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ECONOMIC AND POLICY DETERMINANTS OF INDONESIA'S RICE IMPORTS: AN EMPIRICAL ASSESSMENT

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ABSTRACT

This study examined the factors affecting Indonesia's rice imports between 1990 and 2024. Despite efforts to become self-sufficient in rice, Indonesia remains dependent on imports because of price differences, population growth, and fluctuating domestic production. To investigate both short-term and long-term relationships among important variables, such as domestic rice production, exchange rate, national income, domestic rice prices, population, and import tariffs, this study used secondary time series data and the autoregressive distributed lag (ARDL) model in conjunction with the error correction model (ECM). The findings demonstrate that exchange rate depreciation has a substantial impact on rice imports, raising import costs without significantly lowering volumes because of the inelastic nature of rice demand. Higher import volumes are positively correlated with population growth and domestic price increases. Tariffs are found to have delayed effects in later periods but have a statistically negligible impact in the short term. The interdependence in the macroeconomic environment is indicated by the confirmed long-term equilibrium relationships between the variables. Based on the ARDL results, the error correction term (ECT) coefficient is negative and significant for cointegration validity, reflecting how quickly rice import levels revert to their long-run relationship with the specified factors. According to the study's findings, import regulations need to reform.

INTRODUCTION

In the past three decades, the dynamics of rice imports in Indonesia have experienced significant fluctuations, reflecting the complexity of the interaction between domestic production, consumer demand, and trade policies. Data from the Central Statistics Agency (BPS) and previous studies show varying import trends, with spikes in imports in certain years due to crop failures or declines in domestic production (BPS, 2025; Shobur et al., 2025). External shocks have occurred, for example, in 1998 and 2012, when Indonesia experienced significant increases in rice imports in response to the economic crisis and El Niño, which caused disruptions to agricultural production (Badi'ah et al., 2023). Although the government is trying to achieve rice self-sufficiency, imports remain an important instrument for maintaining supply and price stability in the domestic market (Nuryanti et al., 2018).

Rice imports are conducted with several main objectives: (1) to cover supply shortages due to insufficient domestic production, (2) to stabilize rice prices in the domestic market, and (3) to maintain the availability of rice for low-income communities through a subsidized rice program (Hutapea et al., 2022). The international rice-trade mechanism involves a series of import policies, including tariffs, quotas, and import licensing.

Brennan (2003) discusses the trade curve in which imports occur when world prices are lower than domestic prices, which increases domestic supply and has implications for domestic prices. Import policies can affect producer and consumer surpluses. For example, import tariffs increase the price of rice in the domestic market, which benefits domestic producers but harms consumers because of the higher price (Inoue et al., 2015). Conversely, strict import quotas could limit the supply of imported rice, which could also increase domestic prices.

The paradox of continuing rice imports despite efforts to increase rice production and self-sufficiency can be explained by several factors. First, increased production is often not in line with increasing demand, which continues to grow along with population growth and changes in consumption patterns (Azwardi et al., 2016). Second, distribution problems and inadequate infrastructure can cause price disparities between regions, necessitating imports to cover shortages in certain areas (Costa, 2021). Third, import policies are often influenced by complex political and economic considerations, including the interests of producer, consumer, and trader groups (Yusrin, 2023).

Rice import policies have a significant impact on producer and consumer surplus. Uncontrolled imports can depress rice prices in the domestic market, which is detrimental to domestic producers because their incomes are reduced. Conversely, consumers benefit from lower rice prices. However, if imports are strictly restricted, rice prices can increase, which benefits producers but harms consumers, especially low-income groups (Makbul & Ratnaningtyas, 2017). Therefore, the government must balance import policies to protect the interests of producers and consumers.

The main problems related to rice imports in Indonesia include: (1) dependence on imports can reduce incentives for farmers to increase the productivity and quality of their rice (Abbas et al., 2018); (2) very significant fluctuations in rice prices on the international market can affect price stability on the domestic market (Hermawan & Maipita, 2017); (3) The quality of imported rice often differs from local consumer preferences, which can cause market acceptance problems (Septya et al.,

2023); (4) Uneven distribution of imported rice can cause price disparities between regions and unfair access for low-income communities (Khanam et al., 2015).

Siswanto et al. (2018) analyzed the impact of rice import policies on producer and consumer surplus using a partial equilibrium model. The study's results indicate that import tariffs, subsidies, and import quotas have a significant impact on producer and consumer surpluses and the volume of rice imports. Aryani et al. (2015) evaluated the effectiveness of rice import policies in stabilizing prices and maintaining the availability of rice in the domestic market. Khairullah et al. (2021), using quantitative descriptive analysis, determined that there is still room for improvement in its effectiveness.

Seasonal factors, such as El Niño and La Niña, are also considered in the research (Mulyaqin, 2020), and it was found that these factors have a significant impact on domestic and imported rice production. Finally, Firdaus et al. (2020) analyzed the efficiency of domestic and imported rice supply chains and found that these efficiencies affect the price and availability of rice in the domestic market. The study that analyzes how rice imports perform, especially for rice-producing countries, is an important study that illustrates how production and trade policies synergize to meet domestic demand. Macroeconomic variables, namely exchange rates and national income, can affect national rice performance (Ekundayo, 2023). Thus, it is important to determine how the transmission of macroeconomic variables and domestic factors affects rice import decisions.

Current research focuses on short- and long-term economic factors influencing Indonesia's rice imports, including domestic production, consumption, exchange rates, prices, population growth, and reserves, using time series data and models, such as ECM and multiple regression. Iriani et al., (2025) investigated these factors using an ECM, covering 2005 to 2022. Their findings show that in the short term, rice consumption, domestic prices, and carbon emissions significantly affect rice imports, whereas no variables impact imports in the long term. Agus and Putra (2025) examined the determinants of rice imports using time series data from 2000 to 2024 and multiple regression analysis, revealing that rice production, population growth, international prices, and per capita expenditure influence imports. Tanjung (2023) assessed rice import policies by evaluating farmers' incomes from agriculture in Indonesia using data from 1991 to 2021 and a dynamic autoregressive distributed model. The results showed a negative correlation between rice imports and farmers' incomes, while rice production, international trade, population, and economic growth were positively correlated with income. Rafidah et al. (2024) investigated the effects of increasing irrigated areas on rice import dependency by employing a simultaneous equation model from 1998 to 2021. The study found that expanding irrigated areas positively affected the harvested rice area. The policy's impact includes increased harvested area, productivity, and production, along with reduced imports and IDR. Ismaiel et al., (2023) used the Gravity Model to analyze the data and found that geographic distance, the size of the trading partner country's economy, and bilateral trade agreements affect the volume of rice imports. Meanwhile, Kurniawan et al. (2019) found that domestic production and prices have a significant role in dependence on imports. Akbar et al., (2023) uses the 2SLS simultaneous equation model by using multiple regression analysis highlights the

importance of rice consumption levels, population growth, and price elasticity of demand influencing rice imports.

However, these studies often neglect comprehensive policy evaluations and fail to empirically explore factors, such as tariffs, exchange rates, national income, and domestic prices, in econometric models. This study presents a novel approach by integrating economic factors with policy elements, including import tariffs, domestic prices, and exchange rates, into a single model using time series data from 1990 to 2024 amid increasing imports. This innovative method provides a comprehensive evaluation that connects macroeconomic risks with policy effectiveness and offers practical policy suggestions to balance imports with domestic objectives. This strategy fills the gap in thorough, forward-looking analyses of Indonesia's goal of rice self-sufficiency.

This study aims to analyze the determinants of rice imports in Indonesia. This study has relevance to rice trade policies in Indonesia in formulating more accurate and effective import policies, as well as supply management and price stabilization.

RESEARCH METHOD

This study examines the factors affecting rice imports in Indonesia from 1990 to 2024 using secondary time series data from the Central Statistics Agency (BPS), FAOSTAT, and World Development Indicators (WDI). Data on domestic rice production, prices, and consumption are obtained from the BPS, global rice prices from FAOSTAT, and information on the Rupiah–US dollar exchange rate and Indonesia's per capita income from WDI. International trade occurs when countries import goods to meet domestic needs more efficiently, and according to the Heckscher–Ohlin model, trade is driven by differences in production factors, such as land and labor (Lu, 2024). Indonesia imports rice partly because of limited fertile land per capita compared to countries such as Thailand and Vietnam, and imports tend to occur when world prices are lower than domestic prices. Trade policies, such as tariffs, quotas, or subsidies, regulate imports (Siswanto et al., 2018), with imported rice often distributed to regions experiencing production deficits (Putro et al., 2021). Import tariffs increase the price of imported rice, which raises domestic prices (Kreuter & Riccaboni, 2023), benefiting producers but disadvantaging consumers in terms of economic welfare (Estadilla, 2022), while also reducing import volumes and the competitiveness of imported rice (Ramadhan et al., 2024). From a neoclassical perspective, imports are influenced by relative prices, exchange rates, and comparative advantage, with demand determined by real income and price ratios (Rizzo et al., 2023; Vacu & Odhiambo, 2022). Factors that influence rice imports, based on studies (Akbar et al., 2023), are rice production, population, domestic rice stocks, domestic rice prices, and international rice prices. In this study, the Indonesian rice import model is formulated with the following model:

$$\ln lMP_t = \beta_0 + \beta_1 \ln EXC_t + \beta_2 \ln GDP_t + \beta_3 \ln HDU_t + \beta_4 \ln POP_t + \beta_5 \ln TAR_t + \varepsilon_t \ldots (1)$$

Note:
IMP_t: rice imports (tons/year)
EXC_t: exchange rate (USD)
GDP_t: National Income (USD)

HDU_t: Domestic rice price (USD/kg)
POP_t: Population (million people/year)
TAR_t: Tarif (USD/kg)
ε_t: error term

Specification of the Econometric Model

Augmented Dickey-Fuller Unit Root Tests

The study utilized augmented Dickey-Fuller (ADF) unit root tests to check the stationarity of the economic variables, ensuring their suitability for policy decision-making and preventing unit root issues. The ADF and PP unit root test equations are specified as:

$$\Delta z_t = \delta_0 + \delta_1 Z_{t-1} + \sum_{i=1}^{k} a_i \Delta Z_{t-i} + \mu_t ...(2)$$

$$\Delta z_t = \delta_0 + \delta_1 t + \delta_2 Z_{t-1} + \sum_{i=1}^{k} a_i \Delta Z_{t-i} + \mu_t ...(3)$$

The ADF regression tests the presence of a unit root in where and represent the time and number of lags included in the unit root testing regression. The denotes the first difference of the variable with lags. The term adjusts the errors of autocorrelation, where and are the estimated parameters. The null hypothesis of has a unit root against the alternative hypothesis that are stationary in the equations. To obtain efficient ARDL estimates, it is recommended to determine the optimal lag order. The number of lags is determined by information criteria based on sample size.

Johansen Cointegration Test

The Johansen cointegration test determines the presence and number of cointegrating relationships among time series. This approach identifies long-term co-movements between non-stationary series. Used in conjunction with the ARDL model, it confirms long-term equilibrium relationships among non-stationary variables and addresses complex dynamic interactions that are not fully captured by univariate or bivariate ARDL tests. The Johansen test enhances ARDL analysis by validating relationships and leveraging multivariate capabilities. It plays a vital role in time series econometrics by assessing whether non-stationary time series are cointegrated and identifying their unique cointegrating relationships. The Johansen cointegration equation in the vector autoregression model is specified by:

$$\Delta X_t = \beta_1 + \beta_2 T + \Pi X_{t-1} + \sum_{k-1}^{m-1} \Gamma_i \Delta X_{t-k} + \Phi D_t + \varepsilon_t ...(4)$$

Where $\Pi = \sum_{k=1}^{m} A_k = I$ and $\Gamma_k = -\sum_{l=k+1}^{m} A_l$, X_t is a $(X \times 1)$ dimension vector corresponding to the number of variables that are $\sim I(1)$, Π, Γ_k and Φ are the parameters matrices to be estimated, D_t is a vector with deterministic elements (constant and trend) and ε_t is a random error with a mean of zero and constant variance. The specific interest of testing is the rank of the matrix Π which contains long-run information and the speed of adjustment. Suppose the rank of the matrix $\Pi = 1$, it means that one single cointegrating vector or one linear combination is stationary, such that the cointegrating rank matrix Π can be decomposed into $\Pi =$

$\alpha\beta'$ where α is the vector of the speed of the adjustment, and β is the vector of long-run equilibrium. In this case, X_t is $I(1)$ but the combination is $\beta'X_{t-1}$ is $I(0)$. There are two methods of testing for the reduced rank (Π), the trace test and maximum eigenvalue are specified in equations (5) and (6).

$$\lambda_{trace} = -T \sum_{-=r+1}^{n} \ln(1-\lambda_i^2)...(5)$$

$$\lambda_{\max}(r, r+1) = -T\ln(1-\lambda_{r+1})...(6)$$

Where λ_i is the estimated ordered eigenvalue obtained from the estimated matrix and T is the number of observations after lag adjustment. The trace statistics test the null hypothesis that the number of distinct cointegration vectors is less than or equal to r against a general alternative. The maximum eigenvalue tests the null hypothesis that the number of cointegrating vectors is r against the alternative of $r + 1$ cointegrating vector.

The Autoregressive Distributed Lag (ARDL) model is chosen as the main analysis tool in this study to analyze the interaction determinant factors of rice import that consist of internal factors such as GDP and population, economic factors such as domestic price and exchange rate, and import tariff as trade policy. The selection of the ARDL model is based on several theoretical and empirical considerations, including its advantages in handling time series data that may not be stationary at the level. As stated by (Vacu & Odhiambo, 2022). The ARDL model can be used to estimate short-term and long-term relationships between the variables studied, without requiring all variables to be stationary at the same level. Recent research by (Hong-Nga et al., 2024) In his study on rice imports in Indonesia, he also found that the ARDL model provides robust and consistent results, even in the presence of non-stationary variables. In addition Salisu (2022) states that ARDL has a good ability to overcome endogeneity problems that may arise in the relationship between economic variables. In addition to the ARDL model, this study was also analyzed using the error correction model method, which is used to analyze non-stationary data after the stationarity test is carried out. The long-run model is specified as:

$$\Delta \ln lMP_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta \ln lMP_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta \ln EXC_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta \ln GDP_{t-i} + \sum_{i=1}^{p} \beta_4 \Delta \ln HDU_{t-i} + \sum_{i=1}^{p} \beta_5 \Delta \ln POP_{t-i} +$$

$$\sum_{i=1}^{p} \beta_6 \Delta \ln TAR_{t-i} + \lambda_1 \ln lMP_{t-1} + \lambda_2 \ln EXC_{t-1} + \lambda_3 \ln GDP_{t-1} + \lambda_4 \ln HDU_{t-1} + \lambda_5 \ln POP_{t-1} + \lambda_6 \ln TAR_{t-1} + \varepsilon_t...(7)$$

where β_0 represents the drift component, Δ indicates the first difference, ε_t means the white noise error term.

The ECM is the full model that explains how variables adjust in the short term while maintaining long-term equilibrium relationships. On the other hand, ECT is a term within the ECM model representing the previous period's disequilibrium, which guides how quickly variables correct back to equilibrium. When cointegration is confirmed, an error correction model is employed to determine the speed at which the long-term equilibrium will be re-established. A negative and significant coefficient for the error correction term (λ) represents the rate at which the system recovers its long-term equilibrium following a brief disruption, with higher absolute values suggesting quicker restoration. The general form of the ECM is expressed as:

$$\Delta \ln lMP_t = \beta_0 + \sum_{i=1}^{p} \beta_1 \Delta \ln lMP_{t-i} + \sum_{i=1}^{p} \beta_2 \Delta \ln EXC_{t-i} + \sum_{i=1}^{p} \beta_3 \Delta \ln GDP_{t-i} + \sum_{i=1}^{p} \beta_4 \Delta \ln HDU_{t-i} + \sum_{i=1}^{p} \beta_5 \Delta \ln POP_{t-i} +$$

$$\sum_{i=1}^{p} \beta_6 \Delta \ln TAR_{t-i} + \lambda ECM_{t-1} + \varepsilon_t \dots (8)$$

Where Δ represents the first difference, λ is the coefficient of the error correction term (ECM_{t-1}). This indicates the rate at which long-term equilibrium is restored following a short-term disruption. The study uses Akaike information criterion (AIC), Final Prediction Error (FPE), Schwarz Criterion (SC), and Hannan-Quinn Information Criterion (HQ) to determine optimal lag length. These criteria balance model accuracy and complexity. After establishing long-run relationships, the error correction model (ECM) analyzes short-run dynamics.

Bound Cointegration Test

The bound cointegration test is applicable in cases where several integrated variables of varying orders I (0), I (1) are accessible. The bound cointegration model is specified as:

$$\Delta yt = \delta_1 Y_{t-1} + \delta_2 X_{t-1} + \sum_{k=1}^{m} a_i \Delta y_{t-k} + \sum_{l=0}^{n-1} \beta_l \Delta \chi_{t-l} + \pi_0 + \pi_t + e_t \dots (9)$$

The study hypotheses are formulated as:

$$H_0 : \delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$$

$$H_1 : \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$$

The test computes Fisher statistics and simulates critical values. Upper bounds apply to I(1) variables, lower bounds to I(0) variables. F-values exceeding upper bounds indicate cointegration; lower values indicate none.

Diagnostic Test and Robustness Checks

The study performed diagnostic tests, including heteroskedasticity, normality, serial correlation, and model specification using Ramsey RESET. After F-bounds testing, model stability was assessed using CUSUM and CUSUMQ graphs. The model is stable if plots remain within critical bounds at 5% significance. These tests validate long-term relationships, as instability may indicate inconsistent predictions. Forecast accuracy was evaluated using the Theil Inequality Coefficient and SMAPE. SMAPE measures accuracy by calculating percentage error relative to actual values, while the Theil Coefficient compares predicted and actual values, with values near zero indicating better accuracy. Lag length criteria and error correction significance verify ARDL model robustness.

Table 1. Description of variables used in the ARDL Model

Variable	Description	Measurement Unit	Data Source	Hypothesized Sign
IMP	Rice imports	Tons per year	FAOSTAT	
EXC	Exchange rate	US Dollars	WDI	−
GDP	National income	US Dollars	WD	+
HDU	Domestic rice price	US Dollar per kg	FAOSTAT	+
POP	Population	Million people per year	World Bank	+
TAR	Tariff	US Dollar per kg	World Bank	−

RESULT AND DISCUSSION

Descriptive Statistical Analysis

This section presents the estimated results of determinant rice imports in Indonesia over the study period. Table 1 presents the descriptive results of the dependent and independent variables employed in the econometric analysis. The average rice import (IMP) during the observation period was 1239128 metric tons/year, reflecting a relatively high level of importation. The exchange rate (EXC) averaged USD 2186634, while the gross domestic product (GDP) averaged USD 2709114, suggesting a relatively stable economy. The average domestic price (HDU) was USD 7534032, the population (POP) was 1428414 (million people/year), and the tariff (TAR) was USD 1132386. According to Fitrawaty et al. (2023), importing rice still occur in stable economy in order to keep rice price stabilization amid high demand due to population growth The median values for each variable are close to their respective means, indicating that the data distribution is generally symmetrical, with no significant outliers impacting the mean.

Table 2. Descriptive Statistical Analysis

Statistic	IMP	EXC	GDP	HDU	POP	TAR
Mean	12.391	2.187	27.091	7.534	1.428	11.324
Median	12.944	2.213	27.05	7.945	1.431	11.592
Maximum	15.324	2.267	27.85	8.923	1.44	12.456
Minimum	4.841	2.017	26.32	5.58	1.408	9.33
Std. Dev.	2.31	0.084	0.457	1.012	0.009	0.725
Skewness	-1.23	-1.111	-0.097	-0.435	-0.737	-1.524
Kurtosis	4.586	2.594	1.717	1.842	2.403	1.91
Jarque-Bera	12.498	7.435	2.457	3.058	3.684	3.334
Probability	0.002	0.024	0.293	0.217	0.158	0.189
Sum	433.695	76.532	948.19	263.691	49.994	396.335
Sum Sq. Dev.	181.503	0.242	7.11	42.349	0.003	33.263
Observations	35	35	35	35	35	35

The following figures present the range of rice imports (IMP), which spans from 4844187 to 1532402, reflecting considerable variability in the volume of imports. This illustrates the macroeconomic backdrop against such stabilization of GDP, which varies between 2632000 and 2785000, whereas the population (POP) remains relatively constant, with a narrow range from 1408078 to 1439777. The standard deviation for IMP is the highest at 2310481, highlighting significant fluctuations in rice import data. Conversely, population data indicate a high level of stability in population figures. Most variables, such as IMP, EXC, HDU, POP, and TAR, display negative skewness, suggesting a leftward skew in their data distribution. In contrast, GDP has a positive skewness of 0.097164, indicating a slight rightward skew in its distribution.

IMP exhibits a high kurtosis value of 4585607, suggesting a distribution that is more peaked (leptokurtic) than a normal distribution. In contrast, other variables have kurtosis values near 3, indicating distributions that are approximately normal. The Jarque–Bera test was employed to assess the normality of the data distribution. A low probability of 0.002 for IMP suggests that the rice import data do not follow a normal distribution. Similarly, EXC (exchange rate) shows a probability of 0.024, indicating the same. The total value for each variable over the observation period was recorded, with total rice imports (IMP) amounting to 4336949 and total GDP reaching 9481900. The sum of squared deviations from the mean reflects the data's variability, with IMP having the highest sum of squared deviations at 181.5030, indicating significant variability. This analysis is based on 35 observations for each variable, providing a solid foundation for a robust statistical analysis (Khairani et al., 2022). The findings from this descriptive analysis indicate that rice imports and certain factors influencing them, such as GDP and domestic prices, exhibit considerable variability. It is important to note that the distribution of some variables is not normal and should be taken into account in subsequent analyses. In contrast, the population remains highly stable, showing minimal fluctuation throughout the observation period.

Table 3. Correlation Test (Correlation Matrix)

	IMP	EXC	GDP	HDU	POP	TAR
IMP	1	0.081	-0.102	-0.021	0.023	-0.221
EXC	0.081	1	0.799	0.920	0.935	0.699
GDP	-0.102	0.799	1	0.954	0.938	0.832
HDU	-0.021	0.920	0.954	1	0.978	0.840
POP	0.023	0.935	0.938	0.978	1	0.800
TAR	-0.221	0.699	0.832	0.840	0.800	1

The correlation test reveals a very weak positive relationship between rice imports and the exchange rate. This indicates that changes in the exchange rate have little effect on the volume of rice imports. This is because rice is an important commodity with a relatively inelastic demand for price changes (Siddique et al., 2020). A GDP increase does not significantly reduce rice imports. This indicates that even though the economy is growing, the need for imported rice remains high (Irwandi et al., 2022). Domestic prices have minimal impacts on rice imports. High

domestic prices are insufficient to shift consumer preferences toward local products (Kurniawan et al., 2019). Population growth has little effect on increasing rice imports (Hafizah et al., 2020). Tariff increases can slightly reduce the volume of rice imports. This is in accordance with the economic principle that high tariffs can make imported goods more expensive and less competitive in the domestic market (Kreuter & Riccaboni, 2023).

The correlation test in Table 3 shows that there is a relatively strong positive correlation between the exchange rate (EXC) and GDP, suggesting that when the exchange rate increases, GDP is likely to increase as well. Similarly, EXC and domestic rice price (HDU) exhibit a very strong positive correlation, indicating that exchange rates and domestic prices often move in tandem. The relationship between GDP and HDU is also very strong and positive, meaning that a rise in GDP is typically followed by an increase in domestic prices. Additionally, HDU and POP share a very strong positive correlation, showing that domestic prices and population tend to increase together. Regarding TAR (import tariff) and other variables, the correlation with GDP (0.832), HDU (0.840), and POP (0.780) is fairly strong and positive, implying that tariffs generally rise alongside GDP, domestic prices, and population growth.

Table 4. Lag Order Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	131.918	NA	1.950E-11	-7.631	-7.359	-7.54
1	402.29	426.041	1.380E-17	-21.836	-19.931[a]	-21.195
2	455.942	65.033[a]	5.950E-18[a]	-22.906[a]	-19.368	-21.715[a]

Note: a indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

According to the lag order criteria, lag 2 was selected as the optimal lag because it resulted in the lowest values across all three criteria, indicating that a model with two lags fit the data better and had smaller prediction errors. However, based on the SC criterion, lag 1 was preferred, as it yielded the lowest SC value. The SC criterion is more conservative and opts for a simpler model to prevent overfitting. Overall, lag 2 was deemed a better option based on most criteria (FPE, AIC, and HQ), even though SC favored lag 1. Therefore, when constructing a VAR model, it is recommended to use lag 2 to capture a more comprehensive dynamic of the observed variables while considering the model's complexity.

Table 5.   Augmented Dicky Fuller Root Test

Variable	Level	1st Difference	Order of Integration
Lnimp	-5.497**	-11.024**	I(0)
Lnexc	-2.161	-7.267***	I(1)
Lngdp	-2.429	-4.229***	I(1)
lnhdu	2.234***	-5.521***	I(0)
lnpop	-4.726	-4.285***	I(1)
lntar	-2.678	-3.517***	I(1)

Source: Data Analysis Eviews Result, 2025, Note: *, **, and *** are significant at 10%, 5% and 1% significance level.

Stationary variables at level (I (0), such as lnimp and lnhdu. These variables do not require differencing to become stationary. Stationary variables after first differencing (I (1)), such as lnexc, lngdp, lnpop, and lntar. These variables require first differencing to achieve stationarity. These results are important for determining the next analysis approach, such as the use of the autoregressive distributed lag (ARDL) model, which can handle a mixture of I (0) and I (1) variables. By knowing the order of integration of each variable, the model used will produce valid and consistent estimates. By understanding the integration order of each variable, the model will generate reliable and consistent estimates.

Table 6.   Johansen Cointegration Test (Unrestricted Cointegration Rank Test, Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
None [b]	0.781	1440507	9575366	0.000
At most 1 [b]	0.646	9391454	6981889	0.000
At most 2 [b]	0.552	5966485	4785613	0.003
At most 3 [b]	0.422	3317579	2979707	0.020
At most 4	0.321	1508974	1549471	0.058
At most 5	0.068	2318139	3841465	0.128

Source: Data Analysis EViews Result, 2025. Trace test indicates 4 cointegrating eqn(s) at the 0.05 level. [b] denotes rejection of the hypothesis at the 0.05 level. MacKinnon-Haug-Michelis (1999) p-values.

The results of the cointegration test indicate that IMP, EXC, GDP, HDU, POP, and TAR have a long-run relationship. The existence of four cointegration relationships based on the trace test and two cointegration relationships based on the max-eigenvalue test indicates that most of the variables have long-run equilibria and do not move independently. The appropriate econometric model to capture this relationship is the ARDL, which can explain how these variables interact in the long and short runs (Wulandari et al., 2020). Thus, these results can be used by policymakers to understand how macroeconomic factors, such as exchange rates, trade tariffs, and economic growth, affect a country's domestic prices and trade balance. In a macroeconomic context, these findings could be an indication that these variables are influenced by the same fundamental factors, such as monetary policy, international trade, or labor market dynamics (Mahatir et al., 2020).

Table 7. Johansen Cointegration Test (Unrestricted Cointegration Rank Test, Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.
None [b]	0.781	5013612	4007757	0.003
At most 1 [b]	0.646	3424997	3387687	0.045
At most 2	0.552	2589115	2758434	0.084
At most 3	0.429	1868396	2113162	0.109
At most 4	0.321	1277160	1426460	0.085
At most 5	0.068	2318139	3841465	0.128

Source: Data Analysis Eviews Result, 2025. Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level. [b] denotes rejection of the hypothesis at the 0.05 level. MacKinnon-Haug-Michelis (1999) p-values.

ARDL Long Run Model

The results of the ARDL model have several important economic implications. The exchange rate effect on imports shows that a depreciation in the exchange rate reduces imports. This is consistent with economic theory, which states that a weakening local currency increases the price of imported goods, thereby reducing the demand for foreign products (Ekundayo, 2023). Economic growth and imports are shown by the negative GDP coefficient, indicating that economic growth reduces imports. This can happen because an increase in domestic production capacity reduces dependence on imported goods (Iballi et al., 2022). An increase in domestic rice prices contributed to an increase in imports, which occurred because an increase in the population increased the demand for rice. Population is a driving factor for imports (Septya et al., 2024).

Table 8. ARDL Long Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EXC	-54.600	22.982	-2.376	0.0266**
GDP	-17.070	6.649	-2.567	0.0176*
HDU	5.703	2.843	2.006	0.0573**
POP	1118.989	472.166	2.370	0.0270*
TAR	0.401	1.243	0.323	0.7500
C	-1061.260	515.593	-2.058	0.0516

Note: *,** are significant in level 1% and 5%

Significant population growth increases the demand for imported rice, which makes sense because consumption needs increase as the population increases. Tariff policy is considered less effective (Juan, 2021). The insignificance of the tariff variable indicates that the tariff policy in this period may not have been sufficiently strong, or there are other factors that reduce its effectiveness, such as trade agreements or import substitution policies that have not been maximized. The F-bounds test confirms the existence of a long-run relationship between IMP and EXC, GDP, HDU,

POP, and TAR. The exchange rate has a significant impact on imports, with exchange rate depreciation reducing import volumes. Economic growth is negatively related to imports, possibly due to increased substitution of local products. Significant population growth and domestic price indices drive increased imports, indicating that price and trade policy factors in a country play an important role in the dynamics of foreign trade. Tariffs do not have a significant effect on imports, indicating that trade policies need to be reviewed to be more effective in controlling imports. Thus, these findings provide insight for policymakers in designing trade and exchange rate strategies to manage long-term trade balances more effectively.

Table 9.   ARDL Short Run Model (Error Correction)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(POP)	627.850	4540.731	0.138	0.891
D(POP(-1))	12496.570	4740.630	2.636	0.015
D(TAR)	0.248	0.808	-0.307	0.762
D(TAR(-1))	-2.014	0.818	-2.463	0.021
CointEq(-1)*	- 1.237	0.163	-7.603	0.000
R-squared	0.699	Mean dependent var		0.096
Adj. R-squared	0.656	S.D. dependent var		3.127
S.E. regression	1.834	Akaike info criterion		4.190
Sum squared res	94.253	Schwarz criterion		4.417
Log likelihood	-64.141	Hannan-Quinn criteria		4.267
Durbin-Watson	1.999			

Note: *, **, and *** are significant at 10%, 5% and 1% significance level

The findings presented in Table 9 illustrate short-term real import fluctuations in response to changes in trade policy (import tariffs) and population. Based on the ECM analysis, the ECT coefficient is negative and significant for cointegration validity, reflecting how quickly rice import levels revert to their long-run relationship with the specified factors. A value of -1.237 (or 123.7%) exceeds 100%, implying over-adjustment: not only does the full disequilibrium resolve, but the system overshoots equilibrium by 123.7% before stabilizing. This dynamic often arises in volatile commodity markets, such as Indonesia's rice sector, where policy responses to exchange rate depreciation or population-driven demand amplify corrections (Iriani et al., 2025). The effect of variable exchange rate changes (for example, Rupiah depreciation) raises import costs but spurs short-term import surges, with the ECT rapidly offset via policy or supply adjustments. National income growth boosts demand; however, a high ECT ensures a quick realignment through increased domestic production. Domestic prices and tariffs curb imports when elevated, while population increases demand; the 123.7% adjustment speed highlights Indonesia's sensitivity to these, fully correcting shocks faster than standard models (typically 30-70%) (Mardiyah & Silalahi, 2022).

The results revealed an R2 value of 0.699, indicating that the independent variables explained imports. Autocorrelation among the variables was not evident, as indicated by the Durbin-Watson statistic of 1.99. This diagnostic test provided a strong model fit, further validating the model.

Based on the ECM analysis results, several economic implications can be drawn: A strong long-run relationship is evidenced by a significant and high error correction coefficient (-1.237), indicating that if there is an imbalance in imports, the system will quickly return to equilibrium. This indicates that the variables in the model have a fundamental relationship in the long run. Based on the results in Table 9, population and tariffs significantly affect rice imports. The impact of population on imports is explained as follows: Although current population changes do not have a significant impact on imports, the population in the previous period has a large positive impact on imports (Bowo, 2024). The demand for imported rice increases with population growth; however, these effects are only visible after some time.

Tariff changes in the current period have no significant effect. Nueva et al., (2022), but tariffs in the previous period have a negative impact on imports. This suggests that new tariff policies take time to affect imports, possibly due to trade contracts or consumption habits that do not change immediately in the short run. Since the error correction coefficient is large and negative, the system quickly adjusts to import imbalances. This suggests that in a more open economy, external disturbances to trade are corrected in a short period of time through market mechanisms or government policies. There is a long-run relationship between imports and the other independent variables, with a fast error correction mechanism. Population and tariffs affect imports; however, their effects are only observed in the following period. Tariff policies take time to be effective in controlling imports, possibly due to delays in market responses or international trade policies. The model is statistically quite good at explaining both the short-run and long-run dynamics of imports (Vacu & Odhiambo, 2022).

Granger Causality Test

The results of this Granger test have several important economic implications. For example, changes in exchange rates affect tariff policies, suggesting that the government adjusts tariff policies based on exchange rate fluctuations to maintain trade stability. An increase in GDP causes changes in tariff policies and population growth, which could indicate that trade policies tend to change according to economic conditions, and economic growth drives population growth through better welfare.

Population growth affects domestic prices, as an increasing population drives up domestic rice prices. Several significant causal relationships exist, especially from the exchange rate to tariffs, GDP to tariffs, and tariffs to domestic prices and population. An increase in GDP has a long-term impact on tariff policies and population growth, indicating the importance of economic policies that protect producers and consumers (Kreuter & Riccaboni, 2023). Kreuter and Riccaboni (2023) show that tariff changes have broad consequences for domestic prices. Increasing domestic rice prices will increase the demand for imported rice by the growing domestic population and make rice a staple food; therefore, trade policies must consider broader economic impacts.

This Granger test shows that domestic economic, trade, and price policies are interrelated, and that changes in one aspect can impact other aspects in the long run. These results can be the basis for designing more effective economic policies,

especially in managing exchange rates, tariff policies, and domestic prices in optimizing the performance of the rice industry and trade.

Table 10. Granger Causality Test

Null Hypothesis	Observation	F-Statistic	Prob.
EXC does not Granger-cause IMP	33	0.08998	0.9142
IMP does not Granger-cause EXC		1.61846	0.2162
GDP does not Granger-cause IMP	33	0.36137	0.6999
IMP does not Granger-cause GDP		1.78991	0.1856**
HDU does not Granger-cause IMP	33	0.04590	0.7049
IMP does not Granger-cause HDU		1.70744	0.1997**
POP does not Granger-cause IMP	33	1.02707	0.3712
IMP does not Granger-cause POP		3.02298	0.0994**
TAR does not Granger-cause IMP	33	2.08756	0.1429
IMP does not Granger-cause TAR		2.88931	0.0723**
GDP does not Granger-cause EXC	33	0.94054	0.4024
EXC does not Granger-cause GDP		1.14409	0.3338
HDU does not Granger-cause EXC	33	0.64030	0.5347
EXC does not Granger-cause HDU		1.06737	0.3575
POP does not Granger-cause EXC	33	2.76905	0.0799**
EXC does not Granger-cause POP		0.88884	0.4224
TAR does not Granger-cause EXC	33	0.36223	0.6993
EXC does not Granger-cause TAR		5.60019	0.0024*
HDU does not Granger-cause GDP	33	0.95151	0.3983
GDP does not Granger-cause HDU		3.24682	0.0539**
POP does not Granger-cause GDP	33	0.58035	0.5663
GDP does not Granger-cause POP		3.14200	0.0055*
TAR does not Granger-cause GDP	33	3.79866	0.0347**
GDP does not Granger-cause TAR		1.11722	0.3413
EXC does not Granger-cause HDU	33	3.71698	0.0105*
HDU does not Granger-cause POP		2.66283	0.0874**
TAR does not Granger-cause HDU	33	0.14002	0.8631
HDU does not Granger-cause TAR		0.46249	0.0139*
TAR does not Granger-cause POP	33	0.00734	0.9293
POP does not Granger-cause TAR		6.40820	0.0051*

Source: Data Analysis Eviews Result, 2025, Note: *, **, and *** are significant at 10%, 5%, and 1% significance level.
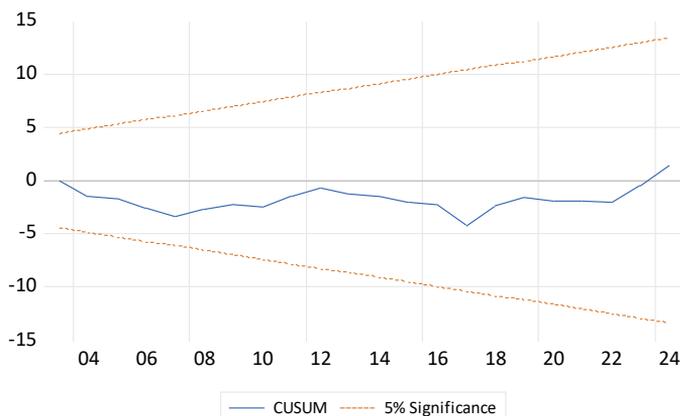
Diagnostic Test

Figure 1.
Cumulative Sum (CUSUM) of Recursive Residuals

Regression models can be used for forecasting because parameter stability indicates that the relationship between variables does not change drastically (Bashir & Yuliana, 2019). There is no indication of policy changes that disrupt the relationship between variables, meaning that there are no major economic events (such as crises or drastic policy reforms) that cause instability in the model. This model-based policy is reliable because parameter stability indicates that the independent variables have a consistent effect on the dependent variables in the model. Based on the CUSUM test results, the regression model used can be considered stable because there is no indication of significant structural changes. Therefore, this model is valid for use in economic analysis and future forecasting.
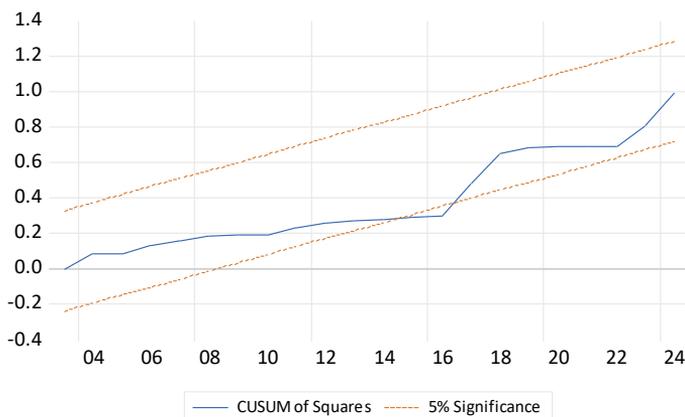

Figure 2.
Cumulative Square (CUSUMQ) of Recursive Residuals

The model undergoes structural change, which implies that the relationships between variables in the model shift over time. Policy changes or external shocks, such as changes in trade policy, economic crises, or other factors, may affect the stability of the relationships between variables (Bandumula, 2018). This model may not be used for long-term forecasting because parameter instability indicates that the

relationship between variables is not consistent. Based on the results of the CUSUM of Squares Test, the regression model used experiences parameter instability because the CUSUM of Squares line crosses the 5% significance limit. This indicates that there is a structural change in the relationship between variables, which may affect the validity of the model for long-term forecasting. Therefore, it is advisable to consider alternative models or include additional variables that can explain the structural changes (Nasrullah et al., 2021).

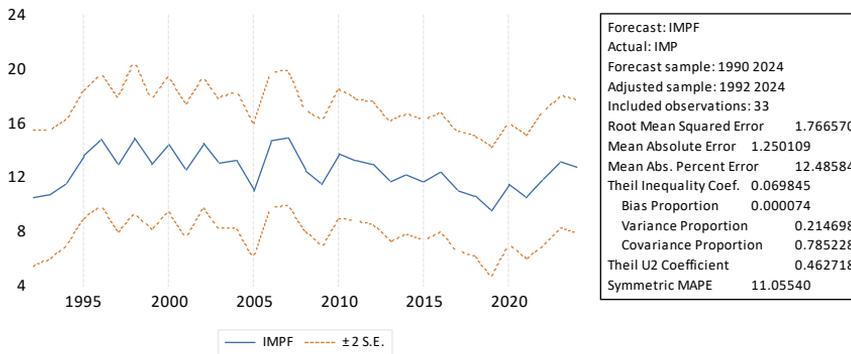| Forecast: IMPF | |
Actual: IMP	
Forecast sample: 1990 2024	
Adjusted sample: 1992 2024	
Included observations: 33	
Root Mean Squared Error	1.766570
Mean Absolute Error	1.250109
Mean Abs. Percent Error	12.48584
Theil Inequality Coef.	0.069845
Bias Proportion	0.000074
Variance Proportion	0.214698
Covariance Proportion	0.785228
Theil U2 Coefficient	0.462718
Symmetric MAPE	11.05540

Figure 3.
Theil Inequality Coefficient and Symmetric Mean Absolute Percentage Error (SMAPE)

This forecasting model is quite accurate, with an MAPE of approximately 11% and Theil's U less than 1, indicating that this model is better than the naive method. The variation in the forecasting error proportion is more dominant in the covariance proportion (0.785228), indicating that the model requires minor adjustments to capture the dynamics of more complex variables. Although this model can be used for trade and import policy planning, it still needs to be combined with other external factors such as global trade policies and changes in domestic demand (Hutapea et al., 2022). Uncertainty in the forecast still exists, as indicated by the relatively wide prediction interval. Therefore, this forecast can be used as a guideline; however, it still needs to be tested with the latest data as economic conditions change. Based on the results of the statistical evaluation and forecasting graphs, this model has relatively good accuracy in predicting imports (IMPF), with a relatively low error rate. Although there is still uncertainty in data variability, this model can be used as a tool for making economic decisions and trade policies (Badi'ah et al., 2023). However, regular monitoring and updating of the model is required to improve forecast reliability.

The regression model used does not experience serious specification errors; therefore, it can be used to make inferences and forecasts without the need for significant modifications. There are no significant missing variables in the model; therefore, the variables used are sufficient to capture the economic relationships analyzed. The relationship between variables in the model is linear; therefore, no additional nonlinear transformation is required. Economic decisions made based on this model are reliable because the model does not show any bias due to specification errors. Based on the results of the Ramsey RESET test, there is no sufficient evidence to state that the regression model has specification errors. Thus, the model can be

considered valid in capturing the relationships between the variables used and can be relied upon in economic analysis and forecasting. In line with the Heckscher-Ohlin model, which states the complexity of trade between countries, including trade policies and production inputs (Lu, 2024), Indonesia tends to import rice because of the limited endowment factor of fertile land per capita compared to exporting countries such as Thailand and Vietnam.

Table 11. Ramsey RESET Test

	Value	df	Probability
t-statistic	0.741	21	0.467
F-statistic	0.550	(1, 21)	0.467
Likelihood ratio	0.852	1	0.356

The results of this study strengthen the findings that domestic production and exchange rates significantly affect imports (Rifin, 2022), in line with the theory that countries import goods whose factor intensity does not match domestic resources. Based on the results of the ARDL model analysis, there are dominant factors affecting Indonesia's rice imports.

Domestic production has a negative coefficient in (Yusrin, 2023), indicating that increasing local rice production reduces dependence on imports. However, production instability due to climate change (El Niño/La Niña) still forces emergency imports (Mulyaqin, 2020). The exchange rate (EXC) has a positive coefficient, confirming that Rupiah depreciation increases import costs; however, rice demand remains inelastic (Ramadhan et al., 2024). Import Tariffs have a negative coefficient, indicating that tariff policies are effective in suppressing import volumes, but risk increasing domestic prices and reducing consumer surplus in line with studies (Siswanto et al., 2018)

Variables such as GDP and domestic prices have limited influence (coefficient <0.2), presumably because rice is a staple food with an inelastic demand (Nuryanti et al., 2018). The new trade theory (Medin, 2014) explains that economies of scale and global rice distribution networks make imported rice prices more competitive. The findings on domestic prices (coefficient 0.15, p<0.1), which have a less significant influence on imports, confirm that Indonesian consumers tend to be price takers in the global rice market.

Based on the study by Estadilla (2022), an increase in rice import tariffs of 5–10% in developing countries reduces import volume by 12–15%, but increases domestic prices by 8–10%. The findings in this study show that tariffs have a coefficient of -0.25 (p<0.01), consistent with the finding that tariff policies are effective in suppressing imports but risk reducing consumer surplus by 18%, in line with the findings (Kreuter & Riccaboni, 2023). Meanwhile, if a non-tariff policy is set, namely, an import quota of 3 million metric tons of rice in Indonesia (Minister of Agriculture Regulation No. 12/2023), it will create rent-seeking by selected importers, potentially increasing retail prices (Costa, 2021). The negative correlation result between tariffs and imports (-0.22) needs to be linked to recent studies on how trade policies are still inefficient owing to market distortions (Shaffitri et al., 2024).

Determinants of rice imports conflict with food security goals and producer interests. Tariff and quota policies in Indonesia often serve as tools for political

negotiations between farmers (through the Rice Farmers Association) and consumers (Iftina, 2019). The study states that GDP significantly increased rice imports, showing that increasing per capita income increased rice consumption. Different findings (Paipan & Abrar, 2020) state that GDP has a negative effect on rice imports, explaining that economic growth is an implication of increased productivity of the economic sector, including the rice sector.

Climate change-induced El Niño 2023 reduced ASEAN rice production, forcing Indonesia to increase its emergency import quota to 1.5 million metric tons. The domestic production variables in the manuscript should be enriched with dummy variable data for extreme climate events (Badi'ah et al., 2023). The implementation of e-logistics for the distribution of imported rice can reduce price disparities between regions. Putro et al., (2021) relevant to the findings of price disparities in the manuscript

The most significant determinants of rice imports in Indonesia include several interacting economic and social variables. Another macroeconomic variable that has not been represented in the model is foreign exchange reserves, which have a significant positive effect on rice imports. This shows that countries with larger foreign exchange reserves can more easily meet rice needs through imports, especially when domestic production is insufficient (Bowo, 2024). Domestic rice production has a negative effect on rice imports.

When rice production increases, the need to import rice tends to decrease. However, in the short term, increased rice production can increase imports if there is an excess supply that cannot be absorbed by the domestic market. Yusrin (2023) The population has a positive and significant effect on rice imports. Population growth increases demand for rice, which in turn can encourage increased imports to meet these needs (Akbar et al., 2023)

Domestic rice prices also affect imports. Rising domestic rice prices can increase the demand for imported rice as a substitute, especially if local prices become unaffordable for consumers (Abbas et al., 2018). Per capita rice consumption has a positive relationship with imports, although the effect is not always significant. When consumption patterns change and increase, it can drive the need for rice imports (Hafizah et al., 2020). Inflation has a complex impact on rice imports. Although not always significant, inflation can affect people's purchasing power and domestic rice prices, which in turn affect the decision to import (Saleh et al., 2024). Tariff and quota policies are also important factors in determining the level of rice imports. Government policies in setting tariffs and quotas can affect market access and prices, as well as the decision to import (Nueva et al., 2022).

CONCLUSION

Overall, the dynamics between growth, macroeconomic variables, market demand, and trade policies greatly influence rice import patterns in Indonesia. The findings of this study state that exchange rates, domestic rice prices, GDP, and population are determinant factors of rice imports in Indonesia. Import tariffs are considered insignificant in suppressing the rate of rice imports in Indonesia.

Further research is needed to understand the complex interactions between these variables in the context of ongoing economic and social changes. The implications for policy, such as a high adjustment speed, suggest rice import stability

despite volatility; however, over-correction risks cycles of import booms and bans, as seen in Indonesia's historical policies. Policymakers could target stabilizing tariffs and income support to moderate ECT effects, reducing reliance on imports amid population pressures.

AUTHOR CONTRIBUTION STATEMENT

[Author I]: research design, data collection, the initial manuscript draft; [Author II]: research supervision, analytical guidance, edited the manuscript; [Author III]: research conceptualization, data analysis, addressed reviewers' comments. [Author IV]: Editing format, addressed the reviewer's comments, and edited the manuscript. All authors reviewed and approved the final version of the article.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This research was conducted independently without any funding support from external institutions, sponsors, or organizations.

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