JBPE | Journal of Business and Political Economy: Biannual Review of the Indonesian Economy
Vol. 8, No. 1, 2026, pp. 41–53 | ISSN 2685-5100 (print) | ISSN 2723-5734 (online)

The Competitiveness of Indonesian Coconut Oil and Its Determinants: A Time Series Analysis

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Abstract

Coconut oil is one of Indonesia's most significant agricultural export commodities, yet its export performance has fluctuated considerably over time because of various domestic and international factors. This study identifies the key determinants of Indonesia's coconut oil export competitiveness, measured by the Revealed Symmetric Comparative Advantage (RSCA) index, using an Autoregressive Distributed Lag (ARDL) model for the 1970–2023 period. The ARDL framework was selected because all variables are stationary after first differencing, I(1), according to both the Augmented Dickey–Fuller and Phillips–Perron tests, thereby satisfying the preconditions for bounds testing. The results indicate that rural population growth, agricultural trade openness, and coconut oil yield have positive and statistically significant effects on export competitiveness, whereas rising coconut oil prices and exchange rate volatility adversely affect export performance. These findings support targeted policy interventions, including exchange rate stabilization measures administered by Bank Indonesia to mitigate the adverse effects of currency volatility on export competitiveness, fiscal incentives for coconut oil processing industries to reduce dependence on primary commodity exports, and strategic investments in agricultural extension programs to enhance yield productivity among smallholder farmers.

Keywords: Autoregressive Distributed Lag (ARDL); coconut oil; competitiveness; international trade
JEL Classification: F14; Q17; C32

Received: September 6, 2025 *Revised*: April 3, 2026 *Accepted*: April 11, 2026
Available online: June 30, 2026 *Published*: June 30, 2026

DOI: https://doi.org/10.46851/254

A. INTRODUCTION

Indonesia's coconut oil exports hold a strong position in the global market. In 2023, the country exported approximately 368,048 tons of crude coconut oil valued at US$346.29 million, making it one of the world's leading exporters (UN Comtrade, 2025). The country's main export destinations were China (104.5 thousand tons), the United States (79.38 thousand tons), and Sri Lanka (62.21 thousand tons), together accounting for more than 50% of total export volume. These figures highlight the growing demand for coconut oil, which is driven by its diverse applications in industries such as food and beverages, pharmaceuticals, personal care, and biofuels (Chomchalow, 2011).

The coconut oil industry plays a critical role in Indonesia's economy by providing employment and supporting the livelihoods of millions of smallholder farmers, particularly in rural areas. Beyond employment generation, the industry earns substantial foreign exchange, thereby supporting economic growth and poverty alleviation.

The sector also contributes to rural development by increasing farmers' incomes and supporting smallholder farmers who depend on coconut cultivation. However, challenges such as limited land availability, aging coconut palms, and inadequate organizational arrangements threaten the industry's sustainability.

Despite these challenges, Indonesia's competitive advantage in coconut oil production can be maintained and strengthened through investments in modern farming techniques, improved agricultural practices, and advanced processing technologies. Continued efforts to improve productivity, enhance product quality, and expand market access could strengthen Indonesia's position as a key player in the global market, foster long-term economic prosperity, and address the needs of ru-

ral communities.

The global coconut oil export market is characterized by dynamic competition among major producing countries. The Philippines stands out as a key competitor that has successfully capitalized on export opportunities by optimizing product value. In 2023, the Philippines exported 163,467 tons of coconut oil, with a total export value of US$816.67 million (World Bank, 2024). The high value-to-volume ratio suggests an emphasis on refined or high-quality products that command premium prices in international markets, an achievement facilitated by the Philippines' long-standing institutional framework for coconut industry governance, including the Philippine Coconut Authority, which has systematically channeled public investment into downstream processing infrastructure and provided structured incentives for value-added product development. This approach has consistently strengthened the Philippines' position in global trade, although it does not always lead in export volume.

Meanwhile, India and Sri Lanka have adopted export strategies targeting niche markets, such as virgin coconut oil and other coconut-based products linked to health and cosmetics. Despite their lower export volumes, these countries have secured substantial economic value through product differentiation and focused market orientation.

In contrast, Indonesia's capacity to replicate such transitions remains constrained by persistent institutional barriers, including the absence of a dedicated coconut industry authority, fragmented smallholder governance structures, inadequate downstream processing incentives, and limited public investment in value-added coconut product certification and market-access facilitation. The success of these competitors highlights the need to reform Indonesia's export strategy through downstream processing, product innovation, and improved access to high-value markets. Indonesia must reconsider its industrial structure to reduce its reliance on raw-material exports and enhance its competitiveness through quality, efficiency, and market diversification.

Several significant challenges currently confront the Indonesian coconut oil industry. Despite Indonesia's position as one of the world's largest coconut producers, its productivity growth slowed notably between 2012 and 2022 (FAO, 2025). This stagnation is largely attributable to aging coconut palms, as many plantations consist of mature trees that produce lower coconut yields.

The decreasing availability of suitable land for coconut cultivation further exacerbates this problem, as agricultural land is increasingly converted to non-agricultural uses, such as residential and industrial development (Abeysekara & Waidyarathne, 2020). Consequently, the area under cultivation has declined, affecting the coconut industry's overall output. Additionally, the effects of climate change—such as shifting rainfall patterns and rising temperatures—pose long-term risks to coconut farming and may lead to more frequent crop failures.

Moreover, both domestic and global economic factors are expected to influence Indonesia's competitiveness in the coconut oil market. Domestically, challenges related to land tenure, aging plantations, and the lack of a structured support system for smallholder farmers impede the industry's ability to innovate and scale.

Globally, increasing competition from other coconut-producing nations and fluctuating demand due to changing economic conditions have complicated Indonesia's efforts to maintain its market position. Although Indonesia is the world's second-largest coconut producer, this status is not fully reflected in the export value of its high-value-added coconut products.

Despite its substantial coconut production, Indonesia continues to rely heavily on exports of primary, unprocessed coconut oil, which limits its revenue potential. This contrasts with the strategies adopted by other leading coconut producers, such as the Philippines and Sri Lanka, which have successfully advanced their coconut industries by focusing on value-added products. By investing in downstream processing and innovation, these countries have captured a greater market share, particularly in high-demand segments such as virgin coconut oil (VCO), desiccated coconut, and other coconut-based consumer goods. Indonesia, however, continues to focus on crude coconut oil exports, which are vulnerable to price fluctuations and shifts in international demand.

The global coconut oil market is heavily influenced by external factors, including global commodity prices, trade regulations, and competition from other vegetable oils, such as palm oil. Furthermore, Indonesia faces increasing competition from coconut-producing countries that have adopted more advanced technologies and efficient processing systems. To improve its competitive position, Indonesia must reduce its reliance on primary-product exports and add value to its coconut products through improved processing methods, stronger quality control, and market diversification.

Embracing innovation and sustainability in the coconut oil sector can significantly enhance market competitiveness and allow Indonesia to better capitalize on growing international demand (Purba et al., 2021; Yulhar & Darwanto, 2019). Therefore, understanding the determinants of Indonesia's coconut oil competitiveness—including production practices, technological advancement, market access, and global demand trends—is essential. This understanding provides a foundation for developing strategies that can strengthen Indonesia's position in the global coconut oil trade, thereby increasing its market share and economic benefits.

The dynamics of Indonesia's coconut oil trade performance reveal that its comparative advantage, as reflected by the RSCA index, has fluctuated substantially

over time, indicating an unstable competitive position in the global market. This condition raises critical questions regarding the underlying drivers of competitiveness and the extent to which domestic structural changes and global trade dynamics have shaped Indonesia's export performance.

To address this gap, the present study investigates the evolving pattern of Indonesia's coconut oil competitiveness and seeks to provide a comprehensive understanding of the factors that determine its strength and sustainability. Accordingly, the study is guided by the following question: What are the key determinants of the short- and long-term competitiveness of Indonesia's coconut oil exports?

B. LITERATURE REVIEW

The theoretical foundation of this study is grounded in the classical theory of comparative advantage, originally introduced by Ricardo (1817) and subsequently extended through the factor-endowment framework of Heckscher and Ohlin (1933), which posits that a nation specializes in commodities whose production intensively uses its relatively abundant factors. In the context of agricultural trade, this theoretical premise has been empirically operationalized through the Revealed Comparative Advantage (RCA) index developed by Balassa (1965), which quantifies a country's export specialization relative to global trade patterns.

The application of comparative advantage theory to agricultural commodities is particularly relevant to resource-abundant developing economies such as Indonesia, where factor endowments, including arable land, rural labor, and natural resources constitute the primary determinants of export competitiveness. This theoretical framework provides the analytical foundation upon which the empirical investigation of Indonesia's coconut oil competitiveness is constructed.

Numerous studies have examined export competitiveness and its determinants across agricultural commodities (Kea et al., 2019). Yego and Siahi (2018) examined the competitiveness and determinants of livestock exports in Kenya using panel data for 1990–2013. The results revealed that Kenya had a comparative advantage in livestock and livestock-product exports based on the RCA index; however, competitiveness measured by the RSCA remained low throughout the period. A random-effects regression model showed that Kenya's exchange rate, domestic GDP, trading partners' GDP, and economic distance significantly influenced livestock-product exports.

Bhattacharya (2019) also identified several determinants of fresh-fruit export competitiveness in India from 1971 to 2012. The results revealed that domestic fruit prices, agricultural investment, and the real effective exchange rate significantly influenced the competitiveness of Indian fresh-fruit exports. These findings highlight the importance of demand-side factors in driving competitiveness and the need to expand India's fresh-fruit export markets.

Tandra et al. (2022) assessed the determinants of competitiveness in the global palm oil trade using panel regression for 1996–2019. The results revealed that global palm oil trade competitiveness was positively influenced by population size and the volume of imports of animal or vegetable fats and oils. In contrast, RSPO certification had a negative effect on competitiveness. Comparable evidence from Indonesia's palm oil sector likewise documents a sustained comparative advantage relative to competing exporters (Prasetyo & Marwanti, 2017; Ramadhani & Santoso, 2019), although the contribution of sustainability certification to export competitiveness remains contested (Rosyadi et al., 2021).

Previous studies have extensively examined the competitiveness of coconut oil exports, particularly the factors that influence a country's position in the global market (Astrini, 2014; Baharsjah, 1974; Siregar & Budi, 2020). Xia and Dewi (2022) made a notable contribution to this literature by analyzing the trade specialization and competitiveness of Indonesian coconut oil between 2010 and 2020 using the Trade Specialization Index (TSI) and Revealed Comparative Advantage (RCA). Their findings demonstrated that Indonesia maintained a strong competitive advantage in the coconut oil market, with both crude and virgin coconut oils recording RCA values greater than 1, indicating Indonesia's strong position relative to other coconut oil exporters.

In a similar vein, Anggrasari and Purba (2023) emphasized Indonesia's market dominance, particularly in key export destinations such as China, the United States, and Sri Lanka. However, their research also highlighted underlying challenges in Indonesia's coconut oil sector, primarily its continued dependence on the export of crude coconut oil, which remains vulnerable to price volatility and shifts in global demand. This reliance contrasts with the strategies adopted by competitors such as the Philippines and Sri Lanka, which have made significant strides in processing higher-value coconut oil products such as virgin coconut oil and desiccated coconut.

These countries have capitalized on technological advances and sustainable practices, positioning themselves as leaders in value-added coconut-product exports. Consequently, although Indonesia's export volumes remain substantial, there is growing recognition that increasing value addition in its coconut oil industry is crucial for long-term competitiveness.

In addition to the inherent challenges posed by domestic agricultural practices, a range of macroeconomic factors also plays a pivotal role in determining the competitiveness of coconut oil exports from Indonesia. Yulhar and Darwanto (2019) examined the impact of macroeconomic variables such as exchange rates and the economic conditions of trading partner countries on the export competitiveness of Indonesian crude co-

conut oil. Their findings revealed that fluctuations in exchange rates significantly affect export performance, consistent with the broader evidence presented by Bhattacharya (2019), who highlighted the interdependence between domestic macroeconomic stability and agricultural trade competitiveness.

Complementing these insights, Anggrasari and Purba (2023) emphasized the central role of agricultural productivity and resource utilization in shaping Indonesia's export advantage, while Purba et al. (2021) demonstrated how exchange rate volatility creates structural vulnerabilities for primary commodity exports. From a technological standpoint, Zhang and Hu (2022) argued that innovation and efficiency improvements in agricultural processing are key to enhancing competitiveness and mitigating external shocks.

Furthermore, Long (2021) noted that production efficiency and domestic market balance determine a country's export capacity, particularly in resource-based industries. On the institutional and policy front, Narayan and Bhattacharya (2019) emphasized that trade agreements, tariffs, and non-tariff barriers critically shape export opportunities, especially in developing economies reliant on raw commodities.

Finally, S.-L. Liew et al. (2021) emphasized the growing importance of sustainability standards and value-added diversification as strategic levers for maintaining long-term competitiveness in the global coconut oil market. Collectively, these studies underscore that Indonesia's export performance is determined not only by domestic production and macroeconomic conditions but also by its capacity to innovate, diversify, and align with global trade and sustainability trends.

The inclusion of rural population (RPOP) as a proxy for agricultural labor supply is grounded in the Heckscher–Ohlin framework, in which labor abundance constitutes a fundamental source of comparative advantage in labor-intensive agricultural production (Heckscher & Ohlin, 1933). Rural population has been widely adopted as a labor proxy in empirical trade studies where disaggregated sectoral labor data are limited, particularly in developing-economy contexts (Bhattacharya, 2019; S.-L. Liew et al., 2021). Its applicability to Indonesia's coconut sector is reinforced by the predominant role of rural smallholder farmers in coconut cultivation and processing (Anggrasari & Purba, 2023), as well as the demonstrated explanatory significance of population-based variables in agricultural commodity competitiveness models (Tandra et al., 2022; Yego & Siahi, 2018).

Long (2021) examined six agricultural commodities in China using the Trade Competitiveness Index (TC) and Revealed Comparative Advantage (RCA), finding persistent weaknesses in most products except tea and live pigs, which maintained a strong comparative advantage. Similarly, S.-L. Liew et al. (2021) analyzed 186 agricultural commodities in Malaysia and found that labor participation and capital formation positively influenced export competitiveness, whereas price shocks and financial crises had adverse effects.

In South Africa, Bahta (2021) found that agricultural productivity and macroeconomic stability were decisive in enhancing competitiveness, whereas structural volatility produced mixed outcomes across commodities. Narayan and Bhattacharya (2019) showed that India's competitiveness in major crops improved through trade liberalization and WTO participation, while Bahta and Mbai (2023) emphasized the dual role of productivity and income growth in shaping Namibia's agri-food trade and food security.

These international experiences are directly relevant to Indonesia's political economy, where institutional constraints, including fragmented land tenure systems, limited smallholder access to credit, and the absence of robust downstream-industry incentives, have historically impeded the transition from primary-commodity dependence to higher-value-added export structures.

The structural parallels observed across these economies suggest that productivity-enhancing policies and institutional reforms constitute indispensable preconditions for Indonesia to replicate comparable gains in agricultural export competitiveness. Collectively, these studies affirm that agricultural export competitiveness is multidimensional, shaped by productivity, technological progress, institutional capacity, and trade policy integration.

C. RESEARCH METHOD

This study used annual data obtained from the World Bank's World Development Indicators (WDI), the Food and Agriculture Organization (FAO), and the UN Comtrade database for the 1970–2023 period. The variables included Indonesia's Revealed Symmetric Comparative Advantage (RSCA) for coconut oil exports as a measure of trade competitiveness, rural population (RPOP) as a proxy for agricultural labor availability, the official exchange rate (EXCR) to reflect the effect of currency values on trade flows, agricultural trade openness (AT) to capture the degree of trade liberalization in the agricultural sector, coconut oil yield (CSY) to measure productivity per hectare, and the coconut oil price (COP) to represent international price dynamics.

The RSCA index is derived from the Revealed Comparative Advantage (RCA) index developed by Balassa (1965), which measures a country's export performance for a specific commodity relative to the world. The RCA is calculated as follows:

$$RCA = \frac{X_{ij}/X_{it}}{X_{wj}/X_{wt}} \tag{1}$$

where X_{ij} denotes exports of commodity j from country i, X_{it} denotes total exports of country i, X_{wj} denotes world exports of commodity j, and X_{wt} denotes total world exports. To address the asymmetry of the RCA index and facilitate comparisons across sectors

Table 1. Variable Definitions and Data Sources

Notation	Definition	Unit	Source
RSCA	Revealed Symmetric Comparative Advantage (RSCA) of Indonesian coconut oil exports, measuring the degree of trade competitiveness.	Index (−1 to +1)	Author's estimation based on UN Comtrade
RPOP	Rural population is the total number of people residing in rural areas of Indonesia.	Million people	World Bank (WDI)
EXCR	The official exchange rate is the average annual exchange rate of the Indonesian rupiah against the US dollar.	IDR per USD	World Bank (WDI)
AT	Agricultural trade openness, calculated as the ratio of total agricultural trade (exports + imports) to agricultural GDP.	Percentage (%)	Author's calculation based on WDI
CSY	Coconut oil yield is the average output per hectare of coconut-producing land.	Tons/ha	FAOSTAT
COP	The international price of crude coconut oil, measured as the annual average.	USD/metric ton	FAOSTAT

Source: Data processed, 2025.

and countries, the RSCA is calculated using the following transformation:

$$RSCA = \frac{RCA - 1}{RCA + 1} \tag{2}$$

The RSCA index ranges from −1 to +1, with positive values indicating a revealed comparative advantage and negative values indicating a comparative disadvantage. Furthermore, Table 1 summarizes all variables used in this study, including their notation, definitions, units of measurement, and data sources.

The ARDL approach was employed to estimate short- and long-run effects. The analysis proceeded through several stages: Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) unit root tests, a cointegration test, short- and long-run estimation, diagnostic testing, and stability testing.

The study used annual Indonesian data from 1970 to 2023. Indonesia was selected because it is one of the world's largest coconut producers and exporters. The country's agricultural sector plays a pivotal role in economic development, making Indonesia a suitable case study for examining the dynamics of competitiveness in agricultural commodities.

Unit root testing is a crucial initial step in time-series analysis because non-stationary variables can produce unreliable results (Engle & Granger, 1987). The Augmented Dickey–Fuller (ADF) test is widely used for this purpose and accounts for serial correlation in the residuals (Dickey & Fuller, 1981). The Phillips–Perron (PP) test serves a similar purpose (Phillips & Perron, 1988). Both tests have the null hypothesis that a unit root is present, indicating non-stationarity, whereas the alternative hypothesis indicates stationarity. However, these tests may not account for structural breaks in time-series data, which can be misinterpreted as unit roots.

Determining the integration order of the variables is essential for selecting an appropriate time-series method. The ARDL bounds-testing approach is suitable for variables integrated at I(0) and I(1), but not at I(2) or higher (Pesaran et al., 2001). This approach overcomes the limitations of earlier cointegration methods, such as those developed by Engle and Granger (1987) and Johansen and Juselius (1990), which require the variables to have the same order of integration. The Akaike Information Criterion (AIC) was used to identify the optimal lag length, facilitating the analysis of both short- and long-run relationships in line with the study's objective of evaluating the determinants of coconut oil export competitiveness.

The ARDL bounds test uses a Wald F-statistic to detect cointegration. The null hypothesis indicates no cointegration, whereas the alternative indicates its presence. If the Wald F-statistic is below the lower bound, cointegration is absent; if it exceeds the upper bound, cointegration is present. When the F-statistic lies between the bounds, the result is inconclusive.

Diagnostic tests were conducted to assess the adequacy of the model and its residuals. These tests examined residual autocorrelation, homoskedasticity, and normality (Wooldridge, 2004). According to Wooldridge (2004), the absence of serial correlation and heteroskedasticity, together with residual normality, is desirable for model reliability. The model's stability was further assessed using the CUSUM and CUSUMSQ tests. The ARDL model is specified as follows:

$$\begin{aligned} \log RSCA_t = {} & \alpha_0 + \alpha_1 \log RPOP_t + \alpha_2 \log EXCR_t \\ & + \alpha_3 \log AT_t + \alpha_4 \log CSY_t \\ & + \alpha_5 \log COP_t + \mu_t \end{aligned} \tag{3}$$

In this model, $RSCA_t$ denotes the Revealed Sym-

metric Comparative Advantage of Indonesian coconut oil exports in year t, which serves as the dependent variable reflecting the country's trade competitiveness in the commodity.

The explanatory variables include $RPOP_t$, representing the rural population as a proxy for the availability of agricultural labor; $EXCR_t$, indicating the official exchange rate, which captures the impact of currency valuation on trade flows; and AT_t, referring to agricultural trade openness, measured by the ratio of total agricultural trade to agricultural GDP.

Additionally, CSY_t stands for coconut oil yield, which captures productivity per hectare of coconut plantations, and COP_t denotes the international price of coconut oil, representing external price dynamics that may influence comparative advantage. The parameter α_0 is the intercept term; $\alpha_1, \ldots, \alpha_5$ are the coefficients of the explanatory variables, and μ_t is the error term, which is assumed to be white noise.

D. RESULTS AND DISCUSSION

This study examines the relationship between various economic and structural factors and the trade competitiveness of Indonesian coconut oil, as proxied by the Revealed Symmetric Comparative Advantage (RSCA) index. In this analysis, particular attention is given to the roles of rural population (RPOP), the official exchange rate (EXCR), agricultural trade openness (AT), coconut oil yield (CSY), and the international coconut oil price (COP) in influencing the dynamics of Indonesia's comparative advantage. The descriptive statistics in Table 2 show that all variables exhibit reasonable dispersion and no extreme asymmetry, indicating that the data are suitable for time-series modeling.

The skewness and kurtosis values for most variables are close to the normal range (skewness between −1.5 and +1.5; kurtosis around 3), suggesting that the distributions are approximately normal and do not exhibit severe outliers. The relatively moderate standard deviations, particularly for RSCA, AT, and CSY, indicate stable variation over time, whereas the higher dispersion in EXCR reflects expected exchange rate volatility rather than data irregularities. Overall, these distributional characteristics indicate that the dataset is suitable for subsequent econometric modeling.

Furthermore, the correlation coefficients among all variables are below 0.90 (Franke, 2010; Senaviratna & Cooray, 2019), indicating that multicollinearity is not a serious concern. The detailed correlation matrix is presented in Appendix 1.

To ensure the validity of the time-series analysis, unit root tests were performed using the Augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) approaches, with the Akaike Information Criterion (AIC) applied to a model with a constant. Stationarity testing is critical because non-stationary variables can produce misleading or spurious regression results if they are not properly differenced, as emphasized by Granger et al. (2001). Because all variables were integrated of order one, I(1), the Autoregressive Distributed Lag (ARDL) bounds-testing approach was appropriate for assessing the existence of a long-run equilibrium relationship among the variables.

Stationarity was examined using two tests: (1) the Augmented Dickey–Fuller (ADF) test and (2) the Phillips–Perron (PP) test. The results indicate that all variables became stationary after first differencing, I(1), at the 1% significance level. Therefore, all variables in the study were integrated of order one (Table 3).

The lag-length selection results are presented in Appendix 2 based on several criteria: the sequentially modified likelihood ratio (LR) test, final prediction error (FPE), Akaike Information Criterion (AIC), Schwarz Information Criterion (SC), and Hannan–Quinn Information Criterion (HQ). According to V. K.-S. Liew (2004), FPE and AIC are more appropriate for relatively small samples (fewer than 60 observations). In this study, the FPE criterion was adopted, leading to the selection of lag 3 for the ARDL model.

Selecting the appropriate lag length is a critical step in ARDL estimation. To ensure robustness, multiple selection criteria were evaluated, including LR, FPE, AIC, SC, and HQ. As reported in Appendix 2, the AIC also identifies lag 3 as the optimal specification, and this result is considered more reliable than the alternatives.

The ARDL bounds test was applied to examine whether a long-run relationship existed among the variables (see Appendix 3). The calculated F-statistic of 8.287 exceeds the upper-bound critical values at the 1%, 2.5%, 5%, and 10% significance levels, confirming the presence of long-run cointegration. Accordingly, the model's long-run relationship was estimated.

Table 2. Descriptive Statistics

	Log_RSCA	Log_RPOP	Log_EXCR	Log_AT	Log_CSY	Log_COP
Mean	0.596	18.602	7.993	−2.632	8.616	13.427
Median	0.924	18.630	7.759	−2.765	8.620	13.459
Maximum	1.847	18.667	9.606	−1.243	8.820	13.834
Minimum	−1.772	18.379	5.894	−3.189	8.357	12.774
Std. Dev.	0.904	0.073	1.338	0.452	0.117	0.241
Skewness	−1.329	−1.616	−0.264	1.403	−0.182	−0.529
Kurtosis	3.553	4.720	1.499	4.713	2.077	2.981
Observations	53	53	53	53	53	53

Source: Data processed, 2025.

Table 3. Unit Root Test

Variable	Augmented Dickey–Fuller		Phillips–Perron	
	Level I(0)	First Difference I(1)	Level I(0)	First Difference I(1)
Log_RSCA	0.647	−9.083***	0.304	−14.404***
Log_RPOP	−1.743	−4.644***	−1.750	−3.991***
Log_EXCR	0.140	−8.709***	−1.379	−8.601**
Log_AT	−1.246	−5.516***	−1.247	−5.962***
Log_CSY	−1.524	−9.975***	−1.579	−10.240***
Log_COP	−0.834	−7.736***	−0.845	−9.283***

Note: ** and *** indicate significance at the 5% and 1% levels, respectively.

In the long run, rural population has a positive and statistically significant effect on Indonesia's coconut oil competitiveness at the 1% significance level: a 1% increase in the rural population is associated with a 1.704% improvement in the RSCA index. Agricultural trade openness also has a positive effect, with a 1% increase corresponding to a 0.953% rise in competitiveness at the 10% significance level. Coconut oil yield contributes positively, with a 1% increase in yield associated with a 1.916% improvement in the RSCA index at the 5% level. Conversely, the official exchange rate has a negative and statistically significant effect at the 1% level: a 1% depreciation of the rupiah corresponds to a 0.001% decline in competitiveness. The international coconut oil price also has a negative and statistically significant effect at the 1% level, with a 1% price increase associated with a 0.364% reduction in the RSCA index.

In the short run (Table 5), rural population, agricultural trade openness, and coconut oil yield retain positive and statistically significant effects on competitiveness, whereas the exchange rate, lagged exchange rate, lagged agricultural trade openness, lagged coconut oil yield, and coconut oil price have negative and statistically significant effects at various lags. The error-correction term, CointEq(−1), is negative and highly significant at the 1% level, with a coefficient of −0.837, indicating that 83.7% of short-run deviations from the long-run equilibrium are corrected within each period.

The Breusch–Godfrey LM test for serial correlation and the Glejser test for heteroskedasticity yielded probability values exceeding the significance threshold of 0.05, indicating no evidence of serial correlation or heteroskedasticity. Therefore, the model was considered statistically valid for further estimation. Additionally, the normality test confirmed that the residuals were normally distributed, with a probability value greater than 0.05 (see Appendix 4).

Model stability was assessed using the CUSUM and CUSUMSQ tests. The plots remained within the 5% critical bounds, indicating that the estimated parameters were stable (see Appendix 5). Therefore, the model was considered stable. These diagnostic results indicate that the ARDL-based ECM is robust and well specified, supporting the validity and reliability of the short- and long-run estimates over the sample period.

This study highlights the multifaceted factors influencing the competitiveness of Indonesian coconut oil exports in the global market, with particular attention to the interplay between domestic agricultural conditions, global economic trends, and international trade dynamics. As shown in the long-run results, the country's comparative advantage in coconut oil exports is significantly driven by domestic production capabilities, particularly in key regions that provide raw materials for coconut oil extraction. The findings support previous literature, such as that of Anggrasari and Purba (2023), emphasizing the critical role of agricultural productivity and resource utilization in determining export performance.

However, the significant negative effect of exchange rate fluctuations ($EXCR_t$) on export performance further underscores the vulnerability of Indonesia's coconut oil sector to external macroeconomic factors, particularly global currency volatility, as also observed by Yulhar and Darwanto (2019). These results indicate that instability in currency markets could adversely affect the trade balance, undermine the profitability of coconut oil exports, and diminish the sector's long-term viability.

This condition reflects, in part, the monetary policy decisions of Bank Indonesia, whose exchange rate management framework directly determines the degree of currency stability experienced by export-oriented agricultural sectors. Periods of expansionary monetary policy or insufficient foreign exchange intervention have historically corresponded with heightened rupiah depreciation, amplifying cost uncertainties for coconut oil exporters and eroding their price competitiveness in international markets.

Moreover, exchange rate volatility has broader implications for international trade because it affects pric-

Table 4. Long-Run Estimation

Variable	Coeff.	Std. Error	t-Stat.	Prob.
$\text{Log}(RPOP_t)$	1.704***	3.240	3.304	0.002
$\text{Log}(EXCR_t)$	−0.001***	0.000	−3.493	0.001
$\text{Log}(AT_t)$	0.953*	0.490	1.943	0.060
$\text{Log}(CSY_t)$	1.916**	3.335	2.373	0.023
$\text{Log}(COP_t)$	−0.364***	2.513	−2.903	0.007
Constant	−2.972***	6.802	−4.174	0.000

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Source: Data processed, 2025.

ing, making Indonesia's coconut oil less competitive than that of other major producers, such as the Philippines, which has stabilized production costs through more effective currency management and export diversification.

This study extends the findings of Bhattacharya (2019), who discussed the influence of economic factors, including trade openness, on agricultural export competitiveness. Increased foreign demand, driven by economic growth in emerging markets, is crucial for sustaining export competitiveness. Consistent with Tandra et al. (2022), who highlighted the role of imports of similar commodities, particularly vegetable oils, this study shows how changes in global consumption patterns influence Indonesia's coconut oil exports. Given the increasing demand for plant-based oils, Indonesian producers have an opportunity to capitalize on shifts in global consumer preferences, particularly in markets with growing health awareness.

However, Indonesia's continued reliance on exporting raw coconut oil—despite its comparative advantage in production—remains a critical challenge, as it limits the ability to capture higher profit margins associated with value-added products like virgin coconut oil and desiccated coconut, as demonstrated by the success of countries like Sri Lanka and the Philippines. To strengthen its competitive position, Indonesia must invest in processing technologies and explore new avenues for value-added coconut oil exports, while addressing the structural limitations in its agricultural sector, including outdated production techniques and aging plantations.

Additionally, the increasing importance of sustainability in global markets presents both a challenge and an opportunity for Indonesia. Demand for sustainably produced coconut oil, driven by certifications such as Fair Trade and organic labels, has grown substantially in recent years, as noted by Yulhar and Darwanto (2019). This trend offers Indonesia an opportunity to improve market access by aligning its production with global sustainability standards. By addressing these factors—exchange rate volatility, technological advancement, and sustainability—Indonesia can enhance its competitiveness, safeguard its market share, and capitalize on emerging global trends in coconut oil consumption.

Table 5. Short-Run Estimation

Variable	Coeff.	Std. Error	t-Stat.	Prob.
DLOG(RPOP)	8.961^{***}	2.923	3.066	0.004
DLOG(EXCR)	-1.649^{*}	0.958	−1.721	0.094
DLOG(EXCR(−1))	2.439^{**}	1.153	2.116	0.042
DLOG(EXCR(−2))	-2.978^{***}	0.942	−3.161	0.003
DLOG(AT)	3.077^{**}	1.176	2.616	0.013
DLOG(AT(−1))	-4.408^{***}	1.352	−3.260	0.003
DLOG(AT(−2))	4.940^{***}	1.059	4.666	0.000
DLOG(CSY)	5.590^{**}	2.549	2.193	0.035
DLOG(CSY(−1))	1.217	2.759	0.441	0.662
DLOG(CSY(−2))	-6.785^{**}	2.532	−2.679	0.011
DLOG(COP)	-0.304^{***}	0.971	−4.662	0.000
CointEq(−1)	-0.837^{***}	0.121	−6.906	0.000

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. Source: Data processed, 2025.

The findings of this study highlight the significant role of trade openness in shaping the competitiveness of Indonesian coconut oil exports. As global economic conditions evolve, especially in emerging markets, demand for Indonesian coconut oil is expected to grow, although competition from countries such as the Philippines and Sri Lanka, which have advanced the production of value-added coconut products, is also increasing. Long (2021) also emphasizes that domestic consumption and production efficiency are pivotal to export success, as greater efficiency enables countries to meet domestic demand while expanding export capacity. Thus, to maintain its competitiveness, Indonesia must focus not only on enhancing production capacity but also on moving towards high-value export segments, such as virgin coconut oil and desiccated coconut, which offer higher profit margins and greater market differentiation. By doing so, Indonesia can secure its position in the global market and navigate the challenges posed by fluctuating commodity prices and the rise of competing producers.

From the perspective of global trade dynamics, the short-run effects presented in this study reveal a complex interplay between exchange rates, domestic agricultural trends, and broader market conditions. Specifically, EXCR and its lags play a significant role in short-term fluctuations, as indicated by the significant negative coefficient for DLOG(EXCR(−2)), which suggests that exchange rate volatility remains a key determinant of export performance. This finding resonates with the work of Purba et al. (2021), who explored the impact of exchange rate movements on Indonesian palm oil exports, noting similar vulnerabilities in commodity exports that are heavily reliant on primary products.

Exchange rate volatility can exacerbate price unpredictability and undermine the stability of export revenues, particularly in developing economies that depend on raw agricultural exports. Moreover, the positive short-run effects of AT, particularly DLOG(AT(−2)), emphasize the role of agricultural trade openness in mitigating the adverse effects of external shocks. Improvements in agricultural practices and processing efficiency can buffer against exchange-rate fluctuations by increasing the overall productivity of coconut oil production. As suggested by Zhang and Hu (2022), the adoption of modern technologies enhances agricultural export competitiveness by reducing costs, increasing yields, and improving product quality. Therefore, Indonesia must prioritize technology adoption and innovation to maintain its competitive edge in the global coconut oil market, especially amid increasing global competition.

Another important aspect of this study is the evolv-

ing relationship between Indonesia's coconut oil industry and its international competitors. Although Indonesia holds a significant share of the global coconut oil market, countries like the Philippines have made substantial progress in diversifying their coconut oil products and integrating sustainability practices into their production processes, as evidenced by Anggrasari and Purba (2023).

The findings for CSY_t (domestic agricultural productivity) demonstrate that although domestic productivity is essential for long-term competitiveness, it must be complemented by strategic efforts to add value to primary products. Indonesia's reliance on raw coconut oil exports exposes it to market volatility and competition from countries that have diversified into value-added coconut products, such as virgin coconut oil and coconut milk. In contrast, Sri Lanka has enhanced the sustainability and appeal of its coconut oil exports by investing in organic certification and Fair Trade labels to meet the growing demand for ethically produced goods in Western markets (Yulhar & Darwanto, 2019). These strategies, which emphasize sustainability and ethical production, are critical to ensuring that Indonesia remains competitive in an increasingly sustainability-conscious global market. As environmental concerns continue to influence consumer behavior and trade policies, Indonesia must integrate sustainability into its coconut oil production processes to secure access to high-value markets.

Furthermore, international competition in the coconut oil market is strongly influenced by global supply-chain shifts, changing consumer demand, and geopolitical tensions. As observed by Narayan and Bhattacharya (2019) in their study of India's agricultural exports, trade agreements and market access play a pivotal role in determining a country's competitiveness. For Indonesian coconut oil, expanding market access and ensuring that trade barriers, including tariffs and non-tariff measures, do not impede exports are essential to sustaining growth. Protectionist policies and trade wars, which have become increasingly common in global markets, can disrupt agricultural commodity flows, and such disruptions can harm countries that depend heavily on raw-product exports, such as Indonesia. These disruptions create uncertainty in global trade, further highlighting the importance of maintaining strong diplomatic relations and securing favorable trade agreements. In this context, Indonesia must pursue strategic trade diversification and establish agreements that open new markets while protecting its interests in existing ones. Such diversification would mitigate the risks of overreliance on a limited number of trading partners and help maintain stable export flows amid global trade uncertainty.

In conclusion, the competitiveness of Indonesian coconut oil exports in the global market is shaped by a combination of domestic production factors, exchange rate fluctuations, technological advances, and evolving international trade dynamics. This study contributes to the literature on export competitiveness by providing insights into the determinants of Indonesia's position in the global coconut oil trade.

As highlighted by S.-L. Liew et al. (2021), the future success of Indonesia's coconut oil exports will depend on its ability to adapt to global shifts in demand, integrate technological innovations into its production processes, and navigate the complexities of international trade relations. Technological advancement, coupled with strategic diversification into value-added products, is vital for Indonesia to enhance its export capacity and compete effectively in an increasingly crowded market. Only by comprehensively addressing these challenges can Indonesia ensure that its coconut oil industry remains competitive in the long term. Moving forward, policy interventions that support innovation, sustainability, and trade diversification will be crucial for securing Indonesia's position as a leading exporter of high-quality coconut products on the global stage.

E. CONCLUSION

This study examined the determinants of Indonesia's coconut oil export competitiveness over the 1970–2023 period using an Autoregressive Distributed Lag (ARDL) model. The empirical evidence confirms a stable long-run relationship among the variables, as indicated by the statistically significant bounds test and the negative and statistically significant error-correction term.

The estimation results demonstrate that rural population growth, agricultural trade openness, and improvements in coconut oil yield have positive and statistically significant effects on Indonesia's Revealed Symmetric Comparative Advantage (RSCA) in both the short and long run. These findings highlight the essential role of structural and productivity-related factors in enhancing competitiveness in global agricultural markets. In contrast, increases in the international price of coconut oil and fluctuations in the official exchange rate adversely affect competitiveness, suggesting that external price pressures and macroeconomic volatility may constrain Indonesia's ability to maintain a stable comparative advantage over time. These conclusions are supported by diagnostic tests confirming residual normality, homoskedasticity, the absence of serial correlation, and structural stability.

The results of this study highlight the need for coordinated and forward-looking strategies to strengthen Indonesia's position in the global coconut oil industry. These include the stabilization of exchange rate dynamics through prudent macroeconomic management administered by Bank Indonesia to mitigate the adverse effects of currency volatility on export competitiveness, the advancement of rural development initiatives to ensure sustainable labor supply, and the reinforcement of agricultural trade frameworks to promote deeper integration into international markets.

Strategic investments in agricultural research and innovation aimed at increasing yield efficiency, including the deployment of improved crop varieties and precision-based agronomic practices, should be prioritized. Moreover, in light of the vulnerability posed by global commodity price fluctuations, it is recommended that Indonesia pursue diversification of export markets and foster fiscal incentives directed at coconut oil processing industries to reduce dependence on primary commodity exports.

A fundamental reorientation of government institutional support is equally imperative—shifting from policies that predominantly incentivize raw-commodity exports toward comprehensive frameworks that facilitate smallholder farmers' transition into value-added coconut oil industries, including virgin coconut oil, desiccated coconut, and other downstream derivatives. Such institutional transformation, underpinned by targeted subsidies, technology-transfer programs, and strengthened cooperative structures, is indispensable for securing Indonesia's long-term competitiveness in the global coconut oil market.

Several limitations should be acknowledged in this study. The use of the rural population as a proxy for agricultural labor supply is an approximation that may not fully capture the nuanced dynamics of labor allocation within the coconut oil sector. Furthermore, the reliance on aggregate national-level time-series data precludes the identification of spatial heterogeneity across major coconut-producing provinces. Future research would benefit from incorporating more precise labor market indicators, institutional quality measures, and regional-level data, as well as applying panel data methodologies to yield more granular policy insights.

DECLARATIONS

Author contributions. M.Y.: conceptualization, methodology, formal analysis, data curation, and writing — original draft. A.: investigation, resources, validation, visualization, supervision, and writing — review and editing. F.D.S.: software, data curation, project administration, and writing — review and editing. All authors have read and approved the final version of the manuscript.

Funding. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of interest. The authors declare no conflict of interest.

Use of artificial intelligence. The authors declare that a generative artificial intelligence tool (Claude) was used solely to check the grammar and readability of the manuscript. It was not used to conduct the analysis or to formulate the substantive findings and conclusions of this research. The authors reviewed all AI-assisted revisions and take full responsibility for the entire content of the published article.

Data availability. All data analysed in this study are secondary time-series data compiled from publicly accessible sources, namely the UN Comtrade database, FAOSTAT, and World Bank development indicators, as cited in the article. The compiled dataset and the EViews workfiles used for the ARDL estimation are available from the corresponding author on reasonable request.

Ethics approval. Not applicable. This study did not involve human participants or animal subjects.

F. REFERENCES

Abeysekara, M. G. D., & Waidyarathne, K. P. (2020). The coconut industry: A review of price forecasting modeling in major coconut-producing countries. *CORD*, *36*, 6–15. https://doi.org/10.37833/cord.v36i.422

Anggrasari, H., & Purba, A. D. (2023). Competitiveness of Indonesian coconut oil exports in global markets. *Journal of Agribusiness and Development*, *29*(3), 87–99.

Astrini, T. (2014). Strengthening competitiveness in the coconut export sector. *Journal of Agricultural Economics*, *10*(4), 123–139.

Baharsjah, S. (1974). *The domestic and international trade of Indonesian coconut products* (Unpublished doctoral dissertation). North Carolina State University, North Carolina, USA.

Bahta, Y. T. (2021). Competitiveness of South Africa's agri-food commodities. *AIMS Agriculture and Food*, *6*(4), 945–968. https://doi.org/10.3934/agrfood.2021057

Bahta, Y. T., & Mbai, S. (2023). Competitiveness of Namibia's agri-food commodities: Implications for food security. *Resources*, *12*(3), 34. https://doi.org/10.3390/resources12030034

Balassa, B. (1965). Trade liberalisation and "revealed" comparative advantage. *The Manchester School*, *33*(2), 99–123. https://doi.org/10.1111/j.1467-9957.1965.tb00050.x

Bhattacharya, P. (2019). Determinants of export competitiveness of fresh fruits in India. *International Journal of Sustainable Economy*, *11*(1), 61. https://doi.org/10.1504/IJSE.2019.096567

Chomchalow, N. (2011). Health and economic benefits of coconut oil production development in Thailand. *AU Journal of Technology*, *14*(3), 181–187.

Dickey, D. A., & Fuller, W. A. (1981). Time series with a unit root. *Econometrica*, *49*(4), 1059.

Engle, R. F., & Granger, C. W. J. (1987). Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, *55*(2), 251–276. https://doi.org/10.2307/1913236

FAO. (2025). *FAOSTAT: Crops and livestock products — coconut production, area harvested and yield, Indonesia, 1970–2023 [data set].* Food and Agriculture Organization of the United Nations. https://www.fao.org/faostat/en/#data/QCL.

Franke, G. R. (2010). Multicollinearity. In *Wiley international encyclopedia of marketing.* Wiley.

Granger, C. W. J., Hyung, N., & Jeon, Y. (2001). Spurious regressions with stationary series. *Applied Eco-*

nomics, *33*(7), 899–904. https://doi.org/10.1080/00036840121734

Heckscher, E. F., & Ohlin, B. (1933). *Heckscher-ohlin trade theory*. MIT Press.

Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration—with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, *52*(2), 169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003.x

Kea, S., Li, H., Shahriar, S., Abdullahi, N. M., Phoak, S., & Touch, T. (2019). Factors influencing Cambodian rice exports: An application of the dynamic panel gravity model. *Emerging Markets Finance and Trade*, *55*, 3631–3652. https://doi.org/10.1080/1540496X.2019.1673724

Liew, S.-L., Arip, M. A., & Puah, C.-H. (2021). Determinants of export competitiveness of agricultural products in Malaysia. *International Journal of Business and Society*, *22*(2), 618–636. https://doi.org/10.33736/ijbs.3747.2021

Liew, V. K.-S. (2004). Which lag length selection criteria should we employ? *Economics Bulletin*, *3*(33), 1–9.

Long, Y. (2021). Export competitiveness of agricultural products and agricultural sustainability in China. *Regional Sustainability*, *2*(3), 203–210. https://doi.org/10.1016/j.regsus.2021.09.001

Narayan, S., & Bhattacharya, P. (2019). Relative export competitiveness of agricultural commodities and its determinants: Some evidence from India. *World Development*, *117*, 29–47. https://doi.org/10.1016/j.worlddev.2018.12.013

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326. https://doi.org/10.1002/jae.616

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika*, *75*(2), 335. https://doi.org/10.2307/2336182

Prasetyo, A., & Marwanti, S. (2017). Comparative advantage and export performance of Indonesian crude palm oil in international markets. *Jurnal Agro Ekonomi*, *35*, 89–103.

Purba, A., Widodo, T., & Marwanti, S. (2021). The impact of non-tariff trade policy on European Union crude palm oil imports from Indonesia. *Jurnal Ekonomi Indonesia*, *9*, 39–52. https://doi.org/10.52813/jei.v9i1.28

Ramadhani, T. N., & Santoso, R. P. (2019). Competitiveness analysis of Indonesian and Malaysian palm oil exports. *Economic Journal of Emerging Markets*, *11*, 46–58. https://doi.org/10.20885/ejem.vol11.iss1.art5

Ricardo, D. (1817). *On the principles of political economy and taxation*. John Murray.

Rosyadi, M., Astuti, E. S., & Winarso, S. (2021). The role of Roundtable on Sustainable Palm Oil (RSPO) certification in Indonesian palm oil export competitiveness. *International Journal of Agricultural Sustainability*, *19*(1), 45–60.

Senaviratna, N. A. M. R., & Cooray, T. M. J. A. (2019). Diagnosing multicollinearity in logistic regression models. *Asian Journal of Probability and Statistics*.

Siregar, M., & Budi, T. (2020). RCA analysis of Indonesian coconut oil products in the European market. *Jurnal Ilmiah Membangun Desa dan Pertanian*, *8*(4), 163–168.

Tandra, H., Suroso, A. I., Syaukat, Y., & Najib, M. (2022). The determinants of competitiveness in global palm oil trade. *Economies*, *10*(6), 132. https://doi.org/10.3390/economies10060132

UN Comtrade. (2025). *UN Comtrade database: Coconut (copra) oil, crude (HS 151311) — Indonesian exports by partner country, 2023 [data set]*. United Nations Statistics Division. https://comtradeplus.un.org/.

Wooldridge, J. M. (2004). *Introductory econometrics: A modern approach* (2nd ed.). South-Western College Publishing.

World Bank. (2024). *Trade statistics for international business development: Coconut (copra) oil, crude (HS 151311), exports in 2023.* (World Integrated Trade Solution (WITS). https://wits.worldbank.org/trade/comtrade/en/country/ALL/year/2023/tradeflow/Exports/partner/WLD/product/151311)

Xia, L., & Dewi, S. S. (2022). Analysis of trade specialization and competitiveness of Indonesian coconut oil in the international market (2010–2020). *Open Journal of Business and Management*, *10*(1), 245–262. https://doi.org/10.4236/ojbm.2022.101015

Yego, H. K., & Siahi, W. V. (2018). Competitiveness and determinants of livestock and livestock-product exports from Kenya (1980–2013). *IOSR Journal of Economics and Finance*, *9*(1), 53–58.

Yulhar, T. F. M., & Darwanto, D. H. (2019). Competitiveness of Indonesian crude coconut oil in international markets. *Agro Ekonomi*, *30*(2), 125–138. https://doi.org/10.22146/ae.49014

Zhang, L., & Hu, S. (2022). Price competition and shifting demand in coconut oil exports: An analysis of the Indonesian market. *Sustainability*, *16*(1), 101–119.

APPENDICES

Appendix 1: Correlation Matrix

	Log_RSCA	Log_RPOP	Log_EXCR	Log_AT	Log_CSY	Log_COP
Log_RSCA	1.000	0.361	0.661	−0.156	0.666	0.499
Log_RPOP	0.361	1.000	0.617	−0.691	0.470	0.708
Log_EXCR	0.661	0.617	1.000	−0.524	0.688	0.611
Log_AT	−0.156	−0.691	−0.524	1.000	−0.383	−0.663
Log_CSY	0.666	0.470	0.688	−0.383	1.000	0.716
Log_COP	0.499	0.708	0.611	−0.663	0.716	1.000

Appendix 2: Lag-Length Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−2330.656	NA	1.06e+34	95.374	95.605	95.462
1	−2020.256	532.114	1.47e+29	84.174	85.795*	84.789
2	−1961.013	87.051	6.07e+28	83.225	86.237	84.368*
3	−1918.440	52.131*	5.55e+28*	82.957	87.358	84.627
4	−1875.340	42.221	6.06e+28	82.667*	88.458	84.864

Note: * indicates the lag order selected by the corresponding criterion.

Appendix 3: Bounds Test

Test Statistic	Value	K
F-Statistic	8.287	5
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Appendix 4: Diagnostic Tests

	R-square	F-statistic	Probability
Breusch–Godfrey serial correlation LM test	8.371	0.048	0.015
Heteroskedasticity test: Breusch–Pagan–Godfrey	18.643	1.342	0.284
Heteroskedasticity test: Glejser	19.885	0.220	0.225
	Jarque–Bera		**Probability**
Normality	3.611		0.164

Appendix 5: CUSUM and CUSUMSQ Stability Tests

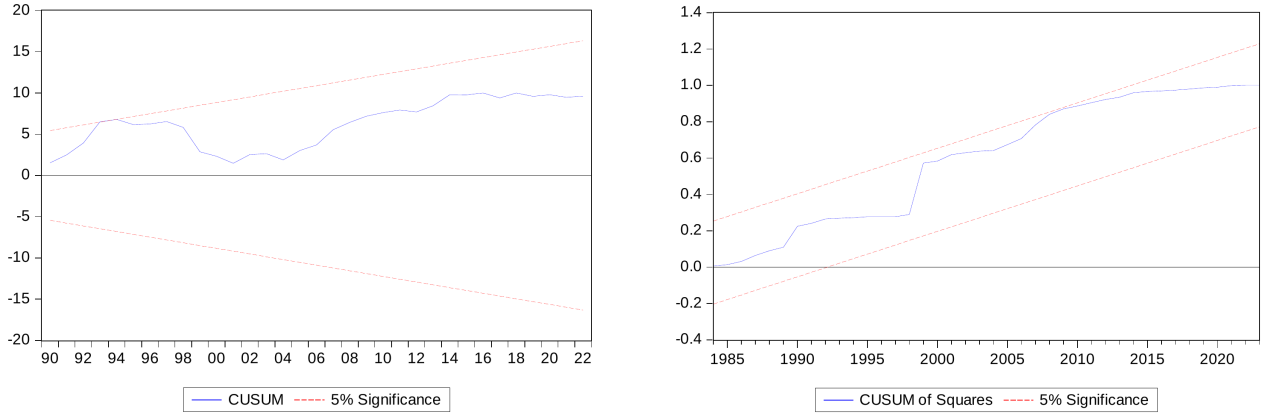

Figure 1. CUSUM and CUSUMSQ stability tests

Source: Data processed, 2025.