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Macroeconomic and Production Determinants of Coffee Export Volume from Central Java, Indonesia: Evidence from Bilateral Panel Data

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Abstract

Coffee is one of Indonesia's leading plantation commodities, contributing significantly to foreign exchange earnings and rural livelihoods. Despite being an important coffee-producing province, Central Java has experienced considerable fluctuations in coffee export volume, indicating that export performance is influenced by both macroeconomic and production-related factors. This study aimed to identify the determinants of coffee export volume from Central Java to six major destination countries—the United States, Japan, Malaysia, Italy, India, and Egypt—during 2004-2023. A balanced bilateral panel dataset comprising 120 observations was analysed using panel data regression. The Fixed Effect Model (FEM) was selected based on the Chow, Hausman, and Lagrange Multiplier tests. The explanatory variables included Free on Board (FOB), International Coffee Price (ICP), Real Exchange Rate (RER), Gross Domestic Product per capita (GDPC) of importing countries, and coffee yield. The results show that FOB and RER have positive and statistically significant effects on coffee export volume, whereas ICP, GDPC, and coffee yield are not statistically significant. These findings indicate that export value and exchange rate competitiveness play a more important role in driving regional coffee exports than production capacity or external market conditions. The study provides empirical evidence to support policies that enhance value addition, maintain exchange rate competitiveness, and strengthen the long-term competitiveness of coffee exports from Central Java.

Keywords: Bilateral panel data, Central Java, coffee export, Fixed Effect Model, Free on Board; real exchange rate

INTRODUCTION

Coffee is one of the world's leading plantation commodities, contributing substantially to foreign exchange earnings, rural livelihoods, and economic development across producing countries. Increasing global coffee consumption, driven by population growth, urbanization, rising incomes, and the expansion of specialty coffee markets, has intensified competition in international trade. As a result, improving productivity, product quality, supply chain efficiency, and export competitiveness has become essential for maintaining market access and ensuring the long-term sustainability of the coffee sector (Barreto Peixoto *et al*., 2023; International Coffee Organization, 2023; Madrid-Casaca *et al*., 2021).

Indonesia is the world's fourth-largest coffee producer after Brazil, Vietnam, and

Colombia, making coffee one of its leading plantation export commodities. Beyond generating foreign exchange, the sector supports regional economic development and the livelihoods of millions of smallholder farmers. Recent development strategies have increasingly emphasized production improvement, value addition, and market competitiveness to strengthen Indonesia's position in global coffee trade (Tampubolon *et al*., 2023). However, coffee exports remain vulnerable to fluctuations in international prices, exchange rates, and global demand, indicating that export growth is determined not only by production performance but also by broader macroeconomic conditions (Badan Pusat Statistik Provinsi Jawa Tengah, 2022; da Cruz Correia *et al*., 2024; International Coffee Organization, 2023).

Central Java is one of Indonesia's major coffee-producing provinces, with production concentrated in Temanggung, Wonosobo, Banjarnegara, Magelang, and Boyolali regency. Favorable agroecological conditions and extensive smallholder plantations enable the province to supply coffee to major international markets, including the United States, Japan, Malaysia, Italy, India, and Egypt. Nevertheless, coffee export volume fluctuated considerably during 2004-2023, suggesting that production potential alone is insufficient to sustain export growth. These fluctuations reflect the combined influence of domestic production conditions and external market forces, highlighting the need to identify the factors shaping regional coffee export performance in order to support evidence-based trade and agricultural policies (BPS, 2023; Hidayattullah *et al*., 2024; Zacharie & Denny, 2024).

International trade theory argues that export performance is determined by the interaction between supply-side capacity and demand-side market conditions. Export value, international commodity prices, exchange rate movements, purchasing power in destination countries, and production capacity jointly influence the availability and competitiveness of exportable products in international markets. Accordingly, coffee export performance should be analysed using an integrated framework that simultaneously considers macroeconomic and production-related factors rather than examining each determinant in isolation (Capoani, 2023; Sihotang *et al*., 2024; Tadesse & Abafita, 2021).

Previous studies consistently report that coffee exports are influenced by macroeconomic conditions and international market dynamics; however, the effects of individual determinants remain inconclusive across countries and study periods. Export value and exchange rates have frequently been identified as major drivers of Indonesia's coffee exports, whereas the effects of international coffee prices, destination-country income, and production-related variables differ according to geographical coverage, analytical methods, and model specifications (Novariani *et a*l., 2021; Prajanti *et al*., 2020; Sihombing *et al*., 2021; Sihotang *et al*., 2024; Zacharie & Denny, 2024). These inconsistencies indicate that coffee export performance cannot be explained by a single factor but instead reflects the interaction between domestic production capacity and external market conditions.

Despite these advances, important research gaps remain. Most previous studies have examined Indonesia's coffee exports at the national level or focused on a limited number of destination countries, providing only limited evidence on export performance at the provincial level. Moreover, few studies have simultaneously incorporated export value, international coffee prices, exchange rates, destination-country income, and production indicators within a bilateral panel data framework. Considering the diversity of production systems, export capacity, and market orientation among Indonesia's coffee-producing regions, provincial-level analysis is essential for improving the understanding of regional export dynamics

and supporting more targeted trade policies (da Cruz Correia *et al*., 2024; Tampubolon *et al.,* 2023).

To address these gaps, this study investigates the determinants of coffee export volume from Central Java using a balanced bilateral panel dataset covering six major destination countries—the United States, Japan, Malaysia, Italy, India, and Egypt—over the period 2004-2023. The analysis simultaneously evaluates the effects of Free on Board (FOB), International Coffee Price (ICP), Real Exchange Rate (RER), Gross Domestic Product per capita (GDPC) of importing countries, and coffee yield within a unified panel regression framework. By integrating macroeconomic and production-related variables while accounting for heterogeneity across destination countries, this study provides new empirical evidence on the determinants of regional coffee exports and offers policy implications for strengthening the competitiveness and long-term sustainability of Indonesia's coffee sector.

MATERIALS AND METHODS

This study employed a quantitative approach using secondary data to examine the determinants of coffee export volume from Central Java, Indonesia. Central Java was purposively selected because it is one of the country's major coffee-producing provinces and has consistently contributed to Indonesia's coffee exports while exhibiting substantial fluctuations in export performance. The analysis focused on bilateral coffee exports to six major destination countries—the United States, Japan, Malaysia, Italy, India, and Egypt—during 2004-2023. This observation period captures long-term export dynamics under different global economic conditions, including commodity price fluctuations, the global financial crisis, and the post-pandemic economic recovery.

A balanced bilateral panel dataset consisting of 120 observations (six destination countries observed over twenty years) was constructed by combining cross-sectional and time-series data. Panel data analysis was selected because it accommodates both temporal variation and cross-sectional heterogeneity, resulting in more efficient and consistent parameter estimates than separate cross-sectional or time-series analyses while reducing omitted-variable bias (Basuki & Prawoto, 2019; Wooldridge, 2021).

Data were compiled from official national and international sources to ensure consistency and comparability. Coffee export volume and Free on Board (FOB) values were obtained from BPS-Statistics Indonesia and BPS Central Java Province. International Coffee Price (ICP) data were collected from the International Coffee Organization (ICO), whereas Real Exchange Rate (RER) and Gross Domestic Product per capita (GDPC) were obtained from the World Bank and Bank Indonesia. Coffee yield data were sourced from the Directorate General of Estate Crops, Ministry of Agriculture, and complemented by statistics from the Central Java Provincial Plantation Office.

The dependent variable was LNNY, representing a transformed measure of coffee export volume. The transformation involved applying a natural logarithmic transformation followed by a normalization adjustment to improve the distributional properties of the data prior to panel regression estimation. Five explanatory variables were included in the model: FOB, representing export value at the port of shipment; ICP, representing international coffee market conditions; RER, measuring Indonesia's price competitiveness after accounting for inflation differentials; GDPC, representing purchasing power in importing countries; and coffee yield, representing regional production performance and export supply capacity. These variables were

selected based on international trade theory and previous empirical studies on agricultural exports and coffee trade competitiveness (Capoani, 2023; Sihotang *et al*., 2024; Tadesse & Abafita, 2021).

The determinants of coffee export volume were estimated using the following panel regression model:

$$LNNY_{it} = \beta_0 + \beta_1 FOB_{it} + \beta_2 ICP_{it} + \beta_3 RER_{it} + \beta_4 GDPC_{it} + \beta_5 YIELD_{it} + \varepsilon_{it}$$

Where LNNY represents the transformed coffee export volume of destination country i in year t; β_0 is the intercept; β_1-β_5 are the regression coefficients; and ε_i is the random error term. The model evaluates the effects of macroeconomic and production-related factors on coffee export volume while accounting for unobserved heterogeneity across destination countries (Basuki & Prawoto, 2019; Wooldridge, 2021).

The econometric analysis was performed using EViews 12. Three alternative panel estimators were evaluated, namely the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). The most appropriate specification was determined sequentially using the Chow, Hausman, and Lagrange Multiplier (LM) tests. After selecting the preferred model, the F-test was used to examine the joint significance of all explanatory variables, whereas the t-test evaluated the significance of individual regression coefficients at the 5% level. Model goodness-of-fit was assessed using the coefficient of determination (R^2).

RESULTS AND DISCUSSION

Coffee exports from Central Java exhibited a dynamic pattern during 2004-2023, with substantial fluctuations across the six major destination countries (Figure 1). Export volume did not follow a consistent upward trend but instead varied considerably from year to year, reflecting changing conditions in both domestic production and international markets. Periods of export expansion were followed by notable declines, indicating that the province's export performance was sensitive to shifts in global demand, exchange rate movements, and changes in the value of coffee exports. These fluctuations suggest that maintaining export growth requires not only adequate production but also the ability to respond to changing market conditions and sustain competitiveness in international trade (Tadesse & Abafita, 2021; Tampubolon *et al*., 2023; Zacharie & Denny, 2024).

The observed variation indicates that coffee export performance is shaped by multiple interrelated factors rather than by production capacity alone. Differences in export value, international coffee prices, exchange rate competitiveness, purchasing power in destination countries, and coffee yield may jointly influence export performance

Table 1. Definition and measurement of variable

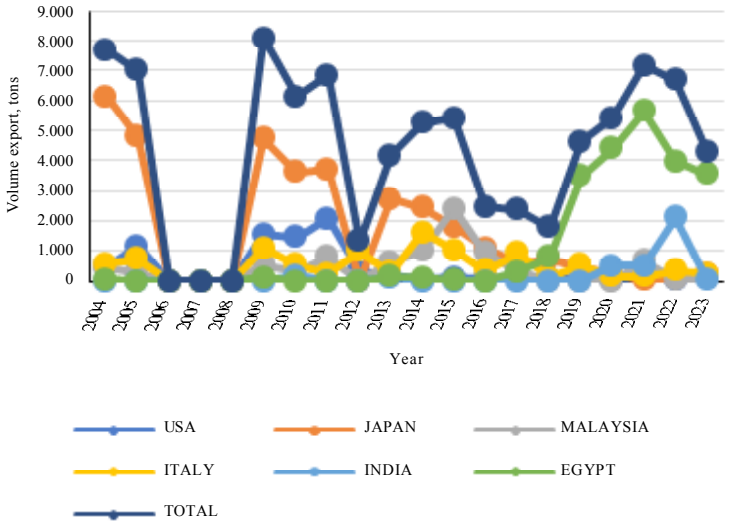
Variable	Symbol	Measurement/Unit	Data source
Transformed coffee export volume	LNNY	Natural logarithm with normalization adjustment	BPS Central Java Province
Free on board	FOB	USD	BPS-Statistics Indonesia
International coffee price	ICP	USD kg^{-1}	International Coffee Organization
Real exchange rate	RER	Index	Bank Indonesia; World Bank
GDP per capita	GDPC	USD $capita^{-1}$	World Bank
Coffee yield	Yield	kg ha^{-1}	Directorate General of Estate Crops

Source: Compiled by the authors based on BPS Central Java Province, BPS-Statistics Indonesia, International Coffee Organization, World Bank, Bank Indonesia, and the Directorate General of Estate Crops.

over time. Therefore, panel data regression analysis was employed to evaluate the simultaneous effects of these macroeconomic and production-related factors while accounting for heterogeneity across destination countries. This approach provides a comprehensive basis for identifying the determinants of coffee export volume from Central Java.

Table 2. presents the descriptive statistics of the variables included in the empirical analysis. The balanced bilateral panel dataset comprised 120 observations representing coffee exports from Central Java to six major destination countries during 2004-2023. The transformed coffee export volume (LNNY) exhibited substantial variation across countries and years, indicating differences in export performance over the observation period. Similarly, Free on Board (FOB) values varied considerably, reflecting differences in export value among destination markets. The Real Exchange Rate (RER) also showed noticeable variation, suggesting changes in Indonesia's external price competitiveness throughout the study period.

The explanatory variables demonstrated sufficient dispersion to capture differences in macroeconomic and production conditions



Source: Authors' Calculation Based on BPS Central Java Province Data (2025).

Figure 1. Coffee export volume from Central Java to six major destination countries during 2004-2023

Table 2. Descriptive statistic of the study variable

	LNNY	FOB	ICP	RER	GDPC	YIELD
Mean	4.108191	1367040	2.979000	11714.97	24134.67	1934925
Median	4.873193	337323.0	2.850000	11260.34	21194.00	1828948.
Maximum	9.963750	11135245	4.530000	15254.41	82304.60	3347491.
Minimum	-4.838470	0.000000	1.880000	8770.400	624.3000	983700.0
Std. dev.	3.321706	2.331089	0.770838	2363.656	21536.60	631639.8
Skewness	-0.302607	2.338733	0.747515	0.113828	0.476490	0.408453
Kurtosis	2.026453	7.935184	2.561053	1.307800	2.121006	2.187273
Jarque-Bera	6.570389	231.1736	12.13895	14.57685	8.404001	6.639311
Probability	0.037433	0.000000	0.002312	0.000683	0.014966	0.036165
Sum	492.9829	1.64E+08	357.4800	1,405,796	2,896,160	2.32E+08
Sum Sq. Dev	1313.014	6.47E+14	70.70868	6.65E+08	5.52E+10	4.75E+13
Observations	120	120	120	120	120	120

Source: Authors' calculation using EViews 12 based on BPS Central Java Province, BPS-Statistics Indonesia, International Coffee Organization, World Bank, Bank Indonesia, and the Directorate General of Estate Crops.

across export destinations and over time. Variations in International Coffee Price (ICP), Gross Domestic Product per Capita (GDPC), and coffee yield indicate that the dataset adequately represents changes in global market conditions, purchasing power, and regional production performance. The relatively large variation observed across several variables further reflects the heterogeneous characteristics of the bilateral panel data. Collectively, these characteristics support the application of panel data regression, as the dataset provides sufficient cross-sectional and temporal variation to identify the determinants of coffee export volume from Central Java (Basuki & Prawoto, 2019; Wooldridge, 2021).

The appropriate panel regression model was determined using the Chow, Hausman, and Lagrange Multiplier (LM) tests. The Chow test produced a probability value of 0.0048 ($p < 0.05$), indicating that the Fixed Effect Model (FEM) was preferred over the Common Effect Model (CEM). This result suggests the presence of significant country-specific effects, implying that differences among the six destination countries should be incorporated into the estimation model.

The Hausman test was inconclusive because the cross-section variance matrix was not positive definite, resulting in an invalid Chi-square statistic. Consequently, the test could not be used to distinguish between the Fixed Effect Model (FEM) and the Random Effect Model (REM). The Lagrange Multiplier (LM) test yielded a probability value of 0.3548 ($p > 0.05$), indicating that the Common Effect Model (CEM) was preferred to the Random Effect Model (REM). Although the LM test did not support the REM, the significant Chow test confirmed the presence of cross-sectional heterogeneity that could not be ignored.

Therefore, the Fixed Effect Model (FEM) was selected as the final estimation model because the Chow test identified significant country-specific effects, while the Hausman test was inconclusive due to an invalid variance matrix. This modelling strategy is consistent with established panel data procedures and provides a more reliable framework for analysing bilateral coffee exports by controlling for unobserved heterogeneity across destination countries (Basuki & Prawoto, 2019; Wooldridge, 2021; Hutagalung & Darnius, 2022). Accordingly, all subsequent interpretations are based on the Fixed Effect Model estimates.

The Fixed Effect Model is statistically significant (Prob. $F < 0.001$), indicating that the explanatory variables jointly explain variations in coffee export volume. The coefficient of determination ($R^2 = 0.5387$) indicates that approximately 53.9% of the variation in LNNY is explained by the variables included in the model, whereas the remaining 46.1% is attributable to factors outside the model. These results suggest that the model provides a satisfactory explanation of regional coffee export performance while confirming the joint importance of macroeconomic and production-related factors.

Table 3. Panel model selection results

Test	Test statistic	P-Value	Decision
Chow	3,586232	0,0048	FEM
Hausman	0,000000	1,0000*	Invalid
Lagrange Multiplier	0,856373	0,3548	CEM

Source: Authors' calculation using EViews 12 based on BPS Central Java Province, BPS-Statistics Indonesia, International Coffee Organization, World Bank, and Bank Indonesia data.
Note: The Hausman test produced an invalid statistic because the cross-section test variance was not positive definite.

Table 4. Determinants of coffee export volume.

Variable	Coefficient	t-statistic	P-Value
Constant	0.231170	0.163570	0.8704
Free on Board (FOB)	8.05E–07	7.630879	0.0000
International Coffee Price (ICP)	0.306491	0.974003	0.3322
Real Exchange Rate (RER)	0.000454	3.843181	0.0002
GDP per Capita (GDPC)	-9.54E–05	-1.965627	0.0519
Coffee Yield	-5.75E–07	-1.277055	0.2043
Model summary			
Statistic		Value	
R-squared		0.538726	
Adjusted R-squared		0.496407	
F-statistic		12.73021	
Prob (F-statistic)		0.000000	
Observations		120	

Source: Authors' calculation using EViews 12 based on BPS Central Java Province, BPS-Statistics Indonesia, International Coffee Organization, World Bank, Bank Indonesia, and the Directorate General of Estate Crops.

Among the explanatory variables, Free on Board (FOB) and the Real Exchange Rate (RER) have positive and statistically significant effects on coffee export volume ($p < 0.05$). In contrast, International Coffee Price (ICP), GDP per capita (GDPC) of importing countries, and coffee yield do not exhibit statistically significant effects. These findings indicate that export value and exchange rate competitiveness are the principal determinants of coffee exports from Central Java, whereas international market prices, destination-country income, and production performance exert more limited direct influences within the estimated model.

The estimation results show that Free on Board (FOB) has a positive and statistically significant effect on coffee export volume ($\beta = 8.05E{-}07$), ($p < 0.001$). The positive coefficient indicates that increases in export value are associated with higher coffee export volumes from Central Java. As the value of goods at the port of shipment, FOB reflects the commercial performance and international competitiveness of exported coffee.

Higher export values provide stronger incentives for exporters to improve product quality, expand market access, and increase export activities. Consequently, greater export value tends to be accompanied by larger export volumes. This result supports international trade theory, which argues that export value reflects the competitiveness of products in international markets (Capoani, 2023). Similar findings were reported by (Prajanti *et al*., 2020; Zacharie & Denny, 2024), who demonstrated that export value positively contributes to Indonesia's coffee exports. These results suggest that strengthening value addition, improving product quality, and enhancing export efficiency are important strategies for increasing the competitiveness of Central Java coffee.

Effect of International Coffee Price (ICP)

The coefficient of International Coffee Price (ICP) is positive but statistically insignificant ($\beta = 0.306491$), ($p = 0.3322$), indicating that fluctuations in global coffee prices did not significantly influence coffee export volume during the study period.

Although higher international prices are generally expected to encourage exports, export decisions are also determined by contractual arrangements, quality standards, destination-market preferences, and long-term trading

relationships. Consequently, short-term changes in world coffee prices may not immediately affect export volume. This suggests that export performance depends more on long-term competitiveness than on short-term price fluctuations. Similar findings were reported by (Novariani *et al*., 2021) and (Sihotang *et al.*, 2024), who concluded that international coffee prices do not consistently influence Indonesia's coffee exports because market-specific and institutional factors often moderate price transmission.

Effect of Real Exchange Rate (RER)

The Real Exchange Rate (RER) has a positive and statistically significant effect on coffee export volume ($\beta = 0.000454$), ($p = 0.0002$). This result indicates that improved exchange rate competitiveness enhances coffee exports from Central Java by increasing the price competitiveness of Indonesian coffee in international markets.

According to international trade theory, exchange rate movements influence export performance through changes in the relative prices of traded goods. A more competitive real exchange rate lowers the effective price of Indonesian coffee for foreign buyers, thereby stimulating export demand. Similar results were reported by (Sihombing *et al*., 2021; Tampubolon *et al.*, 2023; Zacharie & Denny, 2024). These findings highlight the importance of maintaining macroeconomic stability as part of strategies to strengthen agricultural export competitiveness.

Effect of Gross Domestic Product per Capita (GDPC)

The coefficient of Gross Domestic Product per Capita (GDPC) is negative and statistically insignificant ($\beta = -9.54E-05$; $p = 0.0519$), indicating that differences in purchasing power among importing countries did not significantly affect coffee export volume from Central Java.

This result suggests that demand for Central Java coffee is determined less by income levels than by product quality, consumer preferences, certification requirements, and long-term trade relationships. Coffee is a differentiated agricultural commodity whose market performance depends largely on competitiveness rather than purchasing power alone. Similar conclusions were reported by (da Cruz Correia *et al*., 2024; Tadesse & Abafita, 2021). who found that income does not necessarily translate into greater agricultural imports when market access and product characteristics are more influential.

Effect of Coffee Yield

Coffee yield has a negative but statistically insignificant coefficient ($\beta = -5.75E-07$; $p = 0.2043$), indicating that regional production performance did not significantly influence coffee export volume during the study period.

Increased production does not automatically lead to higher exports because additional output may be absorbed by domestic consumption or constrained by post-harvest handling, processing capacity, logistics, and compliance with international quality standards. Consequently, expanding production alone is insufficient to improve export performance without parallel improvements in product quality and export value chains. Similar conclusions were reported by (da Cruz Correia *et al*., 2024; Hidayattullah *et al*., 2024), who emphasized that agricultural export competitiveness depends not only on production capacity but also on value addition and integration into international markets.

Overall Discussion

Collectively, the results indicate that the competitiveness of Central Java coffee exports is influenced more by market-related factors than by production capacity alone. Export value

and exchange rate competitiveness emerged as the principal drivers of coffee export volume, whereas international coffee prices, destination-country income, and coffee yield showed no statistically significant effects. These findings imply that policies aimed at improving regional coffee exports should prioritize value addition, product quality enhancement, market diversification, and trade efficiency alongside production development. Therefore, improving the competitiveness of Central Java coffee requires an integrated strategy that combines productivity enhancement with value addition, quality improvement, market diversification, and efficient trade logistics.

CONCLUSION

This study examined the determinants of coffee export volume from Central Java to six major destination countries the United States, Japan, Malaysia, Italy, India, and Egypt during 2004-2023 using a balanced bilateral panel dataset and the Fixed Effect Model (FEM). The results demonstrate that Free on Board (FOB) and the Real Exchange Rate (RER) are the primary determinants of coffee export volume, highlighting the importance of export value and exchange rate competitiveness in supporting regional coffee exports. In contrast, International Coffee Price (ICP), Gross Domestic Product per capita (GDPC) of importing countries, and coffee yield do not significantly influence export volume. These findings indicate that the export performance of Central Java coffee is driven more by market competitiveness than by production capacity or external market conditions alone, thereby extending the empirical evidence on regional coffee export determinants within a bilateral panel data framework.

The findings have important implications for policymakers and stakeholders seeking to strengthen Indonesia's coffee export competitiveness. Policies should focus on enhancing product quality, increasing value addition, improving export efficiency, diversifying destination markets, and maintaining a competitive exchange rate while supporting sustainable production systems. Such integrated measures are expected to strengthen the resilience and long-term competitiveness of Central Java coffee in international markets. Nevertheless, this study is limited to six destination countries and a selected set of macroeconomic and production-related variables. Future research should incorporate additional determinants, such as logistics performance, trade facilitation, sustainability certification, transportation costs, institutional quality, and non-tariff measures, while extending the analysis to other coffee-producing provinces or broader export destinations to provide a more comprehensive understanding of Indonesia's coffee export competitiveness.

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