

RESEARCH

Open Access



Beyond trade value: essential drivers of Indonesia's coffee exports in the global market—a system GMM approach

Fadhlan Zuhdi^{1,2*}, Anggita Tresliyana Suryana³, Abu Amar Fauzi², Resti Prastika Destiarni⁴, Sri Milawati Asshagab^{2,5} and Eristya Puspitadewi Irwanto²

Abstract

Despite being one of the world's largest coffee producers, Indonesia has experienced relatively stagnant export volumes, raising questions about the determinants of its competitiveness in global markets. This study examines Indonesian coffee exports using a dynamic gravity model estimated with the system Generalized Method of Moments (GMM) on panel data from 25 major trading partners during 2005–2024. By incorporating lagged exports, the model captures persistence in trade flows while addressing endogeneity, unobserved heterogeneity, and dynamic adjustment, limitations often overlooked in static gravity models. The results reveal strong export persistence, indicating that past export performance significantly shapes current exports. Partner-country GDP and trade openness increase exports, whereas economic distance and exchange rate appreciation reduce them. Indonesia's CPI has a positive effect, while Indonesia's GDP per capita, partner-country population, and foreign direct investment are not statistically significant. These findings underscore the importance of market size, trade costs, macroeconomic stability, and long-term trade relationships in sustaining coffee export performance. The study contributes to the international trade literature by highlighting the value of dynamic modeling for commodity export analysis. Policy priorities include preserving established markets, entering high-growth destinations, improving logistics efficiency, maintaining exchange rate stability, deepening trade openness, and promoting higher value-added coffee products.

Keywords Dynamic panel data, Gravity model, Export persistence, Trade costs

JEL Classification F14, C23, Q17, O13

Introduction

Coffee is one of the most widely consumed beverages worldwide. As a result, coffee is a strategic global agricultural commodity that contributes substantially to the economies of producing countries [28, 79]. Within this group, Indonesia plays a significant role as one of the world's leading coffee producers. With the second-largest coffee plantation area globally [54], Indonesia has long held a strategic position in the international coffee market [40]. However, Indonesia's abundant natural resources and long-standing history of coffee production have not fully translated into stronger export performance or improved competitiveness in global markets. Recent data from BPS—Statistics Indonesia [13], presented in Fig. 1,

*Correspondence:

Fadhlan Zuhdi
fadhlan.zuhdi@boku.ac.at

¹ Institute for Sustainable Economic Development, BOKU University, Vienna, Austria

² Research Center for Economics of Industry, Services, and Trade, National Research and Innovation Agency, Jakarta, Indonesia

³ Research Center for Behavioral and Circular Economics, National Research and Innovation Agency, Jakarta, Indonesia

⁴ Department of Agribusiness, Trunojoyo University, Bangkalan, Indonesia

⁵ Doctoral School of International Relations and Political Science, Corvinus University of Budapest, Budapest, Hungary

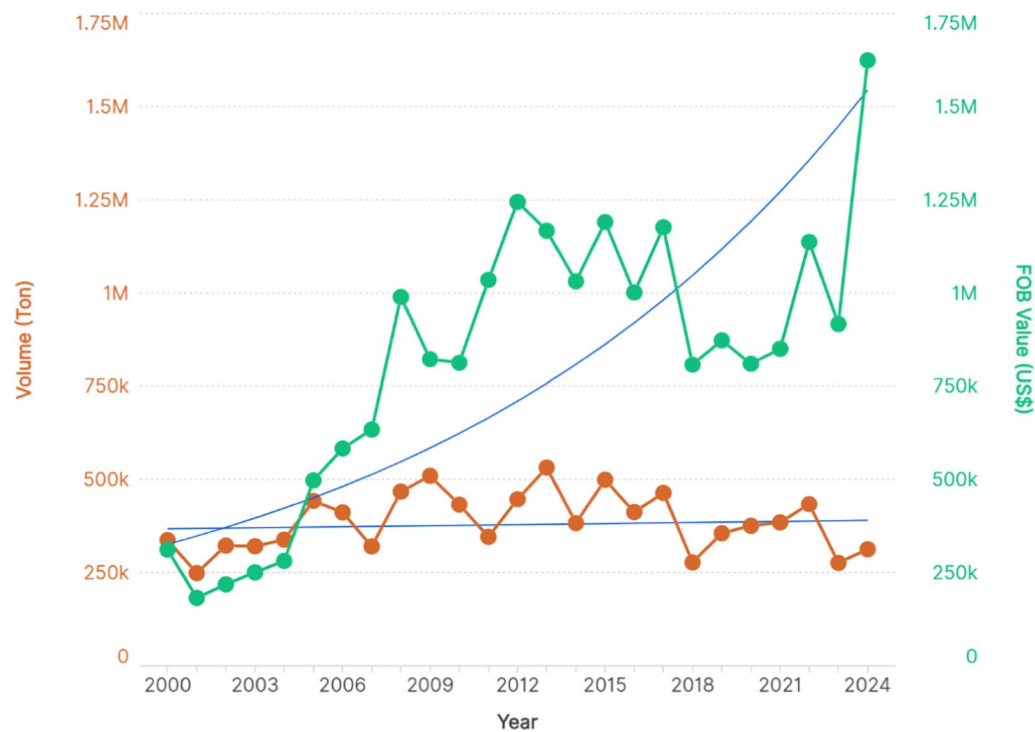


Fig. 1 Indonesian coffee export trends 2000–2024 (adapted from [13])

indicate that the value of Indonesia's exports has generally increased over the past two decades. This upward trend suggests Indonesia's growing role in international trade and its increasing contribution to national revenue. However, despite Indonesia's position as one of the world's largest coffee producers, persistently stagnant coffee export volumes point to structural constraints that may limit the country's ability to build and sustain long-term competitiveness within global value chains. Consistent with this evidence, Gois et al. [23] note that although Indonesia has maintained relatively stable competitiveness in the global market, more substantial efforts are needed to strengthen its export advantage.

Building on the discussion above, it is essential to develop a comprehensive understanding of the factors that shape Indonesia's coffee export performance. This understanding is necessary to design effective policy and strategic interventions so that gains in export value are not merely nominal but are also supported by higher export volumes and a stronger global market share. A substantial body of research has examined the determinants of coffee export performance, both in Indonesia and in other exporting countries. Collectively, this literature provides a strong foundation on the key drivers of coffee exports. However, most studies have a clear limitation: they do not adequately capture the dynamic nature of trade flows. For instance, using a Random

Effects Model, Marbun et al. [38] find that free-on-board (FOB) prices and the Indonesian Coffee Price (ICP) significantly affect Indonesia's export flows to its main destination markets. Studies using the gravity model further identify several determinants of coffee exports, including exporter and importer GDP [9, 67], destination-country population [5, 24], inflation—often proxied by the Consumer Price Index (CPI) [60, 78, 80], exchange rates [34, 64, 67], trade distance [9, 19, 34, 66, 67], trade openness [18, 27], and foreign direct investment (FDI) [60, 78, 80]. Despite these contributions, the literature remains dominated by static panel methods. Some studies have begun to move toward more dynamic analysis by incorporating FDI, but the overall treatment of trade dynamics is still limited. This gap is important because trade flows are inherently dynamic. They reflect adjustment processes, persistence over time, and potential endogeneity. As a result, static panel approaches may not fully explain export performance. Export outcomes are likely to depend not only on current market conditions, but also on past trade relationships, long-term buyer–seller ties, and structural sources of competitiveness.

To address this gap, this study uses a dynamic panel data framework and estimates a system Generalized Method of Moments (GMM) model to identify the main drivers of Indonesia's coffee exports across its 25 major trading partners. This approach allows for a more

rigorous treatment of endogeneity, unobserved heterogeneity, and dynamic adjustment—issues that many prior studies do not fully address. The study makes three key contributions. First, it provides a stronger empirical assessment of both price and non-price determinants of coffee export performance, improving on earlier static estimates. Second, it presents new evidence on trade-flow persistence by examining how past export levels influence current export capacity. Third, it places Indonesia's export dynamics within an evolving global demand environment, offering policy-relevant insights for decision-makers who aim to strengthen Indonesia's position in the global coffee value chain and to maximize the export potential of one of the country's most iconic agricultural commodities.

Literature review

Gravity model in international trade

The gravity model is a central framework in international trade analysis. It posits that trade flows between countries are positively associated with the economic size of trading partners and negatively associated with trade costs, particularly those related to geographic and economic distance. Since the seminal contributions of Salette & Tinbergen [61] and Pöyhönen [52], the gravity model has been widely applied to examine trade in agricultural commodities, including coffee.

In the context of coffee trade, the gravity model is especially relevant because export performance is shaped not only by the production capacity of the exporting country, but also by demand conditions, purchasing power, logistics costs, trade barriers, and established trade relationships with destination markets. Prior studies have shown that GDP, population, distance, exchange rates, inflation, trade openness, and FDI are commonly used variables in explaining trade flows in coffee and other agricultural commodities [9, 10, 19, 67].

However, empirical findings in the literature remain mixed. These inconsistencies suggest that the determinants of coffee exports cannot be fully explained through a simple linear relationship between macroeconomic variables and export value. Rather, the effect of each variable may depend on country-specific characteristics, commodity attributes, market structure, logistics quality, trade relationships, and institutional capacity. In the Indonesian context, Suryana et al. [66] found that the geographic scope of coffee trade is influenced not only by physical distance, but also by the structure of market relationships and the capacity of coffee-sector actors to connect with international buyers. Accordingly, the gravity model should be understood not merely as a framework for capturing market size and trade costs, but also as an analytical lens for interpreting the economic, logistical,

and institutional linkages that shape coffee trade in the global market.

Determinants of coffee export performance

Trade costs are a central component of the gravity model. In this framework, distance is commonly used as a proxy for transportation costs, delivery time, and logistical barriers. Several studies show that distance negatively affects coffee and agricultural commodity exports because more distant destination markets impose higher transaction costs on exporters [9, 19, 67]. However, the effect of distance is not always strong or statistically significant. Other studies suggest that distance-related barriers may decline when countries have stronger logistics infrastructure, stable trade relationships, or more integrated supply chains [34, 66]. These mixed findings indicate that economic distance reflects more than geographic separation. It also captures the efficiency of connectivity, the quality of trade infrastructure, and exporters' capacity to serve more distant markets.

Market size is another key variable in the gravity model. The GDP of the destination country is generally used to represent purchasing power and demand capacity. Several studies find that importing-country GDP has a positive effect on coffee exports because larger economies tend to generate stronger import demand [9, 67]. However, the influence of GDP is not independent of other market conditions. Torga & Spers [72] show that coffee demand is also shaped by consumption culture, developments in the food and beverage industry, consumer preferences, product differentiation, specialty coffee markets, certification, and marketing strategies. Thus, GDP helps explain the economic capacity of a destination market, but it does not fully capture the quality of demand or the segmentation of coffee markets.

Population is also an important factor in gravity-based studies of agricultural trade. Prior research shows that population can significantly influence trade flows, although the direction and strength of this effect depend on the commodity and the characteristics of the destination country [5]. In the context of Indonesian coffee trade, Suryana et al. [66] find that the population of importing countries positively affects trade in green coffee beans. By contrast, Assoua et al. [5] find that importer population has a negative and significant effect on Cameroon's cocoa exports. These findings suggest that population should be interpreted together with income levels, product characteristics, and consumption patterns. A larger population does not necessarily translate into higher demand for a specific commodity.

Macroeconomic variables, such as the CPI, which is commonly used as a proxy for inflation, also influence coffee exports. However, their effects vary across

contexts. Vongphouthong [75] finds that CPI has a positive effect on Laotian coffee export volume. One explanation is that rising domestic prices may reduce local purchasing power and encourage producers to shift toward export markets. Similarly, Siregar et al. [65] find that inflation positively affects the value of Indonesian coffee exports. This result should be interpreted cautiously, however, because export values may rise due to increases in nominal prices rather than higher real export performance. In contrast, Eshetu & Goshu [19] find that inflation negatively affects Tanzanian coffee exports because it increases the cost of production inputs, including fertilizers, pesticides, and agricultural technology.

Theoretically, depreciation of the domestic currency can stimulate exports by making domestic products more price-competitive in international markets. Tadesse & Abafita [67], in their study of global coffee trade, support this argument and find that exchange rate depreciation in exporting countries positively affects coffee trade by improving price competitiveness. Nevertheless, empirical findings remain inconsistent. Vo et al. [74] find that exchange rates negatively affect Vietnamese coffee exports. Their findings suggest that exchange rate fluctuations may create price uncertainty, increase transaction costs, or coincide with trade barriers such as tariffs and non-tariff measures. Meanwhile, Muslima & Kharisma [43] show that the effect of exchange rates may weaken when coffee exports are measured in volume rather than value, or when export decisions are more strongly influenced by global commodity prices.

Trade openness reflects a country's degree of integration into the global economy. Greater openness can expand market access, reduce trade barriers, and strengthen participation in international trade networks. In the Indonesian context, Setiawan & Yusuf [63] and Prilliadi & Birinci [53] show that trade openness supports coffee export performance. Their findings suggest that trade integration can improve access to foreign markets. Similarly, Bekele & Mersha [9] find that importing-country openness has a positive effect on Ethiopian coffee exports because more open destination markets provide greater opportunities for exporters. However, evidence from Vietnam's economy-wide trade openness context [46] and from Ethiopian sesame and coffee exports [18] indicates that trade openness can also have a negative effect. These studies argue that openness alone is insufficient to improve export performance. It must be supported by domestic readiness, the ability to meet international market standards, and efforts to address behind-the-border constraints.

Likewise, FDI may influence coffee exports by improving production capacity, technology, infrastructure, and access to international markets. Barsua et al. [8] find

that FDI increases the value of Indonesian coffee exports because investment can expand production capacity and strengthen export performance. Eshetu & Goshu [19] also show that FDI has a significant positive effect on Ethiopian coffee export volume, suggesting that FDI promotion can help reinforce export capacity. However, FDI does not always translate directly into stronger export competitiveness. Arumatulabala [4] shows that FDI can increase the quantity of coffee exports but does not necessarily improve comparative advantage in export value. This may occur because FDI primarily stimulates the domestic market and may reduce the price competitiveness of exports.

Overall, the mixed findings in the literature suggest that export performance is shaped not only by macroeconomic variables but also by the structural and organizational capacities of economic actors. Rangel Luzuriaga [55] shows that, for small and medium-sized enterprises (SMEs) in developing countries, internal competencies, adaptive capacity, and institutional conditions are critical for responding to market changes. This perspective is also relevant to coffee exports. Exporter competitiveness depends not only on GDP, exchange rates, inflation, FDI, and economic distance, but also on the ability to maintain product quality, comply with market standards, adapt products to consumer preferences, and build long-term trade relationships. Therefore, inconsistencies in empirical findings across studies may reflect differences in macroeconomic conditions as well as variation in structural and institutional capacities across countries.

Dynamic gravity model and export persistence

Most gravity studies continue to rely on static specifications, which limits their ability to capture export persistence arising from repeated trade relationships, reputation, and trust between exporters and importers. This issue is particularly important in the coffee trade because buyers often maintain relationships with suppliers who can consistently ensure product quality, stable volumes, and timely delivery. Dynamic gravity models address this limitation by incorporating lagged exports, which capture the effect of past export performance on current export flows. This approach has been used in studies of Ethiopian coffee exports by Bekele & Mersha [9] and Eshetu & Goshu [19]. However, including lagged dependent variables may introduce endogeneity concerns. As a result, conventional estimators such as Ordinary Least Squares (OLS), Fixed Effects (FE), and Random Effects (RE) may produce biased and inconsistent estimates [3, 12].

The GMM is widely used to address these challenges in dynamic panel models. GMM relies on internal instruments constructed from lagged variables to control for

endogeneity, unobserved heterogeneity, and persistence in the dependent variable. System GMM, developed by Blundell & Bond [11], is frequently preferred because it combines equations in first differences and levels, thereby improving estimation efficiency when variables exhibit high persistence. This method has been widely applied in trade research to capture the adjustment process of trade flows over time [14, 64]. In the context of coffee trade, similar dynamic gravity approaches have been adopted by Bekele & Mersha [9] and Eshetu & Goshu [19] to examine the determinants of coffee exports.

Research gaps and study contributions

Prior research has examined the determinants of coffee exports using the gravity model, but several important gaps remain. First, most studies rely on static specifications, which limits their ability to capture export persistence arising from repeated trade relationships, exporter reputation, and buyer trust. Second, empirical findings on the effects of exchange rates, inflation, FDI, trade openness, and economic distance remain mixed. These inconsistencies may reflect differences in country contexts, market structures, logistics performance, and institutional capacity. In the Indonesian context, studies that apply a dynamic gravity model using System GMM to analyze coffee exports remain limited. This study addresses these gaps by incorporating lagged export performance to capture persistence and by examining how market size, macroeconomic conditions, trade costs, FDI, and trade openness influence Indonesian coffee exports.

Materials and methods

Data sources

This study uses secondary data obtained from multiple sources, primarily international organizations such as the World Bank and the United Nations. Macroeconomic data were collected from the World Bank's World Development Indicators (WDI) database, including GDP, population, exchange rates, FDI, and CPI. Trade data for

coffee products, classified under HS Code 0901, were obtained from the United Nations Comtrade database. These data were compiled into a panel dataset covering the period 2005–2024 and encompassing 25 major destination countries for Indonesia's coffee exports. The countries were selected based on their cumulative contribution to Indonesia's coffee export value during the study period. The selection also aimed to ensure regional representation across Europe, Asia, North America, Africa, the Middle East, and Oceania. Table 1 presents the regional distribution of the selected countries. Countries with relatively small and inconsistent export shares were excluded from the sample to maintain analytical relevance and data consistency. Overall, the selected countries account for the largest share of Indonesia's coffee exports during the study period, thereby providing a suitable basis for examining the determinants of Indonesia's coffee export performance.

Conceptual framework and model

The gravity model is an econometric framework widely used to analyze international trade flows. It has become one of the most established empirical tools for examining bilateral trade relationships [42]. The model is also frequently used as a foundational approach for estimating the effects of various trade policies [9]. Conceptually, the gravity model is rooted in Newton's law of gravitation, which states that objects with greater mass and closer proximity exert stronger gravitational forces than smaller and more distant objects. In international trade, this principle is adapted to suggest that countries with larger economic size and shorter geographic distance tend to engage in more intensive trade. Salette & Tinbergen [61] was the first to apply this concept to explain the factors shaping trade flows between countries. Since then, the gravity model has evolved substantially and has been widely applied in empirical studies of both bilateral and multilateral trade [15, 39]. In general, the gravity model can be expressed as follows [45]:

Table 1 Global distribution of Indonesia's major coffee trading partners

Region	Number of countries	Countries
Europe	12	Belgium, Italy, France, Spain, United Kingdom, Poland, Sweden, Romania, Portugal, Greece, Germany, Netherlands
Asia	5	Japan, Philippines, Malaysia, India, China
Middle East	1	Saudi Arabia
Africa	2	Algeria, Egypt
North America	2	United States, Canada
Oceania	1	Australia
Eurasia	2	Russia, Georgia

$$V_{ijt} = A \frac{Y_{it}^\alpha Y_{jt}^\beta}{D_{ijt}^\gamma} \quad (1)$$

where V_{ijt} represents the trade flow, both exports and imports, from country i to country j in year t . The variables Y_{it} and Y_{jt} reflect the “economic mass” of the two countries in year t , which is generally proxied by GDP. Meanwhile, D_{ijt} denotes the geographical distance between country i and country j , and A represents the gravitational constant in the gravity model. In simple terms, Eq. (1) states that trade flows between two countries are directly proportional to the product of their economic sizes and inversely proportional to the geographical distance separating them.

In empirical applications, the gravity model is generally specified using three main groups of variables. The first group captures demand conditions and market capacity in the importing country, which are commonly proxied by GDP and population. The second group reflects supply-side conditions in the exporting country, including GDP and population as indicators of production capacity. The third group includes factors that may facilitate or constrain bilateral trade, such as geographic distance, common language, shared borders, colonial ties, shared religion, and other relevant determinants [67]. Based on this classification, and after applying a natural logarithmic transformation to the variables to satisfy empirical estimation requirements, the gravity model can be formulated as follows:

$$\begin{aligned} \ln X_{it} = & \alpha + \ln X_{it-1} + \ln \text{GDPP}_{it} \\ & + \ln \text{GDP}_{jt} + \ln \text{POP}_{jt} + \ln \text{EXR}_{it} \\ & + \ln \text{WDS}_{ijt} + \ln \text{CPI}_{jt} + \ln \text{FDI}_{it} + \text{OPN}_{it} + U_{it} \end{aligned} \quad (2)$$

In principle, the gravity model can be estimated using several econometric approaches, including OLS, FE, and RE [41, 59]. However, these approaches are not well suited for dynamic gravity models. This limitation arises because the inclusion of a lagged dependent variable may create a correlation with the error term, leading to biased and inconsistent estimates [3, 77].

Although the FE estimator can control for unobserved individual heterogeneity, it does not fully resolve this problem in dynamic panel settings. The lagged dependent variable may remain correlated with the transformed residuals, thereby violating the exogeneity assumption [21]. Other approaches, such as Two-Stage Least Squares (2SLS), can also be used to address endogeneity. However, their results may be less reliable when valid instruments are limited, weak, or insufficient for the model specification [18].

Given the dynamic nature of international trade flows, exports in the previous period may influence exports in the current period. Therefore, including a lagged dependent variable is theoretically relevant and provides the basis for using the GMM. The GMM estimator is appropriate because it can address endogeneity arising from the correlation between the lagged dependent variable and the error term [48]. Recent studies have also applied GMM to analyze international trade flows, showing that this approach can capture dynamic interactions among trade variables more accurately. GMM allows the use of internal instruments derived from lagged values of the variables. Under appropriate conditions, these instruments can produce parameter estimates that are more consistent, efficient, and reliable. This improves the accuracy of the estimation results. Moreover, GMM can generate consistent estimates in the presence of lagged dependent variables, measurement errors, omitted variables, partial endogeneity among explanatory variables, fixed individual effects, heteroskedasticity, and autocorrelation [18, 77].

There are two main GMM estimators commonly used in dynamic panel models: First-Difference GMM and System GMM. First-Difference GMM, also known as the Arellano–Bond estimator, addresses the correlation between individual effects and the lagged dependent variable by applying a first-differencing transformation to all variables. This transformation eliminates unobserved individual fixed effects and helps produce more consistent estimates [7, 32]. More specifically, the first-difference equation in the Arellano–Bond method can be formulated as follows [21]:

$$\begin{aligned} Y_{it} - Y_{it-1} = & \alpha'(Y_{it-1} - Y_{it-2}) \\ & + \beta'(X_{it} - X_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1}) \end{aligned} \quad (3)$$

$$\Delta Y_{it} = \alpha' \Delta Y_{it-1} + \beta' \Delta X_{it} + \Delta \varepsilon_{it} \quad (4)$$

Although First-Difference GMM is effective in addressing the correlation between individual effects and the lagged dependent variable, it has several limitations. The differencing process may remove important cross-sectional variation, which can reduce estimation efficiency and weaken instrument strength, particularly when variables are highly persistent or strongly autocorrelated. To address these limitations, System GMM, also known as the Blundell–Bond estimator, was developed as an extension of the Arellano–Bond model. System GMM combines two sets of equations: one in first differences and one in levels. This structure allows the use of additional moment conditions, which can reduce bias, improve consistency, and produce more efficient estimates, especially

in models that include a lagged dependent variable [20]. Accordingly, the System GMM specification used in this study is formulated based on the approach developed by Blundell & Bond [11] and Eshetu [18] as follows:

$$\begin{aligned}\Delta LX_{ijt} = & \Delta LX_{ijt-1} + \Delta LGDPP_{cit} + \Delta LGDP_{jt} \\ & + \Delta LPOP_{jt} + \Delta LCPI_{jt} + \Delta LEXR_{it} \\ & + \Delta LFDI_{it} + \Delta LDIST_{ijt} + \Delta OPN_{it} + \Delta \mu_{it}\end{aligned}\quad (5)$$

Equation (5) represents the System GMM estimation model, which utilizes two sets of instruments, namely $Z_i = Z_D + Z_L$, where Z_D denotes the instruments derived from the first-difference equation, and Z_L refers to the instruments derived from the level equation. The System GMM estimator operates under the assumption that all instruments, collectively as a group, are exogenous. This assumption can be formally expressed as follows:

$$E(Z_i U_{it}) = 0 \quad (6)$$

where Z_i is the instrument matrix and U_{it} is the error term. This assumption does not imply that each individual instrument is automatically exogenous; rather, it emphasizes that the validity of the instruments depends on their lack of correlation with the residuals. Therefore, tests for instrument exogeneity and autocorrelation remain necessary to ensure estimation efficiency and to minimize the potential emergence of weak instruments.

Operational definitions

In the model used in this study, each variable plays an important role in explaining the relationships among the factors under analysis. Therefore, clear operational definitions are needed to avoid ambiguity and ensure consistency in interpretation. These definitions also help ensure that each indicator is aligned with the theoretical concepts underlying the study. The operational definitions of the variables included in the model are presented in Table 2.

Based on Table 2, the variable X_{ijt} represents the value of Indonesia's coffee exports under HS 0901 to its major trading partner countries, measured in U.S. dollars. Meanwhile, X_{ijt-1} denotes the lagged export value, or the export value to each partner country in the previous year. Consistent with previous studies, such as Eshetu [18] and Ravi Kumar et al. [56], lagged export value is expected to have a positive and significant effect on current coffee exports. This relationship reflects export persistence, which refers to the tendency of current export performance to be influenced by past export outcomes. Export persistence suggests that strong export performance in the previous year can help build stable trade relationships and strengthen market confidence, thereby supporting higher export levels in the following period. In addition, path dependence may further reinforce export performance. Past export experience can generate learning effects, improve trade efficiency, and strengthen Indonesia's reputation among international trading partners.

The variable GDP_{cit} represents Indonesia's GDP per capita in each year of analysis, measured in U.S. dollars. This variable is expected to be positively associated with the value of Indonesia's coffee exports to its major trading partners. A higher level of GDP per capita reflects greater domestic economic development, which may support production capacity, improve trade efficiency, and strengthen export competitiveness. This expectation is consistent with Rezitis et al. [57], who argue that GDP per capita serves as an indicator of a country's level of economic development and advancement, thereby encouraging greater trade activity. The variable GDP_{jt} represents the GDP of each trading partner country in each year of analysis, also measured in U.S. dollars. This variable is expected to have a positive effect on Indonesia's coffee exports because higher GDP indicates a larger market size, stronger economic performance, and greater purchasing power in the destination country. As

Table 2 List of variables, definitions, data source, and expected sign

Variable	Variable description	Data source	Expected sign
X_{ijt}	Indonesia's coffee export value to partner countries (US Dollars)	United Nations	Dependent Variable
X_{ijt-1}	Indonesia's coffee export value to partner countries in the previous year (US Dollars)	United Nations	+
GDP_{cit}	Indonesia's GDP per capita (US Dollars per year)	World Bank	+
GDP_{jt}	Partner country's GDP (US Dollars)	World Bank	+
POP_{jt}	Partner country's population (persons)	World Bank	+
CPI_{jt}	Partner country's Consumer Price Index (Index, base year 2010 = 100)	World Bank	±
EXR_{it}	Exchange rate of the Indonesian Rupiah against the US Dollar (Rupiah per US Dollar)	World Bank	+
FDI_{it}	Indonesia's Foreign Direct Investment net inflow (US Dollars)	World Bank	-
$DIST_{ijt}$	Indonesia's economic distance to partner countries (Index)	CEPII + own calculation	-
OPN_{it}	Indonesia's trade openness (Ratio)	World Bank	±

economic conditions improve, demand for various commodities, including coffee, tends to increase through both household consumption and industrial use [39].

The variable POP_{jt} denotes the population of the partner country, measured in number of persons. It is expected to be positively associated with Indonesia's coffee exports. This expectation is consistent with Tim-sina & Culas [71], who show that population growth in importing countries significantly increases import demand, including demand for agricultural commodities. As a result, larger populations in destination markets may contribute to higher export volumes from producing countries. The variable CPI_{jt} refers to the Consumer Price Index of the importing country, measured as an index. Its relationship with Indonesia's coffee exports may be either positive or negative. This ambiguity arises because the CPI captures inflationary conditions and price changes, including price shocks, in the importing country. These changes can affect consumers' purchasing power and, consequently, demand for imported products, particularly agricultural commodities [17].

The variable EXR_{it} represents the exchange rate of the Indonesian rupiah against the U.S. dollar, expressed relative to the U.S. dollar. This variable is expected to be positively associated with Indonesia's coffee exports. Theoretically, a depreciation of the domestic currency makes export products relatively less expensive in international markets, thereby enhancing export competitiveness and stimulating export demand [31]. The variable FDI_{it} denotes foreign direct investment inflows into Indonesia, measured in U.S. dollars. This variable is expected to be negatively associated with Indonesia's coffee exports. One possible explanation is that foreign investment may promote domestic industrialization and processing activities. As a result, some coffee that would otherwise be exported in raw form may be redirected toward semi-processed or fully processed products for domestic use or higher-value production. This argument is consistent with Tham et al. [70], who report a negative relationship between FDI inflows and export performance.

The variable $DIST_{ijt}$ represents the weighted economic distance between Indonesia and its trading partners, measured as an index. This measure captures both the geographic distance between countries and the relative economic size of the exporting country. The index is adapted from Karagoz & Saray [33], who define weighted economic distance as the actual geographic distance between two countries multiplied by the exporter's GDP and divided by the exporter's total GDP over the study period. This variable is expected to be negatively associated with Indonesia's coffee exports. Greater economic distance tends to increase trade costs, particularly through higher transportation

expenses, which may reduce export flows. This expectation is consistent with Nawrot [44], who shows that geographic distance has a negative effect on export performance. The variable OPN_{it} represents the degree of trade openness, calculated as the ratio of total exports plus total imports to GDP. Its relationship with Indonesia's coffee exports may be either positive or negative, depending on the extent and quality of openness [27]. On the one hand, greater openness may improve market access and support export growth. On the other hand, excessive openness may increase competitive pressure from imported products, which could weaken the export performance of domestic commodities.

Results and discussions

Panel unit root test results

Because panel data combine cross-sectional and time-series dimensions, it is necessary to assess stationarity before conducting further empirical analysis. The results of the stationarity tests are presented in Table 3. The Levin–Lin–Chu (LLC) unit root test shows that six variables are stationary in levels: coffee exports, Indonesia's GDP, the GDP of partner countries, the population of partner countries, weighted economic distance, and foreign direct investment inflows into Indonesia. These results indicate that the null hypothesis of a unit root can be rejected at conventional significance levels. Therefore, these variables are integrated of order zero, or $I(0)$. In contrast, the LLC unit root test indicates that the Consumer Price Index, exchange rate, and trade openness variables are not stationary in levels. However, these variables become stationary after first differencing. This finding suggests that the three variables are integrated of order one, or $I(1)$.

Table 3 The Levin-Lin-Chu unit root test results

Variables in the models	Level	Difference
Export	−2.85 ***	
GDPPc_Ind	−7.74 ***	
GDP_Partner	−4.08 ***	
Consumer price index	−0.39	−7.83 ***
Population, partner	−11.49 ***	
Exchange rate	−1.6	−10.9 ***
Weighted distance	−8.01 ***	
Foreign direct investment, Indonesia	−7.3 ***	
Trade openness	0.32	−19.7 ***

Author's computation using STATA 13

***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels, respectively

Baseline system GMM estimation

Table 4 presents the results of the dynamic panel data estimation using the two-step system GMM, which identifies the factors influencing Indonesia's coffee exports to its trading partners. The coefficient of the one-period lagged coffee export variable is positive and statistically significant at the 1% level ($p=0.001$). This finding indicates strong export persistence, suggesting that Indonesia's coffee export performance in the previous period is positively associated with export performance in the current period. Specifically, a 1% increase in Indonesia's coffee exports in the previous period is associated with an average increase of 0.55% in current coffee exports. This result implies that past export performance plays an important role in shaping current export outcomes, reflecting continuity in trade relationships, market access, and demand conditions in partner countries.

The GDP of trading partner countries has a positive and statistically significant coefficient at the 10% level ($p=0.082$). This finding is consistent with previous studies by Ambarita & Sirait [2], Balogh & Borges Aguiar [6], Hwang & Lim [30], and Malau et al. [37], which show

that higher GDP in importing countries is associated with increased export demand. The estimated coefficient indicates a positive association between the economic size of Indonesia's trading partners and the value of Indonesia's coffee exports. Indonesia's coffee exports tend to be higher in larger economies. This result is consistent with gravity theory, which predicts that greater economic activity increases the volume of international trade. It also reflects the characteristics of coffee demand, as coffee is widely consumed in many middle- and high-income countries.

The weighted distance variable has the expected negative coefficient and is statistically significant at the 1% level ($p=0.005$). A 1% increase in weighted distance is associated with a 0.5% decrease in Indonesia's coffee exports. This result is consistent with previous empirical studies by Ambarita & Sirait [2], Balogh & Borges Aguiar [6], Leitão [36], Nthebe & Mosikari [49], and Sato [62]. Geographic distance is commonly used as a proxy for transportation and transaction costs. Greater distance can increase logistics costs, delivery time, and trade uncertainty, thereby reducing export flows. Moreover, the negative effect of transportation costs may become more pronounced when exchange rate movements increase the cost of logistics and make trade-related expenses more critical [49].

The CPI of partner countries has a positive and statistically significant coefficient at the 5% level ($p=0.020$). Although this result differs from the initial expectation, it may reflect periods of rising global commodity prices and higher import prices in destination markets, which increase the nominal value of Indonesia's coffee exports. In commodity-importing countries, a higher CPI may also indicate stronger market demand or rising prices of imported goods during certain periods. Because the dependent variable in this study is measured in export value rather than export volume, the positive relationship between CPI and coffee exports may capture broader commodity price dynamics rather than changes in physical export quantities. Therefore, the positive association between CPI and coffee exports is more likely to reflect periods of global commodity price expansion and broader inflationary cycles in commodity markets rather than a direct productivity-enhancing effect of inflation itself.

The exchange rate variable has a negative and statistically significant coefficient at the 5% level ($p=0.046$). This finding is consistent with Vo et al. [74]. The result indicates that a 1% appreciation of the rupiah is associated with a 1.33% decline in Indonesia's coffee exports. An appreciation of the rupiah makes Indonesian coffee relatively more expensive for trading partner countries, thereby reducing its competitiveness in the global

Table 4 Regression result of the system generalized method of moments dynamics panel-data estimation, two-step system GMM

Number of observations = 475				
Number of instruments = 14				
F-statistics = 1586.84, Prob > F = 0.000				
Logarithm of variables	Coffee export			
	Coefficient	Std. error	t-value	p-value
Export LI	0.555 ***	0.142	3.90	0.001
GDPPc, Indonesia	1.177	0.767	1.53	0.138
GDP, Partner	0.34 *	0.187	1.81	0.082
Population, Partner	-0.133	0.098	-1.36	0.188
CPI, Indonesia	4.563 **	1.826	2.50	0.020
Exchange Rate, Indonesia	-1.338 **	0.636	-2.1	0.046
FDI, Indonesia	-0.004	0.509	-0.01	0.993
Weighted Distance	-0.5 ***	0.161	-3.12	0.005
Trade Openness, Indonesia	23.798 ***	8.357	2.85	0.009
Constant	-9.374	6.89	-1.36	0.186
Arellano and bond test for second-order autocorrelation				
Arellano-Bond test for AR (1)	Z = -2.68, Prob > Z = 0.007			
Arellano-Bond test for AR (2)	Z = 0.20, Prob > Z = 0.845			
Sargant test	Chi2(4) = 2.27, Prob > chi2 = 0.686			
Hansen test	Chi2(4) = 4.67, Prob > chi2 = 0.323			

Author's computation using STATA 13, 2025

***, **, and * indicate statistical significance at the 1, 5, and 10 percent levels, respectively

market. As Indonesian coffee becomes more costly for importers, demand for Indonesian coffee exports is likely to decline. In addition, exchange rate movements may affect trade decisions by changing relative costs and altering the incentives received by producers and exporters.

Indonesia's trade openness has a positive and statistically significant effect on coffee exports, which is consistent with Gulzar [25]. A 1% increase in trade openness is associated with a substantial increase in export value. This strong coefficient suggests that greater integration into the global economy plays an important role in facilitating Indonesia's coffee exports by reducing trade barriers and improving market access. However, the magnitude of the coefficient should be interpreted with caution. Because the model is estimated in logarithmic form and trade openness is measured as a ratio, the estimated elasticity may reflect broader structural effects of trade liberalization rather than a purely proportional response. Similar large coefficients have been reported in studies where openness captures both policy orientation and the overall degree of economic integration. Unlike a conventional elasticity measure, trade openness is expressed as the ratio of total trade to GDP and therefore reflects broader changes in a country's integration with international markets. Therefore, this result should be interpreted primarily as evidence of the importance of openness as a structural driver of export performance, rather than as a direct one-to-one elasticity effect.

Indonesia's GDP per capita has a positive coefficient, which is consistent with the findings of Leitão [36]. This result suggests that Indonesia's per capita income is positively associated with export performance, indicating that the size and development level of the domestic economy may support the competitiveness of Indonesian coffee. However, the coefficient is not statistically significant. Therefore, Indonesia's GDP per capita does not appear to have a significant effect on Indonesia's coffee exports in this model.

The population of trading partner countries has a negative coefficient, as also observed in Harach & Rodriguez-Crespo [26] and Sato [62]. However, the direction of the coefficient is contrary to the initial expectation. Moreover, the population variable is not statistically significant at the 1%, 5%, or 10% levels, indicating that it does not have a significant effect on Indonesia's coffee exports. One possible explanation for the negative coefficient is that larger populations may be associated with greater domestic investment and employment, including in the agricultural sector. In such cases, partner countries with large populations and stronger domestic agricultural production may be able to meet part of their domestic demand through local supply, thereby reducing the need to import agricultural commodities [35, 49].

Indonesia's foreign direct investment variable has a negative coefficient, which is contrary to the expected sign. However, the coefficient is not statistically significant. This result indicates that foreign direct investment inflows into Indonesia do not have a significant effect on Indonesia's coffee exports in the estimated model.

Finally, this study uses aggregate coffee export data that combine Arabica and Robusta coffee. This approach allows the analysis to capture Indonesia's overall coffee export performance. However, aggregation may obscure important differences between the two types of coffee, including differences in market segments, price structures, product quality, and consumer preferences. As a result, Arabica and Robusta coffee may not respond to the explanatory variables in the same way. Therefore, the estimates in this study should be interpreted as the average response of Indonesia's coffee export sector as a whole, rather than as the specific response of each coffee type.

Diagnostic tests and instrument validity

Two post-estimation diagnostic tests are used to assess the validity of the one-step and two-step GMM estimates. The first test examines whether the residuals exhibit second-order serial autocorrelation, because serial correlation can render certain lagged variables invalid as instruments for endogenous regressors. Following Arellano & Bond [3], this study applies the Arellano–Bond test, whose null hypothesis is that no serial autocorrelation is present. The test is commonly reported for both first-order autocorrelation, AR(1), and second-order autocorrelation, AR(2). While AR(1) is generally expected in the first-differenced equation, the absence of AR(2) is essential for confirming the validity of the model specification and the instruments. As reported in Table 4, the Arellano–Bond test for AR(1) is statistically significant, with $\text{Prob} > Z = 0.007$, indicating the presence of first-order serial correlation in the differenced residuals. This result is consistent with the expected properties of the first-differenced GMM estimator. By contrast, the Arellano–Bond test for AR(2) is not statistically significant, with $\text{Prob} > Z = 0.845$, suggesting that the model does not suffer from second-order serial autocorrelation. These findings support the validity of the model specification and the use of the selected lagged instruments.

The second specification test assesses the validity of the instruments using the Hansen and Sargan overidentification tests. The null hypothesis (H_0) states that the instruments are collectively exogenous and, therefore, valid. A p -value above the conventional significance level indicates that the null hypothesis cannot be rejected, providing support for the validity of the instrument set. In this study, the Sargan test yields a p -value of 0.686, while the

Hansen test yields a p -value of 0.323. Since both values exceed conventional significance thresholds, the results suggest that the instruments used in the model are valid and satisfy the exogeneity condition.

To mitigate concerns about instrument proliferation in the system GMM estimation, the number of instruments was kept relatively low in the model specification. The final model includes 14 instruments for 25 cross-sectional groups, which helps preserve the reliability of the Hansen test results and is consistent with the recommendations of Roodman [58]. As an additional robustness check, the model was re-estimated using the fixed-effects estimator. The results reported in Table 5 generally show coefficient directions that are consistent with those obtained from the system GMM estimation, particularly for lagged exports, partner-country GDP, CPI, the exchange rate, and trade openness. Although some variables lose statistical significance, the core findings remain largely unchanged, suggesting that the main conclusions are robust to alternative estimation approaches.

Economic interpretation and policy implications

A central finding of this study is the strong persistence of export performance. The statistically significant lagged effect confirms the presence of path dependence in the international coffee trade. In this context, long-term business relationships, trust between trading partners, consistent product quality, and reliable supply create self-reinforcing export dynamics [9, 22]. Importers are often more likely to retain established suppliers than switch to new ones because of sunk costs, reputation effects, and learning-by-doing mechanisms [69, 76].

Beyond this mechanical form of path dependence, the persistence of exports has broader structural implications for Indonesia's trade strategy. Export persistence should not be viewed merely as an inertial effect from past export performance. Rather, it reflects the cumulative outcome of firms' strategic adaptation to changing

international market expectations. Recent studies on technological adaptation and competitiveness show that sustained export performance depends heavily on exporters' ability to respond to evolving buyer requirements, quality standards, and sustainability demands [47]. This suggests that export persistence is endogenous to firms' capacity to learn, reposition themselves, and respond to external shocks, rather than being an automatic outcome of previous success. Therefore, maintaining existing export markets requires active policy support that strengthens exporters' adaptive capabilities, not only passive relationship management. Policy efforts should prioritize trade diplomacy, the facilitation of long-term contracts, and the strengthening of Indonesia's reputation in global markets. At the same time, they should enhance exporters' absorptive capacity to meet increasingly demanding global standards.

The income level of partner countries, proxied by GDP, has a positive and marginally significant effect on Indonesia's coffee exports. This finding is consistent with gravity theory. Higher income levels increase purchasing power and stimulate demand for coffee as a normal good, both for household consumption and for service sectors such as hotels, restaurants, and cafés [67, 73]. This result suggests that Indonesia should strategically target high-growth markets with expanding middle-class consumers, including emerging markets in East Asia, the Middle East, and Eastern Europe. Traditional markets such as the United States, Japan, and the European Union should also remain important priorities.

In contrast, the population of partner countries has an insignificant effect. This indicates that population size alone is not a sufficient indicator of export demand unless it is accompanied by adequate income levels and a strong coffee consumption culture. Similarly, Indonesia's GDP per capita is positive but statistically insignificant, suggesting that domestic economic growth has not yet translated directly into stronger export competitiveness in the coffee sector.

Trade costs, measured by the weighted economic distance variable, have a negative and significant effect, with a coefficient of -0.5 . This finding highlights the importance of logistics and connectivity in shaping export performance. Economic distance reflects not only geographic separation but also transportation costs, delivery times, logistical risks, and institutional differences [74]. For perishable and quality-sensitive commodities such as coffee, efficient supply chains are especially important [51]. These results underscore the need for continued investment in port infrastructure, logistics systems, customs efficiency, and direct shipping routes. Such improvements can reduce trade barriers and strengthen

Table 5 Robustness check using fixed effects estimation

Variable	Coefficient	P-value
Lagged export	0.5396	0.000
GDPPc_Ind	-3.3632	0.507
GDP partner	0.2782	0.303
Population partner	0.9230	0.313
CPI	0.1766	0.472
Exchange rate	-0.8022	0.225
FDI_Ind	0.0578	0.260
Weighted distance	3.0768	0.504
Trade openness	8.0768	0.327

Indonesia's competitiveness, particularly in distant markets such as Europe and the Americas.

Macroeconomic conditions also play an important role. The exchange rate has a negative and significant coefficient of -1.338 , indicating that an appreciation of the Indonesian rupiah reduces export competitiveness by making Indonesian coffee relatively more expensive in international markets [16]. Conversely, rupiah depreciation may improve price competitiveness. This finding highlights the importance of exchange rate stability for export planning and risk management [50]. Indonesia's CPI has a positive and significant effect, with a coefficient of 4.563 . Although inflation is commonly associated with higher production costs, in this context CPI may capture broader economic expansion, rising global coffee prices, or nominal increases in export values [1, 29]. Thus, CPI may reflect favorable market conditions rather than cost pressures alone. Nevertheless, maintaining domestic price stability remains important to prevent rising input costs from reducing producer margins.

Trade openness emerges as the most influential variable, with a large positive coefficient of 23.798 . This result indicates that deeper integration into the global economy substantially enhances export performance [68]. The finding supports policies that expand market access through free trade agreements, reduce tariff and non-tariff barriers, simplify export procedures, and strengthen participation in global value chains. Improving the readiness of small and medium-sized enterprises to participate in export markets is also essential. In contrast, FDI has an insignificant effect, suggesting limited spillover effects in the coffee export sector. This may indicate that FDI has not been sufficiently directed toward the coffee value chain, or that aggregate FDI measures obscure important sectoral differences.

Overall, the results show that non-price factors, particularly export persistence, trade openness, and economic distance, play a more dominant role than several traditional supply-side indicators. The insignificant effects of FDI, GDP per capita, and population suggest that the model captures the core dynamics of Indonesia's coffee trade, but it could be further enriched by incorporating additional variables such as quality differentiation, certification schemes, and climate-related factors. From a policy perspective, improving Indonesia's coffee export performance requires a comprehensive value-chain-based strategy. On the upstream side, policy efforts should focus on increasing farmer productivity through replanting programs, access to high-quality seeds, financing, and training in sustainable agricultural practices. On the downstream side, Indonesia should strengthen processing capacity, improve post-harvest quality, and develop stronger branding for distinctive Indonesian

coffees, including Gayo, Toraja, Kintamani, Java Preanger, and Flores Bajawa. These efforts would help Indonesia move beyond the export of raw beans toward higher value-added products, such as roasted, instant, and specialty coffee. In doing so, Indonesia can enhance its competitiveness and capture greater value in the global coffee market.

Policy recommendations

The policy implications directly supported by the model findings can be organized by time horizon. In the short term, defined as zero to two years, policymakers should prioritize exchange rate management and trade facilitation. The negative and statistically significant coefficient for exchange rate appreciation supports policies aimed at maintaining rupiah stability and avoiding prolonged appreciation that could weaken Indonesia's export competitiveness. Relevant short-term instruments include central bank intervention in foreign exchange markets, export-earnings retention schemes, and hedging facilities for coffee exporters. In addition, the strong positive effect of trade openness justifies immediate efforts to streamline export procedures, reduce documentary requirements, and accelerate customs clearance at major ports, including Tanjung Priok, Tanjung Perak, and Belawan. Digital single-window systems and reforms to pre-shipment inspection procedures could generate relatively rapid efficiency gains.

In the long term, defined as three to ten years, policy priorities should focus on productive diversification and export upgrading. Although Indonesia's GDP per capita is statistically insignificant, the strong persistence effect suggests that accumulated export experience can support future market expansion and product diversification. Long-term policies should therefore encourage a gradual shift away from dependence on raw coffee beans toward more differentiated products, such as single-origin, roasted, and specialty coffees. This transition would help reduce vulnerability to global price volatility and increase value capture in international markets. Moreover, the negative effect of economic distance indicates that sustained investment in logistics infrastructure is essential to overcome geographic disadvantages. Such investment should include port modernization, cold storage networks, and stronger inter-island connectivity. These priorities require consistent multi-year budgeting and coordinated implementation.

Several additional policy considerations require further empirical investigation. Certification systems, geographical indications, and blockchain-based traceability were not included in the estimated model. Evidence from other contexts suggests that sustainability certifications, such as Rainforest Alliance, Fairtrade, Organic, and UTZ,

may improve price premiums and market access. However, this study does not directly estimate their impact on Indonesian coffee export volumes. Similarly, geographical indication protection for origin-specific coffees, such as Gayo, Toraja, and Kintamani, may strengthen branding and product differentiation, but its effect is not directly tested in the model. Blockchain-based traceability technologies were also outside the scope of the GMM specification. Their potential relevance is suggested by the persistence mechanism and reputation effects identified in the analysis. Nevertheless, these instruments require separate empirical validation before broader policy implementation. Pilot programs accompanied by rigorous impact evaluation are therefore recommended.

Improvements in data systems and policy monitoring are also essential. Future policy design should be supported by regularly updated gravity analyses that are disaggregated by coffee type, particularly Robusta and Arabica. Incorporating sustainability indicators would further strengthen evidence-based policymaking. International cooperation with organizations such as the International Coffee Organization could also improve market intelligence, technical standards, and access to global best practices.

Overall, implementing these recommendations would help Indonesia convert nominal export value growth into sustained volume expansion and a larger global market share. Such progress would strengthen the contribution of coffee exports to rural livelihoods, foreign exchange earnings, and broader economic diversification. Achieving these outcomes requires coordinated action among the ministries responsible for trade, agriculture, and finance, as well as close collaboration with private-sector stakeholders. Continuous monitoring through updated panel models would help ensure that policy interventions remain evidence-based and responsive to changing global market conditions.

Conclusions

The estimation results indicate that Indonesian coffee exports exhibit strong persistence. Export performance in the previous period has a positive and statistically significant effect on exports in the current period. This finding suggests that long-term trade relationships, exporter reputation, consistent product quality, and supply stability are important factors in sustaining Indonesia's position in global coffee markets. In addition, the GDP of trading partner countries has a positive and significant effect on Indonesian coffee exports, indicating that economic growth in destination markets increases demand for Indonesian coffee. By contrast, weighted distance has a negative and significant effect, confirming that logistics

costs and geographic barriers remain major constraints in the international coffee trade.

Several macroeconomic and policy-related variables also significantly affect Indonesian coffee exports, including Indonesia's CPI, the exchange rate, and trade openness. These findings suggest that domestic macroeconomic stability and greater integration into international markets are essential for strengthening export competitiveness. Meanwhile, Indonesia's GDP per capita, the population of trading partner countries, and foreign direct investment do not show a statistically significant effect in the estimated model.

Based on these empirical findings, policy recommendations to increase Indonesian coffee exports should focus on four main priorities. First, Indonesia should maintain its traditional export markets while expanding into new and rapidly growing destination markets. Second, policymakers should reduce logistics costs and improve supply chain efficiency. Third, exchange rate stability and a supportive business environment should be maintained to strengthen exporter confidence and planning. Fourth, trade openness should be enhanced through stronger international cooperation and improved market access. Beyond these empirically supported recommendations, several complementary strategies may also strengthen Indonesia's long-term coffee export competitiveness. These include increasing value added through downstream development in the coffee industry, expanding quality certification, and strengthening the global branding of Indonesian coffee. Such efforts would help Indonesia move beyond raw coffee bean exports and improve its position in higher-value segments of the global coffee market.

From an academic perspective, this study contributes to the literature by demonstrating the importance of a dynamic approach in analyzing international coffee trade, particularly for a major coffee-producing country such as Indonesia. The findings show that export performance in commodity markets is dynamic and strongly influenced by previous trade relationships. Compared with static gravity models, the system GMM approach is better able to capture the persistence of coffee exports over time. The results may also be relevant for other commodity-exporting countries with similar trade structures and market characteristics.

Nevertheless, this study has several limitations. It relies on aggregate data and does not distinguish between Arabica and Robusta coffee, product quality differences, or non-tariff factors such as sustainability standards and environmental certification. Future research should incorporate these variables to provide a more comprehensive understanding of the competitiveness of Indonesian coffee exports in global markets.

Author contribution

Author Contributions F.Z. conceptualized the study, conducted the analysis, interpreted the findings, wrote the main manuscript text, revised the manuscript, and prepared the figures and tables. E.P.W., A.T.S., R.P.D., and S.M.A. conducted the analysis, interpreted the findings, and contributed to writing the manuscript. A.A.F. conducted the analysis, interpreted the findings, contributed to writing the manuscript, and prepared the figures and tables. All authors reviewed the manuscript.

Funding

This research received no external funding.

Data availability

The datasets analyzed during the current study are publicly available from international databases and are available from the corresponding author upon reasonable request.

Declarations

Ethics approval

Not applicable.

Consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 5 May 2026 Accepted: 24 June 2026

Published online: 02 July 2026

References

- Abbott P, de Battisti AB (2011) Recent global food price shocks: causes, consequences and lessons for African governments and donors. *J Afr Econ* 20(SUPPL. 1):i12–i62. <https://doi.org/10.1093/jae/ejr007>
- Ambarita YMR, Sirait T (2019) 2020 Penerapan model gravitasi data panel: kajian perdagangan internasional Indonesia ke negara anggota ASEAN. *Seminar Nasional Official Statistics* 1:726–737
- Arellano M, Bond S (1991) Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Rev Econ Stud* 58(2):277–297. <https://doi.org/10.2307/2297968>
- Arumatulabala, A. M. (2023). *Efek Kredit, Pengeluaran Pemerintah, Foreign Direct Investment (FDI) dan Nilai Tukar Terhadap Ekspor Kopi: Studi Pada Negara-Negara Pengekspor Kopi* [Universitas Brawijaya]. <http://repository.ub.ac.id/id/eprint/222959>
- Assoua JE, Molua EL, Nkendah R, Fani DCR, Tabetando R (2022) The effect of sanitary and phytosanitary measures on Cameroon's cocoa exports: An application of the gravity model. *Heliyon* 8(1):e08754. <https://doi.org/10.1016/j.heliyon.2022.e08754>
- Balogh JM, Borges Aguiar GM (2022) Determinants of Latin American and the Caribbean agricultural trade: a gravity model approach. *Agricultural Economics (Czech Republic)* 68(4):127–136. <https://doi.org/10.17221/405/2021-AGRICECON>
- Baltagi BH, Jiménez-Martín S, Labeaga JM, al Sadoon M (2023) Consistent estimation of panel data sample selection models. *Econom Stat* 21(39):1–28. <https://doi.org/10.1016/j.jecosta.2023.11.003>
- Barsua NPEU, Harum NS, Boeaya MA, Gurusina WU (2024) Analisis Determinan Nilai Ekspor Kopi Indonesia (Dampak Nilai Tukar Rupiah, Investasi Asing Langsung dan Harga Kopi Dunia). *JIA (Jurnal Ilmiah Agribisnis) : Jurnal Agribisnis Dan Ilmu Sosial Ekonomi Pertanian* 9(4):327–337. <https://doi.org/10.37149/jia.v9i4.1338>
- Bekele WT, Mersha FG (2019) A dynamic panel gravity model application on the determinant factors of Ethiopia's coffee export performance. *Ann Data Sci* 6(4):787–806. <https://doi.org/10.1007/s40745-019-00198-4>
- Benavidez L, Xia T (2022) A gravity model of Central American organic coffee trade with the United States. *J Food Distrib Res* 53(1):33–40
- Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data models. *J Econometrics* 87(1):115–143. [https://doi.org/10.1016/S0304-4076\(98\)00009-8](https://doi.org/10.1016/S0304-4076(98)00009-8)
- Blundell R, Bond S (2023) Reprint of: initial conditions and moment restrictions in dynamic panel data models. *J Econometrics* 234:38–55. <https://doi.org/10.1016/j.jeconom.2023.03.001>
- BPS - Statistics Indonesia. (2025). *Exports of Coffee by Major Countries of Destination, 2000–2024*. BPS - Statistics Indonesia. <https://www.bps.go.id/en/statistics-table/1/MTaxNCMx/ekspor-kopi-menurut-negara-tujuan-utama--2000-2024.html>
- Bun MJG, Klaassen FJGM (2002) The importance of dynamics in panel gravity models of trade. *SSRN Electron J*. <https://doi.org/10.2139/ssrn.306100>
- Caruso R, Cipollina M (2025) The effect of economic sanctions on world trade of mineral commodities: a gravity model approach from 2009 to 2020. *Resour Policy* 105(May):105574. <https://doi.org/10.1016/j.resourpol.2025.105574>
- Dwi Nugoho A, Lakner Z (2022) Effect of globalization on coffee exports in producing countries: A dynamic panel data analysis. *Journal of Asian Finance* 9(4):419–429
- Emediegwu LE, Rogna M (2024) Agricultural commodities' price transmission from international to local markets in developing countries. *Food Policy* 126(October 2023):102652. <https://doi.org/10.1016/j.foodpol.2024.102652>
- Eshetu F (2024) Determinants of Ethiopian sesame and coffee exports to its major trade partners: application of the gravity model. *Cogent Soc Sci* 10(1):1–15. <https://doi.org/10.1080/23311886.2024.2334114>
- Eshetu F, Goshu D (2021) Determinants of Ethiopian coffee exports to its major trade partners: a dynamic gravity model approach. *Foreign Trade Rev* 56(2):185–196. <https://doi.org/10.1177/0015732520976301>
- Fambeu AH (2021) Poverty reduction in sub-Saharan Africa: the mixed roles of democracy and trade openness. *J Int Trade Econ Dev* 30(8):1244–1262. <https://doi.org/10.1080/09638199.2021.1946128>
- Farzana A, Samsudin S, Hasan J (2024) Drivers of economic growth: a dynamic short panel data analysis using system GMM. *Discover Sustain* 5(1):393. <https://doi.org/10.1007/s43621-024-00612-9>
- Gizaw N, Abafita J, Merra TM (2022) Impact of coffee exports on economic growth in Ethiopia; an empirical investigation. *Cogent Econ Finance* 10(1):1–20. <https://doi.org/10.1080/23322039.2022.2041260>
- Gois TC, Thomé KM, Balogh JM (2023) Behind a cup of coffee: international market structure and competitiveness. *Compet Rev* 33(5):993–1009. <https://doi.org/10.1108/CR-10-2021-0141>
- Görlich, D., Hanley, A., Liu, W.-H., & Semrau, F. O. (2020). *Fostering the development of the coffee global value chain*. In *KIEL Working Paper: December* (Number 2170). <http://hdl.handle.net/10419/229167>
- Gulzar A (2017) Does trade openness has noteworthy effect on bilateral trade flows of E.C.O. countries; an empirical investigation. *Timisoara Journal of Economics and Business* 9(2):95–114. <https://doi.org/10.1515/tjeb-2016-0007>
- Harach, M., & Rodriguez-Crespo, E. (2014). Foreign direct investment and trade: A bi-directional gravity approach. *Kiel Advanced Studies Working Papers*, 467(Kiel Institute for the World Economy (IfW), Kiel), 1–31. <https://www.econstor.eu/handle/10419/103753>
- Hatab AA, Romstad E, Huo X (2010) Determinants of Egyptian agricultural exports: a gravity model approach. *Mod Econ* 01(03):134–143. <https://doi.org/10.4236/me.2010.13015>
- Holmes MJ, Otero J (2020) A tale of two coffees? Analysing interaction and futures market efficiency. *Stud Econ Finance* 37(1):89–109. <https://doi.org/10.1108/SEF-09-2019-0356>
- Hossain MS, Hossain MM, Moshuiddullah ABM (2024) Impact of consumer price index (CPI) and inflation on GDP: evidence from Bangladesh. *Asian Journal of Convergence in Technology* 10(2):1–11. <https://doi.org/10.33130/AJCT.2024v10i02.003>
- Hwang CW, Lim SS (2017) Effect of non-tariff measures on international tea trades. *J Korea Trade* 21(4):309–323. <https://doi.org/10.1108/JKT-05-2017-0054>

31. Irshad MS, Xin Q, Arshad H (2018) Competitiveness of Pakistani rice in international market and export potential with global world: a panel gravity approach. *Cogent Econ Finance*. <https://doi.org/10.1080/23322039.2018.1486690>
32. Jin F, Lee L, Yu J (2020) First difference estimation of spatial dynamic panel data models with fixed effects. *Econ Lett* 189:109010. <https://doi.org/10.1016/j.econlet.2020.109010>
33. Karagoz K, Saray MO (2010) Trade potential of Turkey with Asia-Pacific Countries : evidence from panel gravity model trade potential of Turkey with Asia-Pacific countries : Evidence from Panel Gravity Model. *International Economic Studies* 36(April):19–26
34. Kareem OI (2016) European Union's sanitary and phytosanitary measures and food exports. *Int J Trade Glob Mark* 9(4):287–304. <https://doi.org/10.1504/IJTM.2016.081141>
35. Lateef M, Tong GJ, Riaz MU (2018) Exploring the gravity of agricultural trade in China-Pakistan free trade agreement. *Chin Econ* 51(6):522–533. <https://doi.org/10.1080/10971475.2018.1481008>
36. Leitão NC (2023) The impact of geopolitical risk on Portuguese exports. *Economies* 11(12):291. <https://doi.org/10.3390/economies11120291>
37. Malau LRE, Ulya NA, Martin E, Anjani R, Premono BT, Yulni T (2022) Competitiveness and flow of Indonesian paper trade in the global market. *Jurnal Ekonomi Pembangunan: Kajian Masalah Ekonomi Dan Pembangunan* 23(1):1–18. <https://doi.org/10.23917/jep.v23i1.17648>
38. Marbun PMP, Sihombing FN, Lahay RR, Tampubolon K (2025) Indonesia coffee export performance to the primary destination countries. *Tekirdağ Ziraat Fakültesi Dergisi* 22(4):1072–1085. <https://doi.org/10.33462/jotaf.1701495>
39. Masood S, Khurshid N, Haider M, Khurshid J, Khokhar AM (2023) Trade potential of Pakistan with the South Asian countries: a gravity model approach. *Asia Pac Manag Rev* 28(1):45–51. <https://doi.org/10.1016/j.apmr.2022.02.001>
40. McStocker R (1987) The Indonesian coffee industry. *Bull Indones Econ Stud* 23(1):40–69. <https://doi.org/10.1080/00074918712331335121>
41. Mnasri A, Nechi S (2021) New nonlinear estimators of the gravity equation. *Econ Model* 95(December 2020):192–202. <https://doi.org/10.1016/j.econmod.2020.12.011>
42. Morland C, Tandetzki J, Schier F (2025) An evaluation of gravity models and artificial neuronal networks on bilateral trade flows in wood markets. *Forest Policy Econ* 172(October 2024):103457. <https://doi.org/10.1016/j.forpol.2025.103457>
43. Muslima F, Kharisma B (2023) Exchange rate volatility and leading export commodities of plantations in Indonesia: the gravity model approach. *Jurnal Economia* 19(2):188–205. <https://doi.org/10.21831/economia.v19i2.44430>
44. Nawrot KA (2023) Assessing the effects of trade regionalism in East Asia—evidence from augmented gravity models. *Appl Econ* 55(12):1285–1297. <https://doi.org/10.1080/00036846.2022.2097181>
45. Ngoma G (2020) What determines import demand in Zimbabwe? evidence from a gravity model. *Cogent Econ Finance* 8(1):1782129. <https://doi.org/10.1080/23322039.2020.1782129>
46. Nguyen AT, Anwar S, Alexander WRJ, Lu SH (2022) Openness to trade, foreign direct investment, and economic growth in Vietnam. *Appl Econ* 54(29):3373–3391. <https://doi.org/10.1080/00036846.2021.2009112>
47. Norono Sanchez JG (2025) How entrepreneurs perceive technology in the digital era: from aversion to adoption. *Ceniiac*. <https://doi.org/10.64923/ceniiac.e0002>
48. Noreen S, Mahmood Z (2022) The effects of trade cost components and uncertainty of time delay on bilateral export growth. *Heliyon* 8(1):e08779. <https://doi.org/10.1016/j.heliyon.2022.e08779>
49. Nthebe CT, Mosikari TJ (2025) The threshold effects of exchange rates on agricultural exports: a flow from South Africa to the Southern African development community. *Economies* 13(2):27. <https://doi.org/10.3390/economies13020027>
50. Okoye EI (2025) Exchange rate fluctuation and sustainability of small business enterprises in a developing nation. *Int J Adv Eng Manag* 7(9):610–620. <https://doi.org/10.35629/5252-0709610620>
51. Olyanga AM, Shinyekwa IMB, Ngoma M, Nkote IN, Esemu T, Kanya M (2022) Export logistics infrastructure and export competitiveness in the East African Community. *Mod Supply Chain Res Appl* 4(1):39–61. <https://doi.org/10.1108/mscra-09-2021-0017>
52. Pöyhönen, P. (1963). A Tentative Model for the Volume of Trade between Countries. *Weltwirtschaftliches Archiv*, 90(1963), 93–100. <https://www.jstor.org/stable/40436776>
53. Prilliadi H, Birinci A (2023) A study on determinants of coffee export from Indonesia to the United States of America. *Igdir Univ Fen Bil Enst Derg* 13(3):2174–2184. <https://doi.org/10.21597/jist.1227055>
54. Purnama A, Pradono P, Yudoko G (2025) Coffee beans special handling: analysis the cost of hinterland freight transport. *Acta Logist* 12(1):199–211. <https://doi.org/10.22306/al.v12i1.616>
55. Rangel Luzuriaga EW (2025) A moderated model of digital transformation in SMEs: digital competencies, digital HRM, and organizational culture. *Ceniiac*. 1:e0010. <https://doi.org/10.64923/ceniiac.e0010>
56. Ravi Kumar, K. N., Naidu, G. M., & Shafiwu, A. B. (2024). Exploring the drivers of Indian agricultural exports: a dynamic panel data approach. *Cogent Economics and Finance*, 12(1). <https://doi.org/10.1080/23322039.2024.2344733>
57. Rezitis AN, Zangelidis L, Karytsas S (2024) Investigating factors affecting trade flows in pork and poultry global markets using gravity models. *Agrekon* 63(4):303–318. <https://doi.org/10.1080/03031853.2024.2434470>
58. Roodman D (2009) A note on the theme of too many instruments *. *Oxf Bull Econ Stat* 71(1):135–158. <https://doi.org/10.1111/j.1468-0084.2008.00542.x>
59. Rosselló Nadal J, Santana Gallego M (2022) Gravity models for tourism demand modeling: empirical review and outlook. *J Econ Surv* 36(5):1358–1409. <https://doi.org/10.1111/joes.12502>
60. Saini N, Singhania M (2018) Determinants of FDI in developed and developing countries: a quantitative analysis using GMM. *J Econ Stud* 45(2):348–382. <https://doi.org/10.1108/JES-07-2016-0138>
61. Salette G, Tinbergen J (1965) Shaping the world economy. suggestions for an international economic policy. *Rev Econ* 16(5):840. <https://doi.org/10.2307/3498790>
62. Sato MN (2020) Determinants of Kenyan tea exports: the gravity model approach. *Journal of Economics and Sustainable Development* 10(14):132–143. <https://doi.org/10.7176/jesd/10-14-15>
63. Setiawan AB, Yusuf M (2025) Indonesia's coffee export dynamics: exploring the impacts of climate, trade, and productivity. *Econ Rev* 20(2):101–120
64. Shabbir G, Naveed A, Khan MA, Syed SH (2022) Does peace promote bilateral trade flows? An economic analysis of panel data in Asian perspective. *Comp Econ Stud* 64(1):143–158. <https://doi.org/10.1057/s41294-021-00155-2>
65. Siregar, F. S. A., Sari, A. N., Dila, S. K., & Rohmawati, D. (2025). Pengaruh produktivitas, inflasi, nilai tukar, dan PDB terhadap nilai ekspor kopi Indonesia. *AGRO TATANEN | Jurnal Ilmiah Pertanian*, 7(2), 52–60. <https://doi.org/10.55222/ak94ce12>
66. Suryana AT, Harianto S, Y., & Harmini. (2023) Geographic scope of the global value chain for Indonesian coffee. *Coffee Science* 18:1–11
67. Tadesse, T., & Abafita, J. (2021). Determinants of global coffee trade: Does RTAs matter? Gravity model analysis. *Cogent Economics and Finance*, 9(1). <https://doi.org/10.1080/23322039.2021.1892925>
68. Tahir M, Khan I (2014) Trade openness and economic growth in the Asian region. *J Chin Econ Foreign Trade Stud* 7(3):136–152. <https://doi.org/10.1108/JCEFTS-05-2014-0006>
69. Tampubolon J, Ginting A, Nainggolan HL, Tarigan JR (2023) Indonesian coffee development path: production and international trade. *Asian Journal of Agricultural Extension, Economics & Sociology* 41(12):316–328. <https://doi.org/10.9734/ajaees/2023/v41i122335>
70. Tham SY, Khoon Goh S, Wong KN, Fadhli A (2018) Bilateral export trade, outward and inward FDI: a dynamic gravity model approach using sectoral data from Malaysia. *Emerg Mark Finance Trade* 54(12):2718–2735. <https://doi.org/10.1080/1540496X.2017.1402176>
71. Timsina KP, Culas R (2022) Australia's free trade agreements (FTAs) and potentiality of wheat exports: a panel gravity model approach. *J East-West Bus* 28(1):61–88. <https://doi.org/10.1080/10669868.2021.1974640>
72. Torga, G. N., & Spers, E. E. (2020). Perspectives of global coffee demand. *Coffee Consumption and Industry Strategies in Brazil: A Volume in the Consumer Science and Strategic Marketing Series*, 21–49. <https://doi.org/10.1016/B978-0-12-814721-4.00002-0>
73. Vegro CLR, de Almeida LF (2020) Global coffee market: socio-economic and cultural dynamics. *Coffee consumption and industry strategies in*

- Brazil: a volume in the consumer science and strategic marketing series. Elsevier, pp 3–19. <https://doi.org/10.1016/B978-0-12-814721-4.00001-9>
74. Vo thuyD, Yang L, Dung Tran M (2024) Determinants influencing Vietnam coffee exports. *Cogent Bus Manag*. <https://doi.org/10.1080/23311975.2024.2337961>
 75. Vongphouthong, L. (2019). Influencing Factors of Coffee Exports in Laos. *International Journal of Innovative Science and Research Technology*, 4(9), 306–308. <https://www.ijisrt.com/influencing-factors-of-coffee-exports-in-laos>
 76. Wolor CW, Eranza DRD, Rababah MA, Nurkhin A, Hoo WC (2024) The impact of interpersonal trust development on maintaining business sustainability: a case study of Aceh Gayo coffee from Sumatera, Indonesia. *J Infrastruct Policy Dev* 8(6):3947. <https://doi.org/10.24294/jipd.v8i6.3947>
 77. Wuri J (2024) The role of comparative advantage in enhancing trade in value-added using a dynamic GMM model. *Economies* 12(7):187. <https://doi.org/10.3390/economies12070187>
 78. Younsi M, Bechtini M (2019) Does good governance matter for FDI? New evidence from emerging countries using a static and dynamic panel gravity model approach. *Econ Transit Inst Change* 27(3):841–860. <https://doi.org/10.1111/ecot.12224>
 79. Zelber-Sagi S, Salomone F, Webb M, Lotan R, Yeshua H, Halpern Z, Santo E, Oren R, Shibolet O (2015) Coffee consumption and nonalcoholic fatty liver onset: a prospective study in the general population. *Transl Res* 165(3):428–436. <https://doi.org/10.1016/j.trsl.2014.10.008>
 80. Zhou L, Mao Y, Fu Q, Xu D, Zhou J, Zeng S (2023) A study on the belt and road initiative's trade and its influencing factors: evidence of China-South Asia's panel data. *PLoS ONE* 18(4 APRIL):e0282167. <https://doi.org/10.1371/journal.pone.0282167>

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.