Indonesia due to regional economic integration, geographical proximity, and diverse market dynamics. Regional agreements such as the ASEAN Free Trade Area (AFTA) and the Regional Comprehensive Economic Partnership (RCEP) facilitate trade by lowering tariffs and streamlining trade procedures, making ASEAN a strategic destination for Indonesian exports (Urata & Okabe, 2014). Furthermore, major ASEAN economies, including Singapore, Malaysia, and Thailand, have been trade hubs, enabling re-exports and broader market access (Obashi & Kimura, 2016). Additionally, ASEAN's economic diversity shapes trade patterns indicated by higher-income members that mainly demand manufactured goods, while the relatively lower-income countries rely on imports of raw materials and intermediate goods for industrial processing (Athukorala, 2014).

This study focuses on the primary and manufactured products, two major export categories with distinct characteristics, processes, and economic contributions. Primary products, relatively sensitive to price volatility, expose exporting countries to economic shocks (Collier, 2003) yet remain essential for many developing economies (UNCTAD, 2023). In contrast, manufacturing exports drive faster economic growth, particularly those with higher technological content, which generate positive externalities and foster broader industrial development (Hausmann et al., 2007; Berg et al., 2012; Sheridan, 2014). It is interesting to note that different patterns and shifts occur in Indonesian exports of primary and manufactured products to ASEAN relative to its total exports to the world. According to the Indonesian Ministry of Trade data, the share of manufactured exports to ASEAN has declined from 26 percent in 2013 to 21.12 percent in 2022, with a decreasing annual growth of -2.06 percent over the 10 years, indicating a less concentrated export destination for manufactured goods. Conversely, the share of primary exports to ASEAN has increased from 15.65 percent to 18.45 percent, with an annual growth of 1.66 percent over the decade, suggesting a growing regional importance for Indonesian primary commodity exports.

Despite ASEAN's role as a key export market for Indonesia, the determinants of trade performance across these sectors remain underexplored. The gravity model suggests that economic size, geographical proximity, and

trade costs shape trade flows (Anderson & van Wincoop, 2003). However, the extent to which these factors differently influence primary and manufactured exports has not been comprehensively examined, particularly in a developing economy context. Given their demand-driven nature and susceptibility to global price fluctuations (Collier, 2003), primary commodities may follow distinct trade patterns compared to manufactured goods, which depend more on industrial capacity and competitiveness (Hausmann et al., 2007; Sheridan, 2014). This study investigates whether the gravity model variables explain these trade dynamics equally or if notable differences emerge between the two product categories.

Previous studies have used the gravity model to analyze Indonesian trade flows for groups of products. However, to the author's best knowledge, studies combining exports of primary and manufactured products, particularly for Indonesia, are missing from the literature. Most previous research focuses either on aggregate exports or specific products. Several studies examine Indonesian exports with ASEAN members without differentiating between product groups (Wahyudi & Anggita, 2015; Jayadi & Retnosari, 2020; Leksono & Maryatmo, 2021). For instance, Jayadi and Retnosari (2020) employ the gravity model to analyze the impact of gross domestic product (GDP), distance, economic size similarity, and exchange rate on Indonesian exports with ASEAN and seven trading partners. Their findings reveal a positive and significant effect of GDP and economic size similarity, while distance and exchange rate have a negative and significant impact on Indonesian exports.

While these studies provide valuable insights into Indonesian trade flows, they typically focus on aggregate exports rather than distinguishing between product categories. Studies examining Indonesian trade in specific product groups reveal distinct determinants of trade flows. For instance, research on primary commodity exports within ASEAN finds that GDP, economic distance, and exchange rate significantly impact Indonesian plantation commodity exports, while population and inflation have insignificant roles (Yafi & Adyanti, 2024). For manufactured goods, Siahaan and Ariutama (2021) augment the gravity model by incorporating the role of regional free trade agreements (FTAs). Their panel data analysis of 40 partner countries from 2002 to 2019 highlights the positive impact of economic growth, real effective exchange rate, trade openness, and FTAs on Indonesia's manufactured exports. Similarly, Mareta (2018) and Luthfianto et al. (2016) corroborate that GDP positively affects Indonesian manufactured exports, whereas economic distance has a negative effect. The gravity model has also been applied to Indonesian trade in specific products. For example, Herianingrum et al. (2024) examine determinants of Indonesian seafood exports to OIC countries and identify trade partners' populations, adjusted-Muslim GDP, and the number of Muslim consumers as significant factors. Palm oil exports have also been extensively studied, with findings suggesting that GDP positively impacts trade, while distance and exchange rate exert negative influences (Ridwannulloh & Sunaryati, 2018). Pratiwi (2021) further identifies trade agreements and non-tariff measures as additional determinants of palm oil exports.

The augmented gravity model incorporates key geographical factors such as landlockedness and contiguity, significantly influencing trade flows. Landlockedness hampers trade by increasing transportation and logistical costs and reducing competitiveness (Arvis et al., 2010; Moore, 2018). Conversely, contiguity generally facilitates trade by lowering transportation costs and improving the ease of goods movement (Kim et al., 2022; Nguyen & Wu, 2024). Nonetheless, for manufactured products, neighboring countries with similar industries may compete rather than trade, leading to inverse effects of contiguity (Urata & Okabe, 2014). In ASEAN, this phenomenon can contribute to trade diversion, where domestic production replaces imports from neighboring countries (Handoyo et al., 2021).

Additional studies on Indonesian trade flows reinforce the positive impact of GDP and the negative effect of physical distance. These studies extend the analysis by incorporating variables such as the real effective exchange

rate (Wahyudi & Anggita, 2015) and population (Leksono & Maryatmo, 2021) that positively influence trade. Wahyudi and Anggita (2015) utilize panel data with a fixed-effects model to analyze Indonesia's trade with its ten main export destinations, while Leksono and Maryatmo (2021) examine Indonesian trade with 20 partner countries over the period 2001–2018. A more recent study investigates Indonesian exports with the five largest economies within the Organization of Islamic Cooperation (OIC) and finds that GDP, physical distance, and exchange rate positively influence exports (Ula, 2024).

Despite extensive research on trade patterns, a critical gap remains in the comparative analysis of primary and manufactured exports, as most studies focus separately on either manufacturing (Rasiah, 2003; Rahmaddi & Ichihashi, 2012) or primary commodities (Sugiharti et al., 2020). This fragmented approach overlooks the potential differences in how these two sectors respond to trade determinants, particularly in the ASEAN context. Additionally, while the gravity model is widely applied in trade studies, its use in analyzing Indonesian exports to ASEAN for both product groups remains limited, leaving a gap in understanding the distinct trade dynamics with AMS. Addressing these gaps, the novel contributions of this study are threefold. First, it applies the gravity model to examine Indonesian primary and manufactured exports to ASEAN members, providing a comparative perspective often absent in the literature. Second, by analyzing both product groups within a unified framework, the study uncovers potential variations in the determinants of primary and manufactured exports. Third, the study ensures robustness using multiple estimation strategies, including Pseudo Poisson Maximum Likelihood (PPML), Ordinary Least Squares (OLS), and fixed effects models. By bridging these gaps, this research enhances the empirical understanding of Indonesian trade patterns with ASEAN members and provides differentiated implications for primary and manufactured exports.

Given the significance of trade with ASEAN members, this study raises the main question: Are Indonesian exports of primary and manufactured products attributed to the economic size and physical distance? To what extent could the standard and gravity model explain the factors and potentially different trade patterns? Hence, this study has two objectives. First, it examines the relationship between Indonesia's primary and manufactured exports to ASEAN member states (AMS) and key gravity model variables, specifically economic size and physical distance. Second, it aims to determine the extent to which the standard and augmented gravity models explain these trade flows and whether the relationship differs between the two product categories. In line with gravity model theory, exports are hypothesized to have a positive relationship with economic size, as larger economies possess greater production and consumption capacities, facilitating trade (Mahadika et al., 2017; Cora & Wen, 2020). Conversely, exports are hypothesized to have a negative relationship with physical distance, as greater distances increase transportation costs, potentially restricting trade flows (Murphy-Braynen, 2019). Furthermore, primary exports are likely to be more sensitive to fluctuations in standard and augmented gravity variables than manufactured exports due to their susceptibility to economic shocks and price volatility (Collier, 2003).

METHODOLOGY

This study employs panel data analysis on bilateral trade between Indonesia and nine ASEAN members, namely Brunei Darussalam, Cambodia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam during the period 2013-2022, considering data availability and covering the recent period. The analysis examines the export of primary and manufactured sectors between Indonesia and AMS, with two dependent variables: Indonesia's exports of primary commodities and exports of manufactured products to its trade partners, given the focus of the study centering on Indonesia and following the products grouping provided by the Indonesian Ministry of Trade and Statistics Indonesia. The classification of primary commodities and manufactured products is based on the initial definition using the 3-digit Standard International Trade

Classification (SITC) codes issued by the United Nations Conference on Trade and Development (UNCTAD). For analysis purposes, the SITC codes are linked and adjusted with Statistics Indonesia sectors.

Data and Variables

The independent variables incorporated in the empirical model include the exchange rate of Indonesia, which is measured as the exchange rate of Indonesian Rupiah per US dollar, since the fluctuating exchange rate might influence the balance sheet, reflecting changes in domestic commodity prices and ultimately influencing the level of output available for export (Handoyo et al., 2023). The exchange rate is expected to have either a positive or negative relationship with exports, as an increase in the exchange rate against the US dollar (a lower level of Indonesian Rupiah per US dollar) or a currency appreciation could raise raw materials prices imported by the trade partners and hence, making prices for finished goods to rise and might impact the demand for the respective goods. In contrast, a weaker Indonesian Rupiah against the US dollar (a higher level of Indonesian Rupiah per US dollar) or a currency depreciation could make the price of Indonesian exported goods more competitive in the market of trade partners, which might lead to increased exports (Karno, 2017). The data is from the World Development Indicator developed by the World Bank.

Table 1. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max	Data source
primary exports	1.766e+09	1.764e+09	93533	8.432e+09	Indonesian Ministry
ln export primary	19.786	3.04	11.446	22.855	of Trade
manufacturing exports	2.017e+09	1.952e+09	3749530	6.734e+09	
ln export manufacturing	20.114	2.256	15.137	22.63	
gdpexporter	1.034e+12	1.381e+11	8.609e+11	1.319e+12	United Nations Data
ln gdp i	27.656	.13	27.481	27.908	
gdpimporter	2.142e+11	1.749e+11	1.140e+10	5.440e+11	
ln gdp j	25.398	1.418	23.157	27.022	
distance	2101.746	608.965	1107.691	2989.915	Dynamic Gravity
ln distance	7.603	.322	7.01	8.003	Dataset
contiguity	.111	.316	0	1	
landlocked	.111	.316	0	1	
exchangerate	13452.983	1293.932	10461.24	14849.854	World Development
ln exchange rate	-9.502	.103	-9.606	-9.255	Indicator

Source: Author's compilation

While the primary sector consists of primary commodities (agriculture, mining, minerals, and fuels) and primary industries (agriculture and mining industries), manufactured products consist of labor and natural resource-intensive manufacturing and low-capital-intensive, medium-capital-intensive, and high-capital-intensive manufacturing. Furthermore, the dataset applies the harmonized System (HS 6) code of commodities. Data for exports of primary commodities and manufactured products are gathered from the Indonesian Ministry of Trade.

The main variables of interest are the gravity model variables, which are the gross domestic product (GDP) of Indonesia and trade partners and physical distance. The GDP of Indonesia and its trade partners represent the size of the economy of both parties, measured in the current US dollar, where the data is collected from the United Nations Data. Meanwhile, the distance variable reflects the geodesic distance between major cities in origin and destination countries, weighted by the population of the respective country pair. The distance data is gathered from the Dynamic Gravity Dataset.

Moreover, augmented gravity variables of landlocked and contiguity are employed to capture geographical factors of trade. Landlocked is a dummy variable, with a value equal to 1 if a country has no ocean or water body access and a value of 0 if the country has access to an ocean or water body, reflecting the ability of a country for trade flows through water transportation. Contiguity is a binary

variable with a value of 1 if Indonesia and the trade partner have a land or river border. Both landlocked and contiguity data are sourced from the Dynamic Gravity Dataset. Overall, the variables used in this study and the descriptive statistics are summarized in Table 1.

Estimation Strategy

This study employs the standard and augmented gravity model for its empirical analysis. The structural gravity model is adapted to align with the empirical framework for explaining bilateral trade flows. Notably, the model identifies economic size and geographical distance between trading partners as key determinants of trade flows (Tinbergen, 1962). The fundamental principle of the gravity model posits that bilateral trade flows are directly proportional to the GDPs of the two economies but inversely proportional to the geographical distance between them. This relationship is represented in equation (1):

$$T_{ij} = A.(\frac{Y_i.Y_j}{D_{ij}}) \quad (1)$$

Where T_{ij} is the bilateral trade, which can also be replaced with exports or imports, between country *i* and country *j*, D_{ij} is the geographical distance between the two countries, and *A* is the constant of proportionality.

The gravity model in the analysis is built upon the empirical model of Anderson and Van Wincoop (2003), Olivero and Yotov (2012), and Zeynalov (2017) to analyze Indonesia's primary and manufactured exports to ASEAN. In answering the objectives, the study also contributes to the methodology by examining these product categories separately and investigating the role of standard and augmented gravity variables. Gravity models, widely used in trade analysis (Kim et al., 2022), identify factors shaping bilateral trade. Anderson and Van Wincoop (2003) improved traditional models by incorporating multilateral trade resistance (MTR) beyond bilateral distance and economic size. Moreover, trade costs include exogenous factors such as geographic distance, landlocked status, and contiguity. Following Olivero and Yotov (2012), this study includes country- and year-fixed effects to account for multilateral trade resistance factors. Hence, the constructed estimation model for the standard gravity model in natural logarithm is shown in equation (2):

$$lnT_{ij} = \beta_0 + \beta_1 lnGDP_{i,t} + \beta_2 lnGDP_{j,t} + \beta_3 lnDistance_{ij} + \varepsilon_{ij,t} \quad (2)$$

The augmented gravity model incorporates control variables to estimate the relationship between the export of primary and manufactured sector products and economic size and physical distance, which can be expressed as:

$$T_{ij,t} = \beta_0 + \beta_1 lnGDP_{i,t} + \beta_2 lnGDP_{j,t} + \beta_3 lnDistance_{ij} + \gamma X_{ij,t} + \delta_i + \lambda_t + \varepsilon_{ij,t} \quad (3)$$

Where *T* is Indonesian exports to each AMS, *i* denotes Indonesia, *j* denotes trade partners at year t, respectively; β and γ are coefficients; *X* is a set of control variables: the exchange rate, landlocked and contiguity. Independent variables of GDP, distance, and the exchange rate are in natural logarithm forms, while contiguity and landlocked are binary variables; δ_i is the exporter fixed effect, while λ_t is the time fixed effect, and ε is the error term.

The estimation model is utilized to examine the impact of each independent variable on Indonesian exports of primary and manufactured products to AMS. It includes the exporter's fixed effects to deal with unobserved heterogeneity attributed to the exporter, which are characteristics specific to the exporter that might have an influence on export flows, such as a country-specific trade policy. The research also incorporates time-fixed effects to account for unobserved factors that change over time and permits arbitrary correlation among explanatory variables changing over time (Wooldridge, 2020). It is also imperative to note that this study employs variables that are in line with the standard gravity model and includes control variables relevant to previous literature. Some independent variables are Log-linearized, as it is a common and suggested practice in estimating gravity model (Martínez-Zarzoso, 2013) to handle outliers, allow for elasticity

interpretation, and improve the estimation efficiency (Natanael & Verico, 2019), while the binary variables are in their original forms. It should be noted that the PPML method estimates the model with dependent variables remaining at their level, avoiding significant trade flow underreporting by presenting estimates in actual trade flow values instead of their logarithmic transformations.

The econometric model is estimated using the PPML (Poisson Pseudo Maximum Likelihood) approach, which is particularly effective for addressing challenges such as the high frequency of zero trade values, potential endogeneity, and other econometric issues (Silva & Tenreyro, 2006; Francois & Manchin, 2013). Zero trade flows in the gravity model often arise due to several factors, including the tendency of zero trade flows at higher levels of disaggregation (Shepherd, 2013), small and distant countries that face high fixed and variable trade costs thereby discouraging trade (Frankel, 1997), low GDP per capita and the absence of cultural or historical ties as barriers to trade (Rauch, 1999), trade policies, and when countries neither produce nor demand specific goods (Burger et al., 2009).

Several factors explain the advantages of using the PPML estimation method. First, the PPML estimator, applied to the multiplicative form of the gravity model, effectively tackles heteroscedasticity concerns, a common issue in trade data (Silva & Tenreyro, 2006). The method naturally accommodates observed heterogeneity, while the fixed-effects PPML approach provides a robust solution for incorporating zero trade flows. Its multiplicative formulation ensures that these zero-trade observations are not excluded, enabling consistent estimation even in their presence (Silva & Tenreyro, 2006). Additionally, PPML assigns equal weights to all observations, preventing noisier data points from disproportionately influencing the results. This weighting mechanism enhances its ability to account for heteroscedasticity. Furthermore, PPML effectively addresses biases arising from serially correlated errors and multicollinearity, which are common issues in gravity models due to the high correlation among independent variables (Álvarez et al., 2018). Crucially, among both linear and nonlinear estimators, the PPML estimator has been shown to exhibit the least bias, making it a reliable choice for estimating gravity models of trade.

It is worth noting that although endogeneity is not always a main concern, it is a widely recognized issue that is worth the attention in gravity models of international trade, which could arise from unclear causal relationships, multicollinearity, or measurement errors. The study adopts multiple approaches to address this potential issue: employing exporter and time-fixed effects to control for unobserved heterogeneity and time-varying factors, conducting Variance Inflation Factor (VIF) analysis to detect multicollinearity, using panel data with various model specifications, including theoretically and empirically relevant control variables, and performing sensitivity tests to ensure robustness of the results. Moreover, this study performs sensitivity checks to ensure the robustness of the results through several strategies. First, it uses logarithm transformation to consider the nonlinear form of the dependent variables and conduct the estimation using robust standard error ordinary least squares (OLS) to account for potential heteroskedasticity issues. Second, it performs two model specifications, one that includes fixed effects and one excluding the fixed effects, for both the PPML and OLS methods. Third, control variables are added gradually, and the model is estimated separately.

RESULTS AND DISCUSSION

Descriptive Analysis

During the period from 2013 to 2022, the composition of Indonesian bilateral exports underwent significant transformations, particularly in the relative dominance of primary versus manufactured exports, as shown in Figure 1. These shifts reflect evolving trade dynamics and sectoral competitiveness across Indonesia's regional trading partners. First, a transition from manufactured to primary-dominated exports is observed in trade with Brunei and Myanmar. At the beginning of the analysis period, exports to these countries were primarily composed of manufactured goods. However, by the end of

the period, primary commodities had become the dominant export category. In the cases of Malaysia and the Philippines, exports initially showed a relatively balanced distribution between primary and manufactured goods. Nevertheless, the gap widened with primary commodities taking the lead. The growing dominance of primary exports might signal a response to the evolving industrial needs of Malaysia and the Philippines, which may require more raw material inputs. In contrast, Indonesian exports to Cambodia demonstrated growth in both primary and manufactured sectors, with primary goods maintaining their dominance, indicating that while the manufacturing sector has expanded its reach, primary commodities remain a staple of the Indonesian trade relationship with Cambodia. Manufactured goods consistently dominated Indonesian exports to Lao PDR, Singapore, Thailand, and Vietnam throughout the analysis period.

Table 2. Matrix of Correlation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) primary exports	1.000							
(2) manufactured exports	0.856	1.000						
(3) ln_gdp_i	0.254	0.168	1.000					
(4) ln_gdp_j	0.771	0.864	0.074	1.000				
(5) ln_distance	-0.400	-0.464	0.000	-0.146	1.000			
(6) landlocked	-0.356	-0.366	-0.000	-0.475	0.320	1.000		
(7) contiguity	0.524	0.267	0.000	0.290	-0.393	-0.125	1.000	
(8) ln_exchange_rate	-0.164	-0.082	-0.686	-0.061	-0.000	0.000	0.000	1.000

Source: Author's calculation

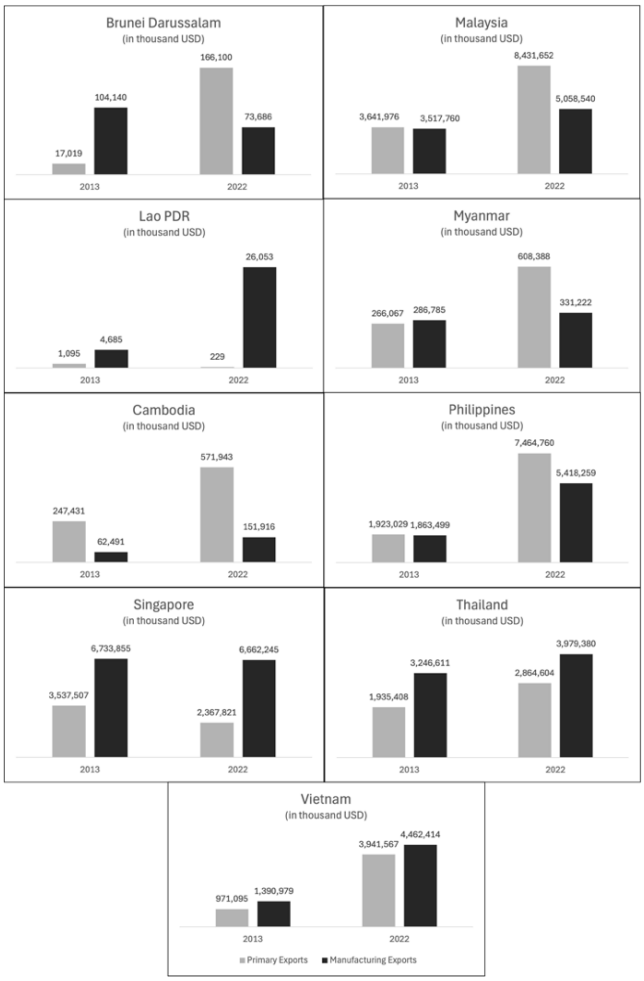

Figure 1. Indonesian Exports of Primary and Manufactured to ASEAN Members, 2013 and 2022
Source: Author's Calculation

Before estimating using regression analysis, it is worth looking at the correlation between the

variables of interest and exports of primary and manufactured products. Table 2 shows the complete correlation of each pair of variables. Although the correlations between the dependent variables and the main variables of interest are in line with the prediction of the gravity model, it is worth highlighting that correlation does not imply causality. Therefore, the next subsection will discuss further using the gravity model regression.

Quantitative Analysis

This paper performs the VIF test to check the existence of multicollinearity, as the test produces a value to quantify and indicate to what extent a coefficient of regression variance increases given an increase in multicollinearity (Natanael, 2024). A VIF value higher than 5 to 10 poses a concern as it indicates the existence of multicollinearity (Kim, 2019). The VIF result in Table 3, combined with the matrix of correlation in Table 2, indicates relatively safe from multicollinearity issues.

Table 3. Variance Inflation Factor

(a) Baseline Gravity Model

	VIF	1/VIF
ln gdp j	1.027	.973
ln distance	1.022	.979
ln gdp i	1.006	.994
Mean VIF	1.018	.

(b) Augmented Gravity Model

	VIF	1/VIF
ln gdp i	1.895	.528
ln exchange rate	1.891	.529
landlocked	1.411	.709
ln gdp j	1.301	.768
ln distance	1.114	.897
Mean VIF	1.523	.

Source: Author's calculation

The study employs the PPML with robust standard error to handle heteroskedasticity issues. The estimation results are shown in Table 4 for estimations of primary and manufactured product exports for the baseline standard gravity model specification, while Table 5 shows the estimation results with additional control variables of the augmented gravity model. For comparison and robustness check purposes, in all estimations, columns (1) and (2) exclude fixed effects, while columns (3) and (4) apply time and exporter fixed effects.

Table 4 presents the results of estimations of primary and manufactured product exports using the standard gravity model specification. Results in all models suggest the positive and significant role of economic size (GDP) of trade partners yet insignificant for Indonesia, except for primary commodities exports. Meanwhile, a negative and statistically significant role of distance is confirmed in all models. These results align with the prediction of the gravity model and highlight that economic size, particularly of trade partners, and physical distance are still relevant and important factors in Indonesian exports with similar implications for both primary commodities and manufactured products.

Table 4. Baseline Standard Gravity Model Estimation Results

Dependent Variable: Exports VARIABLES	(1) Primary	(2) Manufacturing	(3) Primary	(4) Manufacturing
ln_gdp_i	1.111*	0.130	1.223	0.00314
	(0.578)	(0.270)	(0.762)	(0.459)
ln_gdp_j	0.879***	1.242***	0.882***	1.249***
	(0.0495)	(0.0348)	(0.0489)	(0.0306)
ln_distance	-0.643***	-0.717***	-0.638***	-0.710***
	(0.174)	(0.107)	(0.176)	(0.0958)
Constant	-27.52*	-9.291	-30.65	-5.916
	(16.02)	(8.119)	(21.05)	(13.08)
Time Fixed Effect	No	No	Yes	Yes
Exporter Fixed Effect	No	No	Yes	Yes
Pseudo-R^2	0.83	0.95	0.84	0.96

Source: Author's calculation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

In the context of Indonesia's trade with ASEAN countries, the economic size of trade partners has a more pronounced impact on the export of primary products compared to manufactured products. This is evident from the

Table 5. Augmented Gravity Model Estimation Results

Dependent Variable: Exports VARIABLES	(1) Primary	(2) Manufacturing	(3) Primary	(4) Manufacturing
ln_gdp_i	1.338**	0.622*	2.410	2.167
	(0.603)	(0.327)	(3.531)	(1.873)
ln_gdp_j	0.790***	1.194***	0.792***	1.197***
	(0.0457)	(0.0338)	(0.0453)	(0.0309)
ln_distance	-0.423**	-0.764***	-0.420**	-0.761***
	(0.186)	(0.104)	(0.195)	(0.1000)
ln_exchange_rate	0.255	0.861*	1.136	2.237
	(0.476)	(0.460)	(3.284)	(1.856)
landlocked	-6.419***	-2.133***	-6.411***	-2.121***
	(0.351)	(0.274)	(0.350)	(0.263)
contiguity	0.432***	-0.162***	0.432***	-0.162***
	(0.105)	(0.0535)	(0.104)	(0.0504)
Constant	-30.74**	-13.06*	-52.21	-43.01
	(14.30)	(7.313)	(67.42)	(35.13)
Time Fixed Effect	No	No	Yes	Yes
Exporter Fixed Effect	No	No	Yes	Yes
Pseudo-R^2	0.88	0.96	0.89	0.96

Source: Author's calculation.Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

higher coefficient magnitudes associated with primary exports. Additionally, when applying fixed effects to the analysis, there is a slight reduction in the coefficients, indicating that other factors specific to each country, such as unique policies or regional characteristics, slightly diminish the influence of economic size. This nuanced understanding highlights the differentiated effects of economic size and fixed effects on various types of exports.

Gross Domestic Product (GDP) is widely recognized as a critical determinant of exports, as it reflects the economic size of a country and provides insights into its production capacity, productivity, and consumption patterns for both exporters and importers. A higher GDP in an exporting country indicates a higher capability to produce and supply goods to international markets (Mahadika et al., 2017). Similarly, a higher GDP in an importing country signals greater income levels within its population, which can drive higher demand for imported goods. This increased demand, in turn, stimulates exports from the exporting country (Cora & Wen, 2020). Moreover, the negative and significant role of distance on Indonesian exports of primary and manufactured products is in line with theoretical and empirical predictions. Distance is often regarded as a significant barrier to international trade, as it introduces transportation costs that can impact trade flows (Murphy-Braynen, 2019). Distance can be analyzed from two perspectives. First, it can be seen as the cost of service, which refers to the expenses incurred for each shipment, and second, as the value of service, which pertains to the intrinsic value of the traded commodity (Permata et al., 2019). Greater distances between trading countries typically result in higher transportation and logistics costs, which further increase the price of goods. This price escalation can lower the demand for these goods in the importing countries, ultimately hindering trade (Baker & Yuya, 2020).

Table 5 shows the extension of the standard gravity model by augmenting control variables, namely the exchange rate, landlocked, and contiguity. The core gravity variables of economic size and distance indicate consistent results with the baseline model, suggesting that economic size, particularly of trade partners, is significantly and positively associated with Indonesian exports of primary commodities and manufactured products, and geographical distance has a negative and significant relationship with Indonesian exports of both product groups. Other control variables that show statistically significant results in all specifications are landlocked and contiguity. Landlocked is negatively associated with exports of both product groups, which aligns with the literature (Oshota & Wahab, 2022). Landlocked has a significant and negative relationship with primary and manufactured

product exports in all models. This might be related to relatively higher transaction costs for landlocked countries, as they find it difficult to engage in international trade because of a lack of access to water transportation and market accessibility (Oshota & Wahab, 2022).

Meanwhile, contiguity produces a mixed result: it has a positive relationship with exports of primary commodities but an unexpected negative relationship with manufactured product exports. On the one hand, the positive relationship between the export of primary products and contiguity aligns with previous literature (Álvarez et al., 2018). This suggests that being geographically close to trade partners is significantly associated with the increase in Indonesia's primary product exports. This is also supported by the gravity model of trade and trade theories, suggesting that proximity reduces transportation costs and fosters trade relationships. Thus, geographical closeness likely facilitates easier access to markets for primary products.

Additionally, Table 6 compares the predicted export values between the standard and augmented models with the mean value. Overall, The standard gravity model provides better export predictions and closely aligns with the mean values than the augmented one, particularly with fixed effects. In this case, the standard model performs better, while the augmented model may suffer from coefficient inflation, which might indicate that additional variables can introduce noise or overfitting and the influence of extreme values.

Table 6. Comparison of Predicted Export Values from Standard and Augmented Gravity Models

Primary Products			
		Predicted Value	
	Mean	**Without Fixed Effects**	**Fixed Effects**
Standard	1.77.E+09	1.65.E+09	1.80.E+09
Augmented		1.86.E+10	9.40.E+08
Manufactured Products			
		Predicted Value	
	Mean	**Without Fixed Effects**	**Fixed Effects**
Standard	2.02.E+09	1.65.E+09	1.82.E+09
Augmented		9.76.E+10	1.08E+11

Source: Author's calculation

On the other hand, the negative coefficient for the export of manufacturing products to ASEAN indicates that contiguity has a less favorable impact on these exports. This might be related to several reasons, such as higher transportation costs for manufactured goods, trade diversion occurring in ASEAN, particularly in low-technology products (Urata & Okabe, 2014; Handoyo et al., 2021), which might lead to the sourcing of manufacturing products from producers outside the region, and relative comparative disadvantages in the manufacturing sector compared to AMS. According to data from the World Integrated Trade Solution (WITS), Indonesia has comparative disadvantage in this sector with a revealed comparative advantage of 0.66 in 2021, while other AMS have comparative advantage, such as Cambodia (1.13), Malaysia (1.04), the Philippines (1.18), Singapore (1.08), Thailand (1.14) and Vietnam (1.29).

Moreover, most of ASEAN economies have been increasingly shifted to manufacturing sectors, increasing the competition in similar product categories and reducing demand for manufactured goods as they might already have developed domestic industries that reduce the need to import manufactured goods. For instance, several AMS have higher manufacturing value-added to GDP than Indonesia, with a manufacturing sector value-added of 19.24 percent in 2021, according to the World Development Indicator data. These countries include Cambodia (26.65 percent), Malaysia (23.26 percent), Myanmar (25.64 percent), Singapore (20.28 percent), Thailand (27.17 percent) and Vietnam (24.46 percent). Additionally, while Asia is at the center of the global value-chain in manufactured goods (Obashi & Kimura; Padilla et al., 2019), for ASEAN countries GVC served as part of an export-promoting development strategy contingent on major economic partners outside the regional cooperation, such as Japan, and China (Prakash, 2024), which might further make manufactured products in ASEAN to be more traded with these countries compared to be traded within the region.

The exchange rate variable has a positive but insignificant relationship with Indonesian exports of primary and manufactured products. It is only statistically significant in manufactured product exports with fixed effects. Although mainly insignificant, this suggests that when the Indonesian currency depreciates relative to the US dollar, prices of domestically produced goods become more relatively competitive, while imported goods become more expensive, thereby boosting exports. Conversely, currency appreciation generally causes a decline in a country's exports, as it reduces the price competitiveness of its goods in international markets (Narayan & Nguyen, 2016).

Similar to the baseline specification, under the augmented gravity model, the economic size of trade partners is significantly associated with Indonesian primary exports more than its manufactured products, as indicated by the higher coefficient magnitudes for primary exports, suggesting that primary exports are more sensitive to changes in the economic size of trade partners. When using fixed effects, the coefficients are slightly lower, implying that other unobserved factors specific to each country play a role in moderating the overall impact of economic size on trade.

Robustness Check

This paper conducts a robustness check of the results following the explained approaches in the previous section. First, it uses logarithm transformation to consider the nonlinear form of the dependent variables and conduct the estimation using robust standard error ordinary least squares (OLS) to account for potential heteroskedasticity issues. Second, it performs two model specifications, one that includes fixed effects and one excluding the fixed effects, for both the PPML and OLS methods. Third, control variables are added gradually, and the model is estimated separately. The robustness check results are presented in Appendix 1 and Appendix 2. Overall, the results suggest consistent and plausible coefficients and directions of coefficients in all models and specifications, corroborating the main results using the PPML method.

CONCLUSIONS AND SUGGESTIONS

This study aims to examine the relationship between Indonesian primary and manufactured exports to AMS and economic size and physical distance and to explore the extent to which the standard and augmented gravity models explain these trade flows and whether the relationship differs between the two product categories. The findings align with the hypothesis of the gravity model, revealing a positive and significant relationship between trade partners' economic size and Indonesian exports of primary and manufactured products. Meanwhile, the geographical distance between Indonesia and its trade partners is negatively and significantly associated.

From the findings of this study, policy implications related to Indonesian bilateral trade can be inferred. Efforts to reduce transportation and logistic costs might contribute to a further increase in Indonesian exports to AMS, as geographical distance is a significant constraint. As the greater economic size is associated with higher exports, it might imply that AMS with relatively high GDPs, such as Singapore, Malaysia, and Thailand, are key markets for Indonesian exports. The substantial role of landlocked status on primary and manufactured exports suggests that Indonesia might need to focus on improving trade accessibility for landlocked ASEAN members. Higher transaction costs might be due to a lack of direct access to ports make trade more expensive. To mitigate this, Indonesia might have to bolster trade facilitation efforts to improve logistics, enhance customs and trade administration efficiencies by reinforcing ASEAN mechanisms such as the ASEAN Single Window to reduce trade barriers. Moreover, to mitigate the negative impact of contiguity on manufactured exports, Indonesia might need to enhance industrial competitiveness through product quality improvements, innovation, and technology adoption. Additionally, export diversification might focus on higher-technology manufacturing rather than competing in saturated low-tech markets. Given the involvement of ASEAN member states in global value chains, Indonesia might strengthen regional supply chain integration by

aligning its manufacturing exports with ASEAN's industrial demand structure.

It is imperative to acknowledge the limitations of this study. Considering the period of the analysis period and the application and the role of gravity variables, this study excludes free trade agreements in ASEAN in the estimation model, while it might be a useful explanatory variable. Moreover, this paper uses aggregated export data of primary and manufactured products, which are composed of smaller groups of products. However, disaggregating the product groups into smaller categories might shed light and insights on product-specific analysis. Hence, future studies could extend the span of the analyzed period to incorporate the role of trade agreements between Indonesia and ASEAN members in the bilateral trade flows analysis. Furthermore, utilizing data from a more specific product group might be beneficial in analyzing different patterns of each subgroup of primary and manufactured products.

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APPENDIX

Appendix 1. Robustness Check for the Baseline Strandard Gravity Model

Dependent Variable: Exports (log)	**(1)**	**(2)**	**(3)**	**(4)**
VARIABLES	**Primary**	**Manufacturing**	**Primary**	**Manufacturing**
ln_gdp_i	1.541*	0.362	1.381	0.494
	(0.878)	(0.342)	(1.296)	(0.511)
ln_gdp_j	0.376	1.269***	0.515	1.320***
	(0.285)	(0.0857)	(0.420)	(0.0776)
ln_distance	-2.434	-1.378**	-2.344	-1.346**
	(2.437)	(0.642)	(2.327)	(0.627)
Constant	-13.89	-11.66	-13.59	-16.68
	(36.82)	(9.017)	(45.22)	(12.49)
Time Fixed Effect	No	No	Yes	Yes
Exporter Fixed Effect	No	No	Yes	Yes
Adjusted-R^2	0.38	0.93	0.50	0.93

Source: Author's calculation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Appendix 2. Robustness Check for the Baseline Strandard Gravity Model

Dependent Variable: Exports (Log)	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
VARIABLES	**Primary**	**Manufacturing**	**Primary**	**Manufacturing**	**Primary**	**Manufacturing**
ln_gdp_i	1.624	4.342*	1.120	0.543	1.490	0.500
	(1.780)	(2.440)	(1.045)	(0.543)	(1.313)	(0.524)
ln_gdp_j	0.515	1.320***	0.838***	1.259***	0.381	1.313***
	(0.420)	(0.0776)	(0.155)	(0.0275)	(0.459)	(0.0838)
ln_distance	-2.344	-1.346**	-0.0768	-0.739***	-1.890	-1.432**
	(2.327)	(0.627)	(0.701)	(0.127)	(2.661)	(0.647)
ln_exchange_rate	0.254	4.039*				
	(2.917)	(2.151)				
landlocked			-6.550***	-2.054***		
			(0.415)	(0.0555)		
contiguity					1.400	-0.212
					(1.285)	(0.183)
Constant	-17.91	-85.26*	-31.04	-20.90	-16.81	-15.99
	(27.61)	(44.57)	(35.21)	(15.33)	(48.92)	(12.01)
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Exporter Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.48	0.93	0.94	0.98	0.38	0.93

Source: Author's calculation. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1