BORDER TRADE EFFECT ON INDONESIA'S EXPORT: GRAVITY MODEL ANALYSIS

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Abstract

Grounded in Adam Smith's theory of trade favoring high-GDP and proximate partners, we analyze determinants including GDP, Free Trade Agreements (FTAs), Logistics Performance Index (LPI), language, shared borders, and distance across Indonesia's top 30 export partners (2019–2023). Unlike prior studies, we integrate LPI and border effects into a gravity model, addressing endogeneity with Poisson Pseudo Maximum Likelihood (PPML) estimation alongside OLS, FEM, and REM. Results indicate that LPI is the most significant driver, while distance has a negative impact on trade, confirming the advantage of proximity. Contrary to expectations, FTAs showed limited significance, suggesting non-tariff barriers may dominate. Policy implications highlight the importance of investments in port modernization and customs digitization to capitalize on trade with high-GDP neighbors, alongside strategic agreements with distant, high-growth markets.

Keywords: ASEAN trade; Border Trade; Gravity Model; Indonesia's Export; International Trade; Logistics Performance Index (LPI); Panel Data

Introduction

Adam Smith's thoughts on international trade is that one country will have a higher profit to trade with countries with developed and mature economies, due to a larger market and having a more advanced division of labor (Schumacher, 2012). According to Smith, international trade will benefit all countries involved, but not all countries have the same benefits. Smith's theory of international trade is that a country must be able to sell goods that are cheaper than its competitors' if it wants to benefit from international trade.

In the study (Schumacher, 2012) on Smith's theory, the production cost explained by Smith, includes the budget for transporting goods to the market. Therefore, even though each country produces the same products, the proximity between production countries to the market countries will cause differences in production cost based on the cost incurred for the goods. With this, the direction of international trade is determined by the benefits of production costs, which include the cost of producing goods and the cost of transporting goods to the market. According to Smith, economic growth is the effect and impact of international trade.

In line with Smith's theory, Indonesia should trade with countries with higher economies or higher Gross Domestic Products (GDP) and have geographical proximity to benefit from cheaper transportation costs. The picture of Indonesia's exports with partner countries is depicted in the graph below.

Figure 1 - Indonesia Export Data in Billion US$
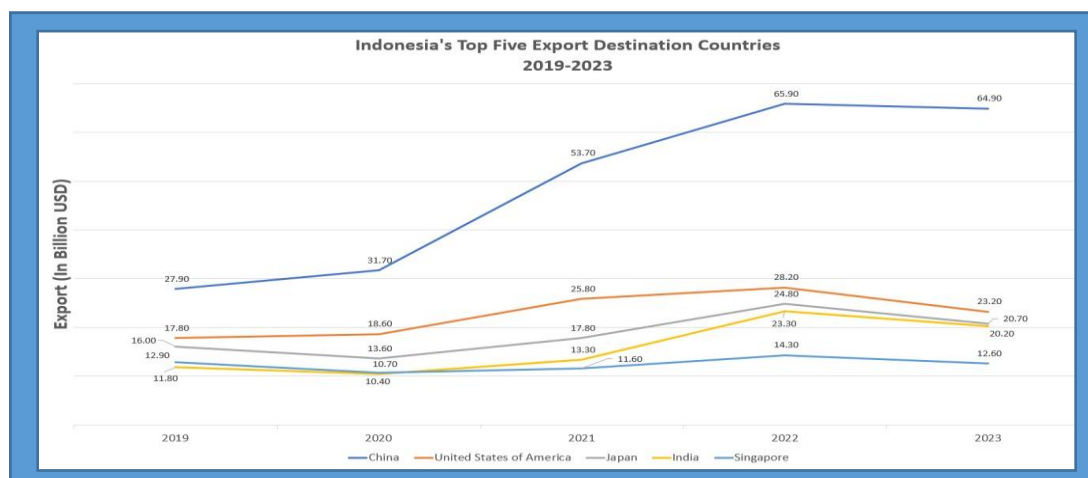
Source: Processed from Trademap.org (2024)

Based on Figure 1, China is Indonesia's largest export destination, reaching 64.9 billion USD in 2023. Other countries are the United States, Japan, India, and Singapore. Until 2023, Singapore was Indonesia's closest neighboring country, which is also included as Indonesia's largest export partner and a member of the Association of Southeast Asian Nations (ASEAN). Singapore shares a sea border with Indonesia and is the country with the highest economy in ASEAN. Indonesia's exports to Singapore reached 12.6 billion USD.

The thought of Smith's is in line with Ricardo's thought, which explains that production costs refer to the comparative advantage, which includes labour costs, demand, political relations, and various barriers to international trade flows, all determinants are relatively related to labor productivity, which has an impact on export value (Salvatore, 2014).

Based on the previous thoughts of Smith and Ricardo, it was concluded that several variables that affect a country's exports to its destination countries are distance, economic size, market access, political relations, transportation infrastructure, international trade barriers, and labor costs.

A previous study conducted by (Retnosari & Jayadi, 2020) focuses on Indonesian exports to ASEAN countries and seven other trading partners (Japan, South Korea, India, China, Australia, New Zealand, and Pakistan), covering data from 2008 to 2017. It primarily examines several of Indonesia's main trading partners, with determinants highly related to international trade. The study regarding determinants that influence international trade based on previous research from (Choi et al., 2019; Chor, 2010; Host et al., 2019; Idris & Idris, 2018; Jámbor et al., 2020; Oh & Selmier, 2008; Sousa & Mayer, 2011) showed that more determinants could influence international trade between two countries.

Based on the previous study, there are some research questions this study will try to answer: (i) Which determinants from partner countries affect Indonesia's exports? (ii) How do distance and shared borders impact Indonesia's exports?

Indonesia has five (5) biggest ports, which have the highest export value, such as Tanjung Priok, Tanjung Perak, Dumai, Banjarmasin, and Samarinda. The value of exports for Tanjung Perak is $4.446 million, and for Samarinda is $802 million

(data.goodstats.id., 2023). Indonesia's main logistic infrastructure for international trade activities still focuses on those five ports. Indonesia has not yet prioritized the development of port infrastructure near its borders with other countries. The issue of logistics has been raised as a crucial factor in international trade (Dos Reis et al., 2020). Logistics involves the strategic oversight of the movement and storage of materials, components, finished goods, and the corresponding information flows throughout organizations and their marketing channels.

Logistics facilitates the trade of industrial and agricultural products between countries worldwide. Numerous studies have explored logistics performance in the context of international trade, utilizing the Logistics Performance Index (LPI) provided by the World Bank and linking it to fundamental elements of gravity models in trade (Dos Reis et al., 2020). Therefore, based on the research gap, this study aims to analyze the effect of geographical proximity on Indonesia's exports to partner countries, with the determinants are Gross Domestic Product, Free Trade Agreements (FTAs), Logistic Performance Index (LPI), Language, and Share Border with thirty (30) main Indonesia's export partner countries. The results of this study were expected to increase understanding of the factors that affect Indonesia's exports and to become policy recommendations for increasing Indonesia's exports.

Literature Review

Following Smith's thought, Indonesia's international trade will generate more profit with neighboring countries. Based on Law Number 43 of 2008 in Article 6, which explains that Indonesia's territory has boundaries with the territories of Malaysia, Papua New Guinea, and Timor-Leste, while at sea it borders the regions of Malaysia, Papua New Guinea, Singapore, and Timor-Leste.

In line with Smith's thinking, in international trade, a country's trading partners are influenced by the size of the GDP of the countries involved. In addition, geographical proximity and distance are calculated as part of the transportation costs that must be borne by consumers. Other factors such as language and cultural similarities, are considered to influence a country's international trade (Salvatore, 2014). The influence of GDP on international trade can be described in the gravity model as the most stable model, where

a country's bilateral trade is positively influenced by GDP and negatively influenced by distance. So, the greater the GDP and the closer the geographical location, the greater the bilateral trade should be (Salvatore, 2014).

According to Smith's theory, transportation costs are part of production costs, so logistics costs are very important to consider in marketing products. The role of logistics has become a key element in international trade. Logistics is the process of managing the movement and storage of materials, spare parts, inventory, and the flow of marketing information for a product (Dos Reis et al., 2020).

The World Bank's Logistics Performance Index (LPI) provides the most comprehensive international comparison tool for measuring a country's trade and transport facilitation. Understanding and breaking down the components of trade and logistics performance can help countries improve the efficiency of goods transport. Performance is evaluated using a 5-point scale, and the overall LPI is aggregated as a weighted average of six areas of logistics performance that can help address barriers (Ojala & Çelebi, 2015.).

Retnosari & Jayadi (2020) have analyzed the impact of Indonesia's Gross Domestic Product (GDP), trade partners' GDP, partners' population, geographical distance, economic index, and exchange rate related to Indonesia's export with panel data from 2008–2017. The study was to analyze the influence of those determinants on Indonesian exports with ASEAN countries and seven other trading partners (Japan, South Korea, India, China, Australia, New Zealand, and Pakistan). Generalized Method of Moments (GMM) was used to overcome the endogeneity problem from the data panel. The research has found that every 1% increase in Indonesia's GDP will increase exports by 0,047%, and the partner's GDP will contribute 0,436%. Every 1% addition in distance will decrease exports by 0,7% due to the increase in the transport budget.

The relationship between distance and exports between the two trading partner countries is an important indicator of export performance. Murphy-braynen (2019) stated that distance can be interpreted as an obstacle to international trade due to distance can present transportation costs in international trade. Similarly, a study of (Permata et al., 2020) showed that distance can be divided into two aspects, such as the cost of services

and the value of commodities. Distance has a negative effect on trade due to higher distance costs higher commodity prices.

Host et al., (2019) conducted a study using Logistic Performance Index (LPI) data from 150 countries published by the World Bank. Based on the results of their research, it was found that the greater the distance between the two countries, trade will decrease, indicating that geographical proximity will increase trade. In addition, the size of the economy measured using GDP shows a positive effect on bilateral trade, indicating that the greater the GDP, the greater the trade.

Oh & Selmier (2008) result by conducted a study using time series data from 1980 to 2021 has explains the unobserved bilateral effect on border trade injected to a gravity model. GDP, Distance, Vector of geography, Culture, Institutional Factors, and Diplomatic relations are the independent variables. Using panel data and Non-linear square regression analysis, it is proven that strong diplomatic relations will increase bilateral trade.

Chor (2010); Jámbor et al. (2020); and Sousa & Mayer (2011) have also examined the incorporation of cultural and language factors in the gravity model concerning Regional Trade Agreements (RTA) between neighboring countries with shared colonization histories. Their analysis resulted that the closer the geographical distance between two countries, the more RTA is needed.

Another study between the borders of China and Kazakhstan was conducted by Choi et al. (2019) found that the distance between importing and exporting countries had a negative impact on bilateral trade. However, apart from distance, several factors influence bilateral trade, namely the entry point of goods (checkpoint), and trade barriers. Including other factors related to the entry point of goods, including customs control, corruption, and infrastructure.

Research concerning the Indonesia-Malaysia border, particularly the North Kalimantan and Sabah boundary examined by Idris & Idris (2018), has highlighted the impact of a common border on exports through a gravity model. The study's results indicate that using Ordinary Least Square (OLS) regression on the gravity model with Malaysian export data to 188 countries reveals that sharing a common border positively influences international trade.

Idris et al. (2018) also conducted research using a gravity model to examine the effect of cultural proximity on Sabah's exports. This study was conducted because there is no land connectivity between Sabah and Kalimantan, so the study estimates that cultural proximity affects Sabah's exports to Kalimantan. Using Sabah's export data to 182 countries for 16 years, it was found that cultural proximity has a very positive effect on Sabah's exports after regression was carried out on the data using the Ordinary Least Square (OLS) method and the Heckman Selection Model.

Prameswari et al. (2024) studied how various factors influence bilateral trade in border regions. Prior research has analyzed multiple factors influencing cross-border trade, such as trade facilitation, strong diplomatic ties (which boost bilateral trade), geographical distance, isolation, tariffs, port effectiveness, trade infrastructure, consumption rates, population size, Free Trade Agreements (FTAs), taxation strategies, market share, exchange rates, and the economic scale of a nation or region.

Based on the previous study, the alignment with Smith's emphasis on production costs (including transportation) and the gravity model's focus on GDP and distance provides a coherent theoretical foundation. Empirical studies (e.g., (Host et al., 2019; Retnosari & Jayadi, 2020)) robustly confirm that proximity and economic size enhance trade.

Highlighting Indonesia's territorial borders (Law No. 43/2008) underscores the strategic importance of neighbors like Malaysia and Singapore, which combine proximity and economic heft. Acknowledging logistics performance (via the World Bank's LPI) adds nuance, as efficient customs and infrastructure mitigate distance-related costs.

Political dynamics (e.g., ASEAN diplomacy, territorial disputes) and institutional frameworks (e.g., ASEAN Trade in Goods Agreement) are underemphasized. Strong diplomatic ties (Oh & Selmier, 2008) matter, but regional instability (e.g., South China Sea tensions) could negate proximity advantages. This study relies on data from secondary resources such as Trademap and World Bank to be processed using gravity models. In this connection, the result will often overlook informal trade (e.g., cross-border small-scale commerce in Kalimantan), which is significant but unrecorded.

Methods

The Gravity Model

The gravity model proposed by Bergeijk & Brakman (2010) is characterized as the most consistent relationship in economics: interactions among nearby economic clusters are more powerful than those that are distant. This model is widely recognized in global trade and capital movements among nations and has been effectively utilized to explain how consumers migrate between various trading hubs. Economic elements like tariff and non-tariff barriers have been incorporated into the use of the gravity model, alongside non-economic aspects such as cultural differences, cultural similarities, colonial ties, institutional disparities, variations in economic development, and more. According to the findings from empirical tests conducted, this theory demonstrates that numerous economic phenomena across various locations can be explained by the gravity equation.

Since its introduction in 1962 by Tinbergen, the gravity model has always been used for policymaking on international trade, because it is more robust and versatile to analyze all kinds of trade policy issues. Initially, the formulation of the gravity model narrative was initiated by Ravenstein in 1885 which explained the current trend at that time regarding migration driven by absorption centers of trade and industry, but its development would decrease proportionally according to the distance (Bergeijk & Brakman, 2010).

The first contribution begins with the application of the gravity model using various phenomena that are generally related to trade, which have the following gravity equation:

$$T_{ij} = \frac{GDP_i{}^{\alpha} GDP_i{}^{\alpha}}{D_{ij}{}^{\theta}}$$

Where T_{ij} represents the bilateral trade flow between country i and country j, GDP_i reflects the economic magnitude of country i as assessed by its GDP. D_{ij} represents the distance separating the two nations, while α, β, and θ are typically approximations of the model's log-linear reformulation. This equation describes bilateral trade in terms of economic size and distance, indicating that as a country's GDP increases, its bilateral trade

rises, and as the distance between two countries decreases, their trade increases; conversely, greater distances lead to a reduction in trade value.

Shahriar et al. (2019) wrote "The gravity model has, in this way, become a useful tool of international trade analysis. It is a device to explain international capitals and labor flows." Tracing the history of international trade from Smith, Ricardo to Heckscher-Ohlin (HO) the model has had a very big influence on the construction of international economic theory.

Linnemann (1966) in Shahriar et al. (2019) made an empirical analysis to calculate trade flows as follows: where Tradeij is the trade value of country i and country j, GDPi and GDPj are the national income of the two countries. The shape above can be made in linear form with the form:

$$Log(Trade_{ij}) = \alpha + \beta_1 \log(GDP_i \cdot GDP_j) + \beta_2 \log(Distance) + u_{ij}$$

Where α, β_1 and β_2 are the estimated coefficients. The error symbol u_{ij} is used to capture other unobserved factors that may affect bilateral trade between the two countries. The equation above is the core of the gravity model, where bilateral trade is predicted to be positive to income and negative to distance.

Fratianni (2009) states that the emphasis on the gravity model is based on two aspects: first, the gravity model is backed by robust theoretical foundations that can be associated with different international trade models. Secondly, the gravity model can be applied with different hypotheses of international trade. In simple terms, the gravity model clarifies the exchange of products between two nations by considering distance, income, and additional specific similarities like borders, shared languages, and common currencies that influence trade. Moreover, several other factors have been utilized by earlier researchers, such as: distance, tariffs, port effectiveness, trading infrastructure, consumption rates, demographic data, Free Trade Agreements, taxation, market presence, and currency exchange values.

Design

The data used is export data to partner countries from 2019 - 2023 with a total of 30 partner countries. Partner countries are selected based on Indonesia's largest exports to

partner countries. Based on the gravity model that has been carried out by previous researchers, the formula that will be used for the quantitative method is as follows:

$$ln\text{X}_{jt} = \beta 0 + \beta 1 ln\text{GDP}_{it} + \beta 2 ln\text{LPI}_{it} + \beta 3 ln(\text{T}_{ij}) + \beta 4 ln(\text{SB}_i + 1) + \beta 5 ln(\text{Lng}_i + 1) + \beta 6 ln(\text{FTA}_{ijt} + 1) + \text{e}_{it}$$

t = 2019, 2020, …, 2023

i = partner country

j = Indonesia

eit = error constant

The data that will be used for this research will be obtained from several sources, namely:

Table 1 - Gravity Model Equation Data Source

Variable type	Data	Source
X	Exports from Indonesia to country i in year t	Trade Map 2019–2023, https://trademap.org
GDP per capita	A measure of individual economic output for each country	IMF (https://www.imf.org/)
FTA	*Free Trade Agreement*	https://ftacenter.kemendag.go.id/ - FTA Center Indonesia
LPI	*Logistic Performance Index* partner countries	World Bank (https://lpi.worldbank.org/
Lng	Language (common language)	https://cepii.fr
SB	*Share Border* (the number of Indonesian territories that have a direct border with the partner country from three areas: land, sea, and jurisdiction). 1: bordering on one area. 2: bordering on two areas 3: bordering on three areas	Source: Law No. 43 of 2008
T	the distance between Indonesia and partner countries	Website: https://www.geodatos.net/en/dist ance s/cities

Source: Adapted by the author.

Variable

Export data was collected from https://trademap.org. Trademap.org provides statistical data related to trade and services for international business monthly, quarterly, and yearly trade data. Import & export values, volumes, growth rates, market shares, etc.

Trademap.org was the result of cooperation between the European Union, United Nations, and World Trade Organization (WTO). GDP per capita from the International Monetary Fund (IMF) in this study was accessed from data.imf.org. GDP per capita is GDP divided by population, indicating the average economic output per person. GDP per capita from IMF Global Coverage includes data for all IMF member countries (190+ nations). GDP from the IMF is updated regularly (e.g., quarterly or annually), with revisions as new data becomes available. The standard data of the IMF follows the System of National Accounts (SNA), ensuring consistency across countries.

Free Trade Agreement data is collected from ftacenter.kemendag.go.id. The data consist of various Indonesian trade agreements from bilateral to multilateral (e.g.: Indonesia-Japan (IJEPA), ASEAN - CHINA FTA (ACFTA), dan Indonesia - EU CEPA (IEU-CEPA)). This study sums up all trade agreements between Indonesia and partner countries from 2019 - 2023. One of the examples is Indonesia and Japan from 2019 - 2022 have signed 2 agreements and 2023 signed an additional 1 agreement, so in total have signed 3 agreements (1 bilateral agreement and 2 regional agreements) from 2019 - 2023.

The Logistic Performance Index (LPI) was collected from the World Bank's website. There are several problems with LPI data due to data being incomplete for certain countries or years, and specifying which data points are missing (e.g., specific countries, periods). LPI was published every two years (2007-2018) and paused until 2023.

The language Index quantifies linguistic ties between countries, recognizing that shared language reduces transaction costs and facilitates economic exchanges. Binary Indicators are traditional variables like comlang_off (1 if countries share an official language, 0 otherwise). Cepii.fr continuous measures datasets may use nuanced indices (e.g., linguistic proximity scores) to capture partial overlaps or dialectal similarities. In the Gravity model, the index is a control variable explaining trade flows, FDI, or migration, alongside distance, GDP, and colonial history (Mayer & Soledad, 2011).

The shared border information is derived from Law No. 43 of 2008 concerning Indonesian territory. According to Law No. 43 of 2008 in Article 6, the land boundaries of Indonesia are adjacent to the territories of Malaysia, Papua New Guinea, and Timor Leste, whereas its maritime boundaries are adjacent to the territories of Malaysia, Papua

New Guinea, Singapore, and Timor Leste. Indonesia's legal territory adjoins the legal territories of Australia, the Philippines, India, Malaysia, Papua New Guinea, Palau, Thailand, Timor Leste, and Vietnam.

Distance (T) in this study was collected from https://www.geodatos.net/en/distances/cities, an application to count the distance between the capital of two countries. Distance in the gravity model has limitations in capturing areas that have direct borders due to the proximity from the capital (e.g.: North Kalimantan with Sabah).

This study employs panel data regression to analyze the gravity model. Panel data offers benefits for forecasting. Panel data is utilized due to its various benefits compared to cross-sectional analysis; it can track the connections among relevant variables over an extended timeframe and isolate country-specific effects that remain constant. In this research, a gravity model employing Ordinary Least Squares (OLS), Fixed Effect Model (FEM), Random Effect Model (REM), and Poisson Pseudo Maximum Likelihood (PPML) analysis is utilized, with the variables adjusted to concentrate on examining the impact of border trade on Indonesia's exports and the connection between Indonesian exports and variables from partner nations.

A previous study from (Anindika Sari et al., 2020; Fitri et al., 2014; Hamin, 2024; Istiqomah & Karim, 2017; Putra & Muhammad, 2024) explained that Ordinary Least Squares (OLS) is a statistical method used in regression analysis to describe the relationship between independent and dependent variables. It minimizes the sum of the squares of the differences between measured and predicted values. The method is commonly applied in various fields, including finance and economics, to analyze trends and data correlation.

The Fixed Effect Model is a method to control unobserved variables but it can affect other variables. Madany & Rais (2022) used the Fixed Effect method to evaluate the effect of financial performance between cross-section data and time series data, and the study explores variations in data over time for each individual or company.

Random Effect Model (REM) estimates data panel regression with different individual characteristics and time, which accounts for error in the model. The function of REM is coefficient regression estimation, sum of standard error, hypothesis testing, and measuring the independent variable significance (Septianingsih et al., 2022).

The Poisson regression model is a standard model for discrete data and is included in the nonlinear regression model. Poisson regression is based on the use of the Poisson distribution. Before this modelling is carried out, the data need to meet the assumption of non-multicollinearity. Multicollinearity is when independent variables are highly correlated with each other (Futri et al., 2024).

Table 2 - Descriptive Statistics

Variabel	Min	Max	Std.Dev
Export	10.902	65.924.117	6.358.899
GDP per capita	456,58	108.438,5	23.434,3
LPI	2	4,3	0,595
Distance	886,14	19.772,34	4.553,9
Share Border	0	3	0,546
Language	0	0,218	0,04
FTA	0	5	0,95

Source: Adapted by the author.

Data Analysis

The purpose of this study is to see the effect of border and geographical proximity on Indonesia's exports to 30 partner countries. The variables of distance and LPI are incorporated into the gravity model as a proxy in describing the effect of distance to partner countries and LPI from partner countries on Indonesia's exports. The regression results are summarized in Table 3 below:

Table 3 - Estimation Results

Estimation	REM	FEM	OLS	PPML
Cons	16.217	-0.7713	12.1034	2.4937
ln (GDP per capita)$_{jt}$	0.3957	1.2646	-0.2334	-0.0179*
ln (LPI)$_{jt}$	1.8180	1.8988	5.3019	0.4115
ln (Distance)ij	-0.9830	-	-0.3703	0.0289*
ln (Share Border +1)$_{ij}$	-0.2595*	-	0.0790*	-0.0019*
ln (Languange +1)$_{jt}$	-3.2089*	-	-0.0937*	-0.0102*

ln (FTA+1)$_{ijt}$	-3.2089	0.3170	1.5596	0.1117
P-value	0.000	0.000	0.000	1
R-squared Overall	41.90%	18.18%	52.5%	11.08%
Hausmantest P-values	0.0566			

* : variable has no significant effect
Source: Adapted by the author.

The analysis with the gravity model approach has been processed using four regression methods, namely OLS, REM, FEM, and PPML. The results of data processing using the four methods can be seen in the table above. The results of the analysis show that the highest R2 is produced by OLS at 52.5% followed by REM, FEM, and finally PPML. Analysis using OLS provides the highest R2 results, where the variables GDP, LPI, Distance, and FTA have a significant impact on Indonesia's exports to partner countries. Estimation using OLS in this gravity model is the most appropriate compared to REM, FEM, and PPML.

A Hausman test was conducted to statistically determine the appropriate model between the Fixed Effects Model (FEM) and the Random Effects Model (REM). The test used only three explanatory variables—log GDP per capita, log LPI, and log FTA—because other variables (distance, common language, and shared border) are time-invariant and thus absorbed in the fixed effects estimation. As shown in the table, the test yielded a p-value of 0.0566, indicating that the Random Effects Model is preferred.

The constant coefficient (β0) of the processing results using OLS is 12.1034, which means that if all independent variables (log GDP per capita, log LPI, log distance, etc) are zero, the value of Indonesia's export is estimated at 12.1034 (ceteris paribus).

The GDP of partner nations adversely impacts Indonesia's exports to those countries. According to the OLS estimation results, there is a negative correlation between the GDP of partner nations and Indonesia's exports, meaning that an increase in the GDP of partner countries results in a decline in Indonesia's exports. Specifically, for every 1% rise in a partner country's GDP, Indonesia's exports to that nation decrease by 0.2%. On the other hand, for REM results, GDP has a positive correlation with exports. Specifically, for every 1% rise in the partner country's GDP, Indonesia's exports will rise 0,3% but this correlation is weaker than the OLS results, because the R2 value is only

41.9%. FEM also results in a positive correlation between GDP to Indonesia's export. Unfortunately, the R2 value is very weak at around 18%, so it cannot be used as a reference. GDP correlation with Indonesia's export from PPML results has no significant effect.

A country's LPI is a determining factor in the ease of conducting international trade activities. Based on the results of the OLS estimation, the LPI value of the partner country affects the amount of Indonesia's exports to that country. The results of the OLS estimation also illustrate that the coefficient value of the LPI is the highest, namely 5.3019, which shows that the logistics infrastructure of the partner country has a large influence compared to other variables in this study on Indonesia's exports to partner countries. The results of LPI correlation with Indonesia's export after OLS, are FEM, REM, and PPLM. FEM has the second highest correlation with the value 1.8988 and REM with value 1.8180, but R2 for REM is higher than FEM, and REM has the value of 0.056 for Hausmantest P-values.

Result

The result from OLS estimation showed that every 1% increase in LPI will increase 5.3% of Indonesia's exports. Based on this result, a higher value of LPI from partner countries will boost Indonesia's exports. On the contrary, the neighboring countries with shared borders but a lower LPI index, have a lower impact on Indonesia's exports.

On the other hand, for the result of REM, 1% of LPI of partner countries will increase by 0.3% of Indonesia's Export. In line with the result of OLS, REM results showed that the result of distance is negative in correlation with Indonesia's exports. Every additional distance will decrease Indonesia's exports.

The results from OLS and REM have similar values, even though REM is lower than OLS and has a lower R2. Based on these results, we can assume OLS and REM have more consistency for this method.

Figure 2 - Export vs LPI
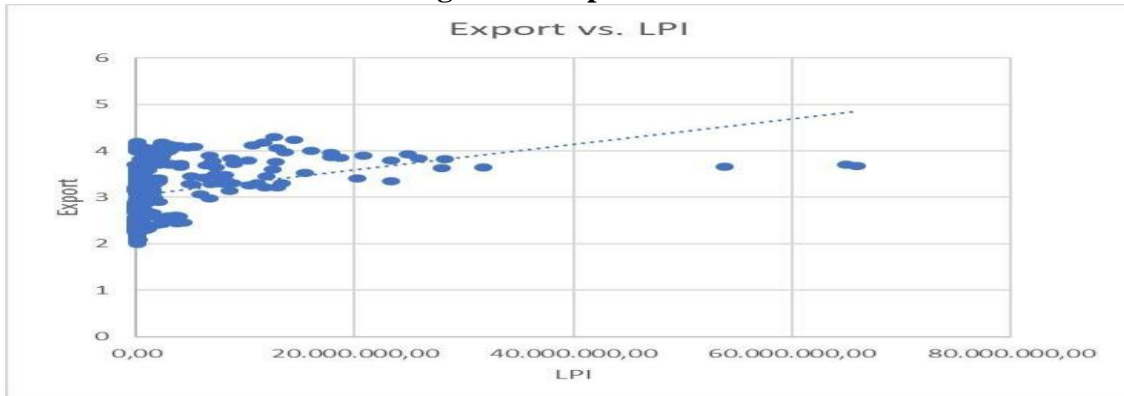
Source: Processed by author from World Bank Data

Based on Figure 2, the correlation between Indonesia's exports and LPI has a low correlation with a value of 0,294, which means the value of LPI from partner countries is not determined by the volume of Indonesia's exports. In this relation, there is the probability that Indonesia's export is dominated by several countries that need to import raw materials from Indonesia.

Distance between countries has an impact on international trade. Based on the results of the OLS estimation, the distance to partner countries has a negative effect on Indonesia's exports to partner countries. The farther the distance to the partner country, the smaller Indonesia's exports to the partner country will be. Although the distance variable has a negative effect on Indonesia's exports, it must still be correlated with other variables such as GDP and LPI.

In addition, FTAs also have a positive impact on Indonesia's exports to partner countries. FTAs with partner countries provide convenience for Indonesia's exports to partner countries. Based on the results of the OLS estimate, FTAs with partner countries significantly affect Indonesia's exports. Therefore, the Indonesian Government must encourage the number of FTAs with partner countries to facilitate the entry of Indonesian products into partner countries.

Shared border and language determinants do not significantly affect Indonesia's exports. The results of OLS estimation show that shared borders and language similarities have little effect on Indonesia's exports. This is likely because the areas of other countries that border it have not developed so the existence of direct borders does not significantly affect Indonesia's exports.

In addition, language similarities also do not affect Indonesia's exports, this can be seen from Indonesia's largest export partner, China, which does not have a language in common.

Discussion

Based on OLS estimation, Indonesia's exports to partner countries are influenced by the partner country's GDP, partner country's LPI, geographical distance or proximity, and FTA agreements. The partner country's GDP has a negative impact on Indonesia's exports, because the better the economic condition of a country, the more openness to international trade will increase. Jung & Marshall (1985) propose the theory of "unbalanced growth," suggesting that the surplus output from these highly productive sectors is expected to be exported. As a result, in this scenario, the increase in production results in the rise of exports. Simultaneously, an increased GDP indicates enhanced purchasing power for individuals, resulting in more imports from overseas. In summary, economic expansion can increase a nation's exports and imports. As partner countries experience economic growth, their imports from different nations will rise, negatively affecting Indonesia's exports, particularly if Indonesia fails to deliver a clear advantage on the products offered to these partner countries, leading them to seek better suppliers elsewhere.

In line with Smith's theory (Schumacher, 2012), transportation costs, and technology will determine the direction of a country's international trade. Therefore, Indonesia's exports will be influenced by the logistics infrastructure to bring products from Indonesia to partner countries. The higher the LPI value, the better the logistics infrastructure to support international trade, which will reduce logistics costs and have an impact on the price of goods. Likewise, technology in producing goods will have an impact on the efficiency of production costs. To support Indonesia's international trade, Indonesia needs to improve its logistics infrastructure so that it can reduce logistics costs.

Indonesia's largest trading partner, based on data from 30 Indonesian export partner countries between 2019–2023 that have a direct border with Indonesia, is only Singapore. Singapore has a higher GDP and LPI value than Indonesia. Although Indonesia has direct borders with several countries other than Singapore, Indonesia's largest exports are to

China, America, and India, which do not have close geographical proximity. If we return to the theory of gravity, the distance

between countries will have a negative impact on international trade, where the further the distance between countries, the smaller the trade will be. This is in line with the results of the OLS estimate. However, based on data from Trademap, Indonesia's exports in the past five years have been dominated by exports to China and not countries that are geographically close. This is because, in addition to the distance variable, Indonesia's exports are influenced by the GDP per capita of partner countries and logistics infrastructure, so geographical proximity does not have a major impact on Indonesia's exports. In addition, this could also indicate that Indonesia has not been optimal in utilizing border areas to increase exports, where the logistics infrastructure in the border area is not prepared to be one of the export routes for Indonesian products to countries that have direct borders.

In addition to the variables that have been studied in this study, there are still other factors that influence Indonesia's exports to be studied in further research. Understanding the factors that influence Indonesia's exports will help in making policy recommendations.

Conclusion

Novelty of this study is on analyzing the proximity of Indonesia's exports to partner countries with determinants such as GDP, FTA, LPI, Language, and Share Border with thirty (30) main Indonesia export partner countries from the year 2019 - 2023. Different from the previous study from Retnosari & Jayadi (2020) mainly focuses on Indonesia's export with ASEAN plus 7 other export partners, this study focuses on the impact of the shared border between Indonesia and 30 partner countries on Indonesia's export.

The gravity models with OLS, REM, FEM, and PPLM methods were used in this study to estimate the research. The gravity model in this study is best estimated using OLS, as determined by the estimation findings. This study's findings suggest that the FTA between Indonesia and partner nations and the LPI of those partner nations have the greatest impact on Indonesia's exports. But distance and the GDP of partner nations have a detrimental impact on Indonesia's exports.

Meanwhile, the distance variable that describes the geographical proximity has a negative effect on Indonesian exports, which means that Indonesia should benefit from the trade with the nearest countries, but Indonesia's export partners are predominantly non-neighbouring countries such as China and the United States. In this connection, there are several possibilities such as Indonesia not yet developing the border area for international trade, the border area is considered an underdeveloped area, and there are no special border trade regulations for international trade.

So, Indonesia must optimize its closest neighboring countries as one of the main export destinations because they have cheaper logistics costs than distant countries. In this regard, Indonesia can make the border area a gateway for international trade to neighboring countries, as has been done on several borders, such as between Thailand and Malaysia (Anuar & Harun, 2019), the United States border with Canada (Sands & Fellow, 2009), the development of tourism and trade on the China-Russia border (Mikhailova, 2015), and the China-Kazakhstan border (Choi et al., 2019).

There are several variables that affect Indonesia's exports and have not been included in this study, which can be studied in the future. It is recommended to add other variables to the model so that a more accurate model is obtained and describes the reality in the real world. In addition, these results are based on the data used, if using other data sets, the results may be different.

Policy Implication

Based on the results from OLS as the highest estimator, several things can be suggested, as follows:

1. The correlation between the GDP of partner countries with Indonesia's export in this research has have different impact from the previous study by (Retnosari & Jayadi, 2020), which showed a positive correlation, but in this research, the correlation is negative. This occurs since a country's GDP increases its openness to international trade. This aligns with Adam Smith's theory of international trade, suggesting that nations with high GDP will engage more in global trade and diversify their imports from multiple countries to achieve absolute advantages. Consequently, Indonesian export products will face numerous competitors if the GDP of its partner nations exceeds that of Indonesia. In

this relation, Indonesia shall diversify its export products to compete with other trading partners from partner countries.

2. The variable of LPI has the highest result. In this connection, Indonesia shall boost and expand the development of international logistics ports, to provide facilities for international trade and to increase international trade. The Indonesian government shall develop new port to support regions or provinces that have export potential but do not yet have adequate ports. Indonesia shall enhance its LPI components by investing in port modernization and customs digitization to capitalize on proximity. Indonesia also needs to have a balance of trade with high-growth markets, even though it's a distant market (E.g., India and the Middle East).

3. Border has a negative correlation with Indonesia's export, in line with this, Indonesia shall give more focus on the nearest country to Indonesia. The closer the distances, will decrease the logistic cost. Neighbours with lower GDP like Timor Leste and Papua New Guinea, shall need attention, especially to boost border trade for the small and medium enterprises from the surrounding area.

4. Recommendation by (Prameswari et al., 2024) highlights the priority of the Indonesian Government to focus on infrastructure development. Apart from the main infrastructure, such as roads and electricity, logistics connectivity is one of the necessities to be provided. One way to improve infrastructure in border areas is by incorporating Public-Private Partnership (PPP) financing. In correlation with this research, investment on logistic infrastructure is becoming an essential policy to be prepared to boost international trade.

Declaration Of Interest

There are several variables that affect Indonesia's exports and have not been included in this study, which can be studied in the future. It is recommended to add other variables to the model to obtain a more accurate representation that describes reality in the real world. In addition, these results are based on the data used, if using other data sets, the results may be different.

Ethical Consideration

During the preparation of this article, various open-source articles and journals were used to deepen the theoretical foundation and understanding of the issues discussed in the study. The online application Mendeley was used to organize the references. The authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Credit Authorship Contribution Statement

Septania Rubi Prameswari: Writing – original draft, Methodology, Data curation, Conceptualization, Conclusion.
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