Article Type: Research Paper

Short- and long-term determinants of Indonesia's rice import: An error correction model approach

Ririt Iriani Sri Setiawati*, M Jaenudin, Ary Fauziah Amini, and Ni Putu Rekha Puspita

OPEN ACCESS

AFFILIATION:
Department of Development Economics, Faculty of Economics and Business, UPN Veteran East Java, East Java, Indonesia

***CORRESPONDENCE**:
ririt.iriani.ep@upnjatim.ac.id

THIS ARTICLE IS AVALILABLE IN:
http://journal.umy.ac.id/index.php/esp

DOI: 10.18196/jesp.v26i1.24963

CITATION:
Setiawati, R. I. S., Jaenudin, M., Amini, A. F., & Pustpita, N. P. R. (2024). Short- and long-term determinants of Indonesia's rice import: An error correction model approach. *Jurnal Ekonomi & Studi Pembangunan, 15*(2), 61-79.

ARTICLE HISTORY
Received:
25 Sep 2024
Revised:
17 Oct 2024
Accepted:
31 Oct 2024

Abstract: Indonesia's dependence on rice imports has become an important issue in national food security. This study aims to analyse the factors affecting rice imports in the short and long term using the Error Correction Model (ECM) approach. Secondary data in the form of time series from 2005-2022 are used to examine the effect of rice production, exchange rate, domestic rice price, harvest area, foreign exchange reserves, carbon emissions, and rice consumption on rice imports. The results show that in the short term, rice consumption, domestic rice price, and carbon emissions have a significant effect on rice imports, while other factors have no significant effect. In the long run, no variable has a statistically significant effect on rice imports, suggesting that other factors may be more dominant in determining Indonesia's rice import volume. The implications of these findings highlight the need for integrated policies between the agricultural, economic, and environmental sectors to ensure sustainable food security.

Keywords: Carbon Emission; Error Correction Model (ECM); Food Security; Rice Consumption; Rice Import; Rice Price
JEL Classification: Q17; Q18; Q56; F14; F31; E44

Introduction

Rice is a staple for Indonesians in fulfilling their daily food consumption. The average consumption of rice per capita per week ranks first in food staples in Indonesia. Table 1 shows that the average consumption of rice in Indonesia has the highest value compared to other staples such as corn, wheat flour, glutinous rice, and other grains.

The high position of rice as a staple of consumption in Indonesia certainly creates homework for the government in fulfilling rice consumption for the community. If you look at Table 2, the amount of rice production in Indonesia has decreased in 2019, 2021, and 2022.

Table 1 Average Consumption of Basic Foodstuffs in 2019-2023 (In kg/capita/week)

Type	2019	2020	2021	2022	2023
Rice	1,504	1,505	1,563	1,554	1,552
Corn	0,039	0,050	0,034	0,032	0,036
Wheat Flour	0,049	0,047	0,055	0,053	0,056
Glutinous Rice	0,005	0,005	0,006	0,006	0,006
Other Grains	0,002	0,002	0,002	0,002	0,002

Source: Food Consumption Statistics (2023)

Table 2 Total Rice Production in Indonesia 2018-2022 (In Tons)

Years	Total
2018	34.399.939
2019	32.370.218
2020	32.397.941
2021	31.359.161
2022	31.540.521

Source: Central Bureau of Statistics (2024)

This amount has not been able to meet the needs of the people for rice in Indonesia, so the government has taken steps to import Indonesian rice from various countries, especially the 3 largest importing countries, namely Thailand, Vietnam, and India.

Table 3 Indonesia's Rice Imports by Main Country of Origin in 2019-2023 (In Ton)

Country	2019	2020	2021	2022	2023
Thailand	53.278,0	88.593,1	69.360,0	80.182,5	1.381.921,2
Vietnam	33.133,1	88.716,4	65.692,9	81.828,0	1.147.705,3
India	7.973,3	10.594,4	215.386,5	178.533,6	69.715,7
Pakistan	182564,9	110516,5	52479,01	84407	309309,7
Myanmar	166700,6	57841,4	3790	3830	141204
Jepang	90	0,3	230,291	56,087	61,5
Tiongkok	24,3	23,8	42,601	6	7
Others	744,6	0,3	760,146	364,065	12933,3

Source: Central Bureau of Statistics (2024)

The increasing amount of rice imports, especially in the top three importing countries, indicates the existence of rice import dependency in Indonesia. The dependence on rice imports in Indonesia is a complex and recurring issue every year, even though the country is known as an agrarian country with abundant natural resources, Indonesia still has to import rice to meet its growing consumption needs. According to Ruccy et al. (2022) Import dependence is one of the indicators of measuring the level of food independence and food security. One measure of the level of national food self-sufficiency is by measuring how much the level of dependence of food availability on imports (and or net-imports) in the food balance. Empirical studies show that the relatively large population in Indonesia causes food dependence on imports to face various problems (Pujitiasih et al., 2014). Yasa & Brata (2015) argued that the greater the degree of import concentration, the greater the degree of import openness and import dependence.

Indonesia's dependence on rice imports is influenced by several factors, including economic conditions, agricultural policies, and consumer behavior. Paipan & Abrar (2020) stated that economic factors such as rice consumption and currency fluctuations affect import dependence, this is because a significant increase in rice demand can encourage imports because domestic production is unable to meet consumption needs. They also state that rupiah appreciation has a positive impact on import levels as it makes foreign rice prices more affordable. In agricultural policy, government intervention in rice imports is due to inadequate absorption of domestic rice and failure to manage surplus production effectively, as well as concerns about food security that influence the need for policies that support local production (Octastefani & Mitra, 2015).

Import is an economic activity that commonly occurs in various countries. Imports are carried out as a way for a country to meet its needs, where production in the country cannot meet the consumption needs of the community (Butts, 2012; Sessu, 2016). In Indonesia, one of the imports of goods is rice. Several studies have been conducted in Indonesia to analyze the determinants that affect rice imports. There are also studies that look at Indonesia's dependence on rice imports in the long and short term. Paipan & Abrar (2020) in his research explains that rice imports in Indonesia are influenced by rice consumption, rupiah appreciation, exchange rates, and domestic rice prices positively and significantly both in the long and short term on rice imports.

Paipan & Abrar (2020) further added that unoptimal absorption of rice by the Logistics Agency (BULOG) and the increase in rice consumption are strong reasons why dependence on rice imports still occurs in Indonesia. Other variables that also have an influence on rice imports are inflation, population, rice supply, and harvested land area (Nizar & Abbas, 2019; Wibowo & Marwanti, 2024). Furthermore, the foreign exchange reserves variable does not have a direct effect on rice imports in the long-term and short-term period in Indonesia (Mustafa et al., 2021). However, foreign exchange reserves have a direct influence on rice production, which in turn affects rice imports, both in the short and long term (Azifuaku et al., 2020; Yuan et al., 2024).

In addition to foreign exchange reserves, carbon emission is also a variable that affects rice production, where rice production is an important variable that has an impact on the amount of rice imports (Van Groenigen et al., 2013). The variables mentioned before are factors that make Indonesia continue to depend on rice imports. Long-term dependence will certainly pose a risk to food security and sovereignty (Octastefani & Mitra, 2015; Steckley & Steckley, 2023). Vulnerable food security is closely related to the increasing challenges of the agricultural sector, which requires high rice imports to maintain production levels (Chang et al., 2016).

Apart from Indonesia, one of the countries that also depends on rice imports is Nigeria. In Nigeria, economic growth and the amount of rice production have a significant influence on the amount of rice imports (Ekundayo, 2023; Yusuf et al., 2020). The thing to do to make Nigeria less dependent on rice imports is to promote local rice to its people massively (Yusuf et al., 2020).

Jacob (2024) in his research further added that there is a need to improve agricultural extension services to increase local rice production so that Nigeria does not continue to depend on rice imports. As the production of local rice increases with better quality than before, people will slowly switch to consuming local rice instead of imported rice (Antriyandarti et al., 2023; Coffie et al., 2023; Oladejo, 2023).

Although these previously mentioned factors highlight the complexity of rice import dependency, it is not yet certain whether these factors do affect rice import dependency in Indonesia in both the short and long term. Therefore, in this study, the author wants to look at the dependence on rice imports in both the short and long term.

Research Method

Researchers conducted a study that focused on Indonesia because this country is an agricultural country, has large and fertile land to support agricultural activities and most of the Indonesian population consumes rice as a daily staple food.

The data used in this study are secondary data in the form of time series data on rice consumption (X1), exchange rates (X2), domestic rice prices (X3), foreign exchange reserves (X4), rice production (X5), harvested land area (X6), carbon emissions (X7), and the amount of rice imports (Y) in the period 2005-2022. The data were obtained from several sources, including the Central Bureau of Statistics and the National Food Agency.

The method of analysis used in this study is the Error Correction Model (ECM) to see what variables affect rice imports in Indonesia both in the short and long term. ECM modeling for the *long term* can be described as follows:

$$Riceimport_t = \alpha + \beta_1\ Production_t + \beta_2\ Exchangerate + \beta_3\ Harvesterlandarea_t + \beta_4\ Riceconsumption_t + \beta_5\ Riceprice + \beta_6\ Carbonemission + \beta_7\ Foreignexchangereserves + \varepsilon_t$$

ECM modelling for the *short term* can be described as follows:

$$\Delta Riceimport_t = \alpha + \beta_1\ \Delta Production + \beta_2\ \Delta Exchangerate_t + \beta_3\ \Delta Havesterlandarea_t + \beta_4\ \Delta Riceconsumption_t + \beta_5\ \Delta Riceprice + \beta_6\ \Delta Carbonemission + \beta_7\ \Delta Foreignexchangereserves + \varepsilon_t$$

Result and Discussion

Data Analysis Test

Stationarity Test

Preliminary tests for stationarity often employ the Augmented Dickey-Fuller (ADF) test, which is a common unit root test used to determine whether a series is non-stationary at its levels or whether it becomes stationary after differencing (Sujianto & Azmi, 2020). If a series is found to be non-stationary at the levels and stationary at first differences, this indicates that the series is integrated of order one, denoted as I(1) (Islam, 2020). The results of these tests are foundational in deciding the application of cointegration methods, such as the Engle-Granger method or the Johansen cointegration test, both of which are effectively implemented in ECM analysis (Anshasy, 2014).

Table 1 Stationarity Test Results at *Level* and *First Difference level*

Variables	ADF t-statistic	Terms	Prob	Terms	Conclusion
		Level			
Amount of Rice Import	-3.971640	< -2.666593	0.0085	< 0.05	Stationary
Rice production	-1.304722	< -2.666593	0.6022	< 0.05	Non-stationary
Exchange Rate	-0.233942	<-2.666593	0.9164	< 0.05	Non-stationary
Harvester Land Area	-1.256949	<-2.673460	0.6238	< 0.05	Non-stationary
Rice consumption	-1.639986	< -2.666593	0.4418	< 0.05	Non-stationary
Domestic Rice Price	-2.702634	< -2.666593	0.0939	< 0.05	Non-stationary
Carbon Emission	0.234101	< -2.681330	0.9652	< 0.05	Non-stationary
Foreign Exchange Reserves	-1.745734	<-2.666593	0.3923	< 0.05	Non-stationary
First Difference					
D (Amount of Rice Import)	-4.385055	< -2.690439	0.0051	< 0.05	Stationary
D (Rice production)	-2.673460	< -3.275457	0.0340	< 0.05	Stationary
D (Exchange Rate)	-4.438563	<-2.673460	0.0037	< 0.05	Stationary
D (Harvester Land Area)	-3496056	<-2.673460	0.0225	< 0.05	Stationary
D(Rice consumption)	-6.668447	< -2.673460	0.0001	< 0.05	Stationary
D(Domestic Rice Price)	-3.158886	<-2.673460	0.0422	< 0.05	Stationary
D(Carbon Emission)	-4.566620	< -2.681330	0.0033	< 0.05	Stationary
D(Foreign Exchange Reserves)	-3.879379	< -2.673460	0.0108	< 0.05	Stationary

After testing at the *first difference* level, all variables are stationary. This is indicated by the ADF t-statistic value that is smaller than the critical value and the probability that is smaller than 0.05 for all these variables. Thus, it can be concluded that the variables do not have unit roots or are stationary at the *first difference* level.

Cointegrity Test

Cointegrity Test is a pivotal process in econometrics that seeks to identify long-run equilibrium relationships between non-stationary time series variables. The ECM framework is employed to analyze how deviations from the long-run equilibrium affect changes in the explanatory variables in the short run. This is particularly useful in capturing the adjustment dynamics when any of the variables deviate from their long-run path. The significance of the error correction term, usually representing the speed of adjustment back to equilibrium, indicates how quickly equilibrium is restored following a shock (Correa, 2023). In this context, the presence of causality can also be inferred, underscoring the dynamic interrelationships among the variables involved (Ahmed, 2019; Cao et al., 2014).

Table 2 Stationarity Test Results of Regression Residuals at the *Level Level*

Variables	ADF t-statistic	Terms	Prob	Terms	Conclusion
			Level		
ECT	-5.912823	< -2.666593	0.0002	< 0.05	Stationary

Based on the regression residual stationarity test results at the level presented in Table 2, it is found that the ECT (*Error Correction Term*) variable has an ADF *t-statistic* of -5.912823with a probability of 0.00020. Thus, it can be concluded that there is cointegration between the variables in the model.

***Error* Correction *Model* (ECM) Test**

Short-Term *Error Correction Model* (ECM) Test

Empirical applications of the ECM are widespread across various fields, including economics, finance, and agricultural sciences, where it is utilized to analyze variables such as rice production, exchange rate, and commodity prices. For example, studies have effectively employed ECM to explore the short-run impacts of macroeconomic variables on growth rates or prices, demonstrating the method's versatility as a dynamic modeling tool (Persyn & Westerlund, 2008; Prasada et al., 2018). The ability of ECM to distinguish between short-term dynamics and long-term trends enhances the understanding of the socio-economic phenomena being investigated (Kapetanios et al., 2003; Michinaka & Onda, 2024).

Table 3 Short-Term ECM Estimation Results

Variables	Coefficient	Prob.	Conclusion
C	-576920.7	0.1636	
D (Rice production)	0.011893	0.9450	Not Significant
D (Exchange Rate)	189.5326	0.6047	Not Significant
D (Harvester Land Area)	-0.2468856	0.6650	Not Significant
D(Rice consumption)	173259.6	0.0397	Significant
D(Domestic Rice Price)	524.1781	0.0190	Significant
D(Carbon Emission)	0.008186	0.0491	Significant
D(Foreign Exchange Reserves)	41.21323	0.3126	Not Significant
ECT(-1)	-1.0	0.0154	

Based on Table 3, the short-term equation results are as follows:

$$\begin{aligned} D(Riceimport)_t = & -576920.7 + 0.0118931D(Riceproduction)_t \\ & + 189.5326D(Exchangerate)_t - 0.2468856D(Harvesterlandarea)_t \\ & - 173259.6D(Riceconsumption)_t + 524.181D(Domesticriceprice)_t \\ & + 0.008186D(Carbonemission)_t \\ & + 41.21323D(Foreignexchangereserves)_t - 1.0ECT(-1) + \varepsilon_t \end{aligned}$$

The short-term Error Correction Model (ECM) test results reveal several important findings. In the short term, the constant term (-576,920.7) represents the baseline level of the dependent variable when all independent variables are zero, helping the model to better fit the observed data. The coefficient for rice production (0.0118931) is positive, indicating that an increase in rice production slightly increases rice imports. Similarly, the exchange rate (189.5326) also has a positive coefficient, suggesting that a depreciation of the local currency leads to higher rice imports. Conversely, the harvester land area (-0.2468856) has a negative coefficient, implying that an expansion in harvested land reduces rice imports.

Rice consumption (-173,259.6) also shows a negative relationship, meaning that higher domestic rice consumption tends to decrease rice imports. On the other hand, the domestic rice price (524.181) has a positive effect, suggesting that higher domestic prices encourage greater rice imports. Carbon emissions (0.008186) are positively associated with rice imports, although the impact is relatively small. In addition, the foreign exchange reserves (41.21323) positively influence rice imports, indicating that stronger reserves may facilitate greater import activities. Finally, the error correction term (ECT) has a coefficient of -1.0, meaning that any short-term deviation from the long-term equilibrium is fully corrected in the following period, demonstrating a complete adjustment mechanism after a shock.

Long-Term *Error Correction Model* (ECM) Test

Following the confirmation of cointegration, the long-term ECM is employed, specifically designed to represent the long-term relationship while accommodating short-term dynamics. The equation can be expressed in a form where the error correction term (ECT) captures the deviation from long-term equilibrium, allowing for the estimation of how quickly the variables revert to equilibrium after a disruption (Aulia, 2022). For instance, in macroeconomic studies, the model could examine how macroeconomic variables impac rice import in the long run while also adjusting for short-run fluctuations in response to economic shocks (Katrakilidis et al., 2014).

Table 4 Long-Term ECM Estimation Results

Variables	Coefficient	Prob.	Conclusion
C	-11 523388	0.4644	
Rice production	-0.167843	0.5206	Not Significant
Exchange Rate	-322.3639	0.1234	Not Significant
Harvester Land Area	0.551955	0.4866	Not Significant
Rice consumption	106730.2	0.4259	Not Significant
Domestic Rice Price	306.8871	0.2230	Not Significant
Carbon Emission	0.004232	0.5562	Not Significant
Foreign Exchange Reserves	0.942742	0.9695	Not Significant

Based on Table 4, the long-term equation results are as follows:

$$\begin{aligned}(Riceimport)〗\_t &= -11.523388 - 0.167843(Riceproduction)\_t \\ &- 322.3639(Exchangerate)\_t + 0.551955(Harvesterlandarea)\_t \\ &+ 106730.2(Riceconsumption)\_t + 306.8871(Domesticriceprice)\_t \\ &+ 0.004232(Carbonemission)\_t \\ &+ 0.942742(Foreignexchangereserves)\_t + \varepsilon\_t\end{aligned}$$

The long-term results of the Error Correction Model (ECM) provide several critical insights into the determinants of rice imports. The constant coefficient (−11.523388) reflects the expected baseline level of rice imports when all explanatory variables are zero; however, its practical significance is limited, as it is unlikely that all independent variables would simultaneously assume a value of zero. Nevertheless, it functions as a reference point within the model. In terms of specific relationships, rice production exhibits a negative and statistically meaningful coefficient (−0.167843), indicating that increases in domestic rice production are associated with reductions in rice import volumes, thereby highlighting the importance of self-sufficiency in curbing reliance on external supply. Similarly, the exchange rate demonstrates a negative effect (−322.3639), suggesting that a depreciation of the local currency discourages rice imports by increasing their cost.

Conversely, the harvester land area presents a positive coefficient (0.551955), implying that expansions in harvested areas are associated with a marginal increase in rice imports, which may reflect underlying inefficiencies or structural constraints in agricultural productivity. Rice consumption exerts a significant positive influence (106,730.2) on rice imports, underscoring the dominant role of domestic demand in shaping import needs.

Moreover, the domestic rice price (306.8871) is positively correlated with rice imports, suggesting that elevated domestic prices may incentivize greater reliance on imported rice to meet consumer demand.

Carbon emissions display a small but positive association (0.004232) with rice imports, hinting at possible environmental or policy-related linkages. Finally, foreign exchange reserves are positively associated (0.942742) with rice imports, indicating that greater reserve holdings enhance the country's capacity to finance external procurement of rice. Collectively, these findings illustrate the multifaceted and interconnected nature of economic, agricultural, and environmental variables in influencing long-term rice import pattern.

Hypothesis Test

Partial Test (t Test)

The partial test in ECM analysis aims to determine whether specific explanatory variables significantly contribute to predicting the dependent variable in the model. After using methods like the Engel-Granger or Johansen tests to establish cointegration among the variables, the ECM can be specified with an error correction term (ECT) that reflects any disequilibrium from long-run relationships (Salim & Soelistyo, 2024).

Table 5 Short-term t-test results

Variables	t-statistic	Prob.
D (Rice production)	0.0712	0.9450
D (Exchange Rate)	0.5388	0.6047
D (Harvester Land Area)	-0.4495	0.6650
D(Rice consumption)	2.4546	0.0397
D(Domestic Rice Price)	2.9300	0.0190
D(Carbon Emission)	2.3171	0.0491
D(Foreign Exchange Reserves)	1.0776	0.3126
ECT(-1)	-3.0673	0.0154

Based on the partial test results (t-test) in the short-term Error Correction Model (ECM) presented in Table 5, several important interpretations can be drawn. The variable D(Rice Production) shows a t-statistic of 0.0712 with a probability value of 0.9450. The t-statistic, being close to zero, and the very high probability value indicate that changes in rice production do not have a statistically significant short-term effect on rice imports. Similarly, D(Exchange Rate) exhibits a positive t-statistic of 0.5388 and a probability of 0.6047, suggesting a weak positive relationship with rice imports; however, the effect is not statistically significant given the probability value exceeds the conventional 5% significance level. The variable D(Harvester Land Area) records a negative t-statistic of

−0.4495 with a probability of 0.6650, indicating a weak inverse relationship with rice imports, yet this relationship is also statistically insignificant.

Conversely, D(Rice Consumption) demonstrates a positive and statistically significant relationship with rice imports, as evidenced by a t-statistic of 2.4546 and a probability value of 0.0397, which falls below the 0.05 threshold. This finding suggests that increases in rice consumption are associated with an increase in rice imports in the short term. Furthermore, D(Domestic Rice Price) exhibits a t-statistic of 2.9300 with a probability value of 0.0190, indicating a statistically significant positive relationship between domestic rice prices and rice imports, whereby higher domestic rice prices drive greater import volumes.

D(Carbon Emission) also shows a positive and borderline statistically significant relationship, with a t-statistic of 2.3171 and a probability of 0.0491, implying that rising carbon emissions are modestly associated with increased rice imports. On the other hand, D(Foreign Exchange Reserves) presents a positive t-statistic of 1.0776 but a probability value of 0.3126, suggesting a weak and statistically insignificant relationship with rice imports in the short term. Lastly, the Error Correction Term (ECT) is found to be statistically significant, with a negative t-statistic of −3.0673 and a probability value of 0.0154.

This result indicates that deviations from the long-term equilibrium are corrected over time, with the adjustment process being both significant and negative, thus reinforcing the stability of the system toward its equilibrium path following short-term shocks. In the short term, rice consumption, domestic rice prices, and carbon emissions have statistically significant positive effects on rice imports, suggesting that increases in these variables are associated with increases in rice imports. The error correction term's significance indicates that the model includes a mechanism to return to long-term equilibrium after short-term shocks. Other variables, such as rice production, exchange rate, harvester land area, and foreign exchange reserves, do not have a statistically significant impact on rice imports in the short term.

Table 6 Long-term t-test results

Variables	t-statistic	Prob.
Rice production	-0.6657353	0.5206
Exchange Rate	-1682425	0.1233
Harvester Land Area	0.722382	0.4866
Rice consumption	0.830013	0.4259
Domestic Rice Price	1.299364	0.2229
Carbon Emission	0.608876	0.5561
Foreign Exchange Reserves	0.039154	0.9695

Based on the partial test results (t-test) in the long-term Error Correction Model (ECM) as presented in Table 6, several important interpretations can be drawn. The variable Rice Production exhibits a negative t-statistic of −0.6657 with a probability value of 0.5206.

Although the negative sign suggests that an increase in rice production is associated with a decrease in rice imports, the relatively high probability value indicates that this relationship is not statistically significant. Therefore, no conclusive evidence supports a predictable impact of rice production changes on rice imports in the long run. Similarly, the Exchange Rate shows a negative t-statistic of −1.6824 and a probability of 0.1233. This result implies that a depreciation of the local currency may be associated with a decrease in rice imports; however, the probability remains above the conventional 5% significance level, rendering the relationship statistically insignificant despite being closer to significance compared to rice production.

The Harvester Land Area variable presents a positive t-statistic of 0.7224 with a probability of 0.4866, suggesting a positive association between harvester land area and rice imports. Nevertheless, the lack of statistical significance implies that changes in harvester land area cannot be reliably linked to fluctuations in rice imports. Likewise, Rice Consumption yields a positive t-statistic of 0.8300 with a probability of 0.4259, indicating a potential positive relationship; however, the result does not achieve statistical significance, preventing firm conclusions regarding its effect on rice import dynamics.

The Domestic Rice Price variable demonstrates a t-statistic of 1.2994 and a probability of 0.2229. Although the positive sign suggests that higher domestic rice prices may encourage rice imports, the evidence remains statistically insignificant due to the probability exceeding the 0.05 threshold. In the case of Carbon Emission, the t-statistic is 0.6089 with a probability of 0.5561, suggesting a slight positive association that is also not statistically significant. Finally, Foreign Exchange Reserves show an extremely low t-statistic of 0.0392 coupled with a very high probability of 0.9695, indicating no meaningful statistical relationship between reserve levels and rice imports.

None of the variables in the model are statistically significant at the conventional 0.05 level (or even at a more lenient 0.10 level), as indicated by the probability values associated with their t-statistics. This means that, based on this regression analysis, we do not have sufficient evidence to conclude that any of the included factors have a predictable impact on rice imports. It may be necessary to collect more data, consider additional variables, or review the model specification to improve the explanatory power of the regression model for rice imports.

Simultaneous F Test

The primary aim of the Simultaneous F Test in ECM analysis is to assess the hypothesis that a set of coefficients associated with independent variables is simultaneously equal to zero. This evaluation is critical when determining whether multiple predictors have a meaningful combined impact on the dependent variable's behavior, especially in the short-term dynamics modeled by ECM. The simultaneous nature of this test helps identify the overall significance of various factors, facilitating a more comprehensive understanding of the relationships among the variables being analyzed (Salim & Soelistyo, 2024).

Table 7 Short-Term F Test Results

	Results	Terms
F-statistic	30.78534	> 2.44
Prob (F-statistic)	0.004067	< 0.05

Based on the short-term ECM regression results in Table 7, **F-statistic: 30.78534**: The F-statistic measures the ratio of explained variance to unexplained variance in the model, assessing the overall significance of the regression equation. A high F-statistic value, such as 30.78534, indicates that the model explains a significant portion of the variability in the dependent variable (rice imports) relative to the unexplained variability. And **Prob (F-statistic): 0.004067**: The probability value associated with the F-statistic, also known as the p-value, indicates the likelihood of observing an F-statistic as extreme as 30.78534 if the null hypothesis were true.

The null hypothesis in this context states that all regression coefficients are equal to zero, meaning the model has no explanatory power A p-value of 0.004067 is significantly lower than the conventional threshold of 0.05, leading to the rejection of the null hypothesis. The short-term F test results indicate that the regression model is statistically significant. The high F-statistic (30.78534) and the low p-value (0.004067) suggest that at least one of the independent variables has a statistically significant relationship with the dependent variable (rice imports). This means the model has strong explanatory power in the short term, effectively capturing the relationships between the predictors and rice imports.

Table 8 Long-Term F Test Results

	Results	Terms
F-statistic	0.986361	> 2.79
Prob (F-statistic)	0.491026	< 0.05

Based on the long-term ECM regression results in Table 8, F-statistic: 0.986361: The F-statistic compares the model with multiple predictors to a model with no predictors (intercept-only model). An F-statistic value of 0.986361, which is less than the critical value of 2.79 (assuming a certain level of degrees of freedom), suggests that the model does not provide a better fit to the data than a model without any predictors. In other words, the collective explanatory power of the independent variables is not statistically significant.Prob (F-statistic): 0.491026: The p-value is the probability of observing an F-statistic as large as 0.986361, or larger, if the null hypothesis is true. The null hypothesis for the F-test in regression is that the model with no predictors explains the data as well as your model.

A p-value of 0.491026 is much higher than the conventional alpha level of 0.05, which indicates that there is not enough evidence to reject the null hypothesis. The long-term F test results suggest that the regression model is not statistically significant. The low F-statistic value and the high p-value indicate that the independent variables, when considered together, do not have a significant effect on the dependent variable in the long term. This implies that the model may not be useful for predicting or understanding the behavior of the dependent variable over the long term.

Thus, In the short term, a high F-statistic value and a low p-value indicate that the regression model is statistically significant. In the long term, a low F-statistic value and a high p-value suggest that the regression model is not statistically significant. The model may not be useful for long-term predictions

Test Coefficient of Determination (R)²

The coefficient of determination, commonly denoted as R^2, quantifies the proportion of variation in the dependent variable that can be explained by the independent variables in the model. R^2 values range from 0 to 1, where a value closer to 1 indicates that a significant amount of variance in the dependent variable is explained by the model. In ECM analysis, evaluating R^2 is crucial as it provides insights into the explanatory power of the variables integrated into the model (Kuzior et al., 2022).

Table 9 Results of the Coefficient of Determination in the Short Term

	Results
R-squared	0.888
Adjusted R-squared	0.777375

In Table 9, This value indicates that approximately 88.8% of the variability in rice imports can be explained by the independent variables included in the short-term model. This suggests a very high level of explanatory power, meaning the model is effective in capturing the relationship between the predictors and rice imports in the short term. The Adjusted R-squared value accounts for the number of predictors in the model and adjusts for the degrees of freedom.

A value of 0.777375 indicates that after accounting for the number of predictors, the model still explains about 77.74% of the variability in rice imports. This high value suggests that the model is robust and not overfitted, effectively capturing the underlying relationships between the variables. The high R-squared and Adjusted R-squared values indicate that the short-term model has strong explanatory power and effectively captures the relationship between the independent variables and rice imports. This model is reliable for understanding the factors influencing rice imports in the short term.

Table 10 Results of the Coefficient of Determination in the Long Term

	Results
R-squared	0.4084
Adjusted R-squared	--0.0054

In Table 10, This value indicates that approximately 40.84% of the variability in rice imports can be explained by the independent variables in the long-term model. This suggests a moderate level of explanatory power, meaning the model captures some of the relationship between the predictors and rice imports over a longer time horizon. The negative Adjusted R-squared value indicates that the model performs worse than a simple mean model, which predicts the mean of the dependent variable for all observations.

This suggests that the included variables do not contribute significantly to explaining the variability in rice imports in the long term, and the model may be overfitted or poorly specified. The moderate R-squared value and negative Adjusted R-squared value suggest that the long-term model has limited explanatory power and may suffer from issues such as overfitting or irrelevant predictors. This model is less reliable for understanding the factors influencing rice imports over a longer period.

Rice consumption has a positive and significant impact on rice imports in the short term. This is primarily because increased consumption leads to higher demand, which domestic production may not always meet, necessitating imports to fill the gap (Paipan & Abrar, 2020). In Indonesia, for instance, the government often resorts to imports to satisfy excess demand, especially when domestic production falls short (Paipan & Abrar, 2020).

Domestic rice prices also have a positive and significant effect on rice imports in short term. When domestic prices rise, it can become economically viable to import rice, especially if international prices are lower or more stable (Paipan & Abrar, 2020; Sani et al., 2020). The price effect is significant in the short term as consumers and policymakers respond to immediate price changes by adjusting import levels to stabilize the market (Sani et al., 2020).

While the direct impact of carbon emissions on rice imports is less explicitly discussed, the environmental implications of rice production and trade are significant. Increased trade, including imports, can lead to shifts in emission patterns, as seen in the global rice trade dynamics (X. Wang et al., 2023). The study highlights that trade flows have increased from low- to high-emission intensity countries, suggesting that environmental considerations are becoming increasingly relevant in trade decisions (X. Wang et al., 2023).

Rice production levels directly impact the volume of rice imports. In this study, rice production has no significant effect on rice import in short term period. Ideally, when domestic production is insufficient to meet national demand, imports are necessary to fill the gap. This relationship is evident in Indonesia, where despite increasing production, imports are still required due to inadequate production levels relative to consumption needs (Mustafa et al., 2021; Wibowo & Marwanti, 2024). The study by Mustafa et al. (2021) highlights that while there is a co-integration between rice production and imports, this relationship does not extend to foreign exchange reserves, indicating that production levels are a more immediate concern for import decisions.

Foreign exchange reserves are crucial for financing imports, but their direct impact on rice import volumes is not significant in the short term. The study by Dwitama et al. (2022) shows that while foreign exchange reserves are important for overall economic stability, they do not directly influence rice import decisions in the short term.

The exchange rate plays a crucial role in determining the cost-effectiveness of rice imports. A higher exchange rate can make imports more expensive, potentially reducing the volume of rice imported. Conversely, a lower exchange rate can facilitate increased imports by making them cheaper (Fitrawaty et al., 2023; Dwitama et al., 2022). The research by Fitrawaty et al. suggests that fluctuations in the exchange rate can also affect domestic rice prices, which in turn influences import volumes as the government seeks to stabilize prices (Fitrawaty et al., 2023).

Next variable is the harvester land area, which is a critical factor in determining production capacity, its direct impact on rice imports is less significant in the short term. The study by Wibowo and Marwanti indicates that while the harvester land area affects production, it does not individually have a significant impact on import volumes (Wibowo & Marwanti, 2024).

Several independent variables in the short term have an influence on rice imports in Indonesia. However, in the long run, all independent variables have no significant effect on rice imports. In the long term, rice production does not significantly affect rice imports. This is attributed to the inefficiencies in domestic production and distribution, which do not adequately meet the demand despite increased production (Mustafa et al., 2021; Paipan & Abrar, 2020). Exchange Rate and Harvester Land Area do not individually have a significant long-term effect on rice imports. The exchange rate, while important, does not show a direct long-term impact on import volumes (Mustafa et al., 2021; Wibowo & Marwanti, 2024).

Furthermore, carbon emissions from rice production are a growing concern globally, they do not directly influence rice import decisions in the long term. However, the environmental impact of rice trade is significant, with trade flows contributing to global GHG emission reductions (Y. Wang, 2023). Meanwhile, studies consistently show that rice consumption has a significant positive effect on rice imports in the long term. As domestic consumption increases, the need for imports rises to meet the demand (Paipan & Abrar, 2020; Wibowo & Marwanti, 2024). Foreign exchange reserves also have a significant positive impact on rice imports. This is because higher reserves provide the financial capability to import more rice, thus influencing import volumes (Paipan & Abrar, 2020).

Conclusion

This study analyses Indonesia's reliance on rice imports in the short and long term using the Error Correction Model (ECM) approach. The variables tested include rice production, rice consumption, domestic rice price, rupiah exchange rate, harvest area, foreign exchange reserves, and carbon emissions, with time series data for the period 2005-2022. The approach in this study shows that previously hypothesized variables in long-term, namely rice production, rupiah to dollar exchange rate, rice consumption, harvested land area, domestic rice price, carbon emissions, and foreign exchange reserves, statistically do not have a significant effect on the volume of rice imports in Indonesia. This indicates that there are other factors are more dominant in determining the level of rice imports in the country. However, in short-term variables such as rice consumption, domestic rice prices, and carbon emissions have statistically significant positive effects on rice imports. Meanwhile, the rest of variables, such as rice production, exchange rate, harvester land area, and foreign exchange reserves, do not have a statistically significant impact on rice imports.

Overall, the results of this study confirm that Indonesia's rice import dependency is still high, especially in the short term, due to increasing consumption and unstable domestic prices. Therefore, integrated policies between the agricultural, economic and environmental sectors are needed to increase food self-sufficiency and reduce dependence on imports. However, the results of this study still show that other factors outside the research variables have a considerable influence on the dependence of rice imports in Indonesia. Therefore, it is necessary to conduct further research related to other variables that have the potential to influence the high dependence on rice imports.

More complex models, such as the Vector Error Correction Model (VECM) or Autoregressive Distributed Lag (ARDL) to better capture the dynamics of variable relationships in the long run can also be applied as a reference for analysis. Future research could also compare Indonesia's rice import dependency with other countries that also have large rice production, such as Thailand, Vietnam, or the Philippines, to understand effective policies in reducing imports. Through a broader and more in-depth approach, future research can provide more accurate policy recommendations to reduce import dependence and improve national food security.

Author Contributions

Conceptualisation, R.I.S.S.; Methodology, M. J.; Investigation, M. J. and A.F.A.; Analysis, A.F.A. and M. J.; Original draft preparation, N.P.R.P.; Review and editing, A.F.A.; Visualization, N.P.R.P.; Supervision, R.I.S.S.; Funding acquisition, R.I.S.S.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

References

Ahmed, N. H. S. (2019). Dynamic Relationship Between Interest Rate and Tourism Stock Performance: Empirical Evidence From Egyptian Exchange. *International Journal of Heritage Tourism and Hospitality*, *13*(2), 274–285. https://doi.org/10.21608/ijhth.2019.93166

Anshasy, A. A. E. (2014). Oil Shocks and Oil Producers' Growth: Where Did All the Spending Go? *Opec Energy Review*, *38*(3), 243–271. https://doi.org/10.1111/opec.12022

Antriyandarti, E., Agustono, Ani, S. W., Rusdiyana, E., & Sukaton, D. L. A. (2023). Consumers' Willingness to Pay for Local Rice: Empirical Evidence from Central Java, Indonesia.

Journal of Agriculture and Food Research, *14*. https://doi.org/https://doi.org/10.1016/j.jafr.2023.100851

Aulia, A. (2022). Impact of Inflation on Main Food Commodities Prices in Central Java (2019-2021). *Journal of Humanities Social Sciences and Business (Jhssb)*, *2*(1), 75–89. https://doi.org/10.55047/jhssb.v2i1.381

Azifuaku, E. N., Ugwumba, C. O. A., Okoli, T. O., & Okeke, U. (2020). Price Competitiveness and Supply Response of Rice Producers in Nigeria: Implications for Agricultural Trade. *Asian Journal of Agricultural Extension, Economics & Sociology*, 88–101. https://doi.org/10.9734/ajaees/2020/v38i1230492

Butts, H. C. (2012). An Empirical Analysis of Small Country Import Demand Function: A Case of Guyana. *Problems and Perspectives in Management*, *10*(1), 105–121.

Cao, X., Lee, W., & Yang, Y.-H. (2014). Study on Synergistic Fluctuation of Exchange Rate Between Renminbi and New Taiwan Dollar. *International Journal of Economics and Finance*, *6*(10). https://doi.org/10.5539/ijef.v6n10p55

Chang, C., Lee, H., & Hsu, S. (2016). Food Security: Global Trends and Regional Perspective with Reference to East Asia. In *East Asia and Food (In)Security* (1st ed.).

Coffie, I. S., Tweneboah-Koduah, E. Y., Ocloo, E. C., Nkukpornu, A., & Kastner, A. N. A. (2023). Improving Local Rice Consumption in Sub-Saharan Africa through Social Marketing: Evidence from Ghana. *International Review on Public and Nonprofit Marketing*, *21*(1), 177–196. https://doi.org/10.1007/s12208-023-00370-w

Correa, E. C. (2023). Effect of Unemployment, Inflation and Foreign Direct Investment on Economic Growth in Sub-Saharan Africa. *Journal of Developing Economies*, *8*(2), 297–315. https://doi.org/10.20473/jde.v8i2.47283

Ekundayo, B. P. (2023). Rice Production, Imports and Economic Growth in Nigeria: an Application of Autoregressive Distributed Lag. *International Journal of Advanced Economics*, *5*(2), 48–56. https://doi.org/10.51594/ijae.v5i2.449

Fitrawaty, Hermawan, W., Yusuf, M., & Maipita, I. (2023). A Simulation of Increasing Rice Price Toward the Disparity of Income Distribution: An Evidence from Indonesia. *Heliyon*, *9*(3). https://doi.org/10.1016/j.heliyon.2023.e13785

Islam, Md. S. (2020). Do Education and Health Influence Economic Growth and Food Security Evidence From Bangladesh. *International Journal of Happiness and Development*, *6*(1), 59. https://doi.org/10.1504/ijhd.2020.108754

Jacob, A. (2024). A Review on Economic Implications of Nigeria's Border Closure on Rice Importation. *Open Journal for Research in Economics*, *7*(1), 9–22. https://doi.org/10.32591/coas.ojre.0701.02009j

Kapetanios, G., Shin, Y., & Snell, A. (2003). Testing for Cointegration in Nonlinear STAR Error Correction Models. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.428602

Katrakilidis, C., Kyritsis, I., & Patsika, V. (2014). On the Dynamic Linkages Between CO2 Emissions, Energy Consumption and Growth in Greece. *European Research Studies Journal*, *XVII*(Issue 3), 79–90. https://doi.org/10.35808/ersj/426

Kuzior, A., Vasylieva, T. A., Kuzmenko, O., Койбічук, B., & Brożek, P. (2022). Global Digital Convergence: Impact of Cybersecurity, Business Transparency, Economic Transformation, and AML Efficiency. *Journal of Open Innovation Technology Market and Complexity*, *8*(4), 195. https://doi.org/10.3390/joitmc8040195

Michinaka, T., & Onda, N. (2024). Rethinking the Factors Affecting the Arrival Quantity and Price of Sawlogs in Japanese Sawmills: An ARDL Approach. *Japan Agricultural Research Quarterly Jarq*, *58*(2), 129–140. https://doi.org/10.6090/jarq.58.129

Mustafa, Aprilia, A. P., & Fauzi, T. (2021). Co-integration Analysis between Rice Production and Exchange Reserves with Rice Consumption in Indonesia. *IOP Conference Series: Earth and Environmental Science*, *667*(1). https://doi.org/10.1088/1755-1315/667/1/012092

Nizar, J., & Abbas, T. (2019). Faktor-Faktor yang Mempengaruhi Impor Beras Indonesia. *Jurnal Ekonomi Pertanian Unimal*, *02*(01), 31–47. http://ojs.unimal.ac.id/index.php/JEPU

Octastefani, T., & Mitra, B. M. A. (2015). The Impact of Dependence on Rice Import Policy towards Indonesian Food Security. *Jurnal Politik Dan Kebijakan Publik*, *2*(1), 66–80.

Oladejo, J. A. (2023). Consumer Preference for Local and Imported Rice in Ifako- Ijaiye Local Government Area of Lagos State, Nigeria. *International Journal of Social Sciences And Management Research*, *8*(5), 43–54. https://doi.org/10.56201/ijssmr.v8.no5.2022.pg43.54

Paipan, S., & Abrar, M. (2020). Determinants of Rice Import Dependency in Indonesia. *Jurnal Ekonomi & Kebijakan Publik*, *11*(1), 53–64.

Persyn, D., & Westerlund, J. (2008). Error-Correction–Based Cointegration Tests for Panel Data. *The Stata Journal Promoting Communications on Statistics and Stata*, *8*(2), 232–241. https://doi.org/10.1177/1536867x0800800205

Prasada, I. M. Y., Dhamira, A., & Nugroho, A. D. (2018). Supply Response of Paddy in East Java: Policy Implications to Increase Rice Production. *Agraris Journal of Agribusiness and Rural Development Research*, *4*(2). https://doi.org/10.18196/agr.4268

Pujitiasih, H., Arifin, B., Situmorang Jurusan Agribisnis, S., Pertanian, F., Lampung, U., & Soemantri Brojonegoro No, J. (2014). Analysis of the Position and Level of Dependency on Imported White Sugar and Refined Sugar Crystals of Indonesia in International Market.

Dwitama, D. R., Nasution, L. N., Efendi, B., & Sari, W. I. (2022). The Effectiveness Of The Exchange Rate on The Amount of Foreign Exchange Reserves in Indonesia. *Economic: Journal Economic and Business, 1*(1), 14–19. https://doi.org/10.56495/ejeb.v1i1.226

Ruccy, M. V, Suharno, S., & Asmarantaka, R. W. (2022). Analisis Tingkat Ketergantungan Impor pada Industri Susu Indonesia. *Jurnal Agribisnis Indonesia (Journal of Indonesian Agribusiness)*, *10*(1), 101–112.

Salim, T., & Soelistyo, A. (2024). Analysis of Exchange Rates in the Economic Uncertainty Era. *Optimum Jurnal Ekonomi dan Pembangunan*, *14*(1), 82–94. https://doi.org/10.12928/optimum.v14i1.9750

Sani, Y., Hodijah, S., Prodi, R., Pembangunan, E., Ekonomi, F., & Universitas Jambi, B. (2020). Analisis Impor Beras Indonesia. *Journal Perdagangan Industri Dan Moneter*, *8*(2), 89–98.

Sessu, A. (2016). Examining of Production, Consumption, Imports and the Effect on Sugar Self-Sufficiency. *Researchers World : Journal of Arts, Science and Commerce*, *VII*(3), 120–129. https://doi.org/10.18843/rwjasc/v7i3/15

Steckley, M., & Steckley, J. (2023). Food Sovereignty for Food Security, Nutrition, and Climate Resilience. In *Transformations of Global Food Systems for Climate Change Resilience* (1st ed.).

Sujianto, A. E., & Azmi, M. F. U. (2020). Associative Study on Government Spending, Inflation, Trade Balance, and Gross Domestic Product. *Ekuilibrium Jurnal Ilmiah Bidang Ilmu Ekonomi*, *15*(1), 27. https://doi.org/10.24269/ekuilibrium.v15i1.2363

Van Groenigen, K. J., Van Kessel, C., & Hungate, B. A. (2013). Increased Greenhouse-gas Intensity of Rice Production Under Future Atmospheric Conditions. *Nature Climate Change*, *3*(3), 288–291. https://doi.org/10.1038/nclimate1712

Wang, X., Chang, X., Ma, L., Bai, J., Liang, M., & Yan, S. (2023). Global and Regional Trends in Greenhouse Gas Emissions from Rice Production, Trade, and Consumption. *Environmental Impact Assessment Review*, *101*. https://doi.org/https://doi.org/10.1016/j.eiar.2023.107141

Wang, Y. (2023). Trade Liberalization and Trade Protection Based on Game Theory. *BCP Business & Management, 44*, 619-624. https://doi.org/10.54691/bcpbm.v44i.4900

Wibowo, A. S., & Marwanti, S. (2024). Faktor-Faktor Yang Memengaruhi Volume Impor Beras Di Indonesia. *Agricultural Socio-Economic Empowerment and Agribusiness Journal*, *2*(2), 97. https://doi.org/10.20961/agrisema.v2i2.81605

Yasa, I. G. W. M., & Brata, I. G. C. S. (2015). Derajat Keterbukaan Impor dan Derajat Konsentrasi Komoditas Kedelai di Indonesia. *E-Jurnal Ekonomi Pembangunan Universitas Udayana*, *4*(8), 873-1047.

Yuan, S., Saito, K., van Oort, P. A. J., van Ittersum, M. K., Peng, S., & Grassini, P. (2024). Intensifying Rice Production to Reduce Imports and Land Conversion in Africa. *Nature Communications*, *15*(1). https://doi.org/10.1038/s41467-024-44950-8

Yusuf, W. A., Yusuf, S. A., Adesope, A. A. A., & Adebayo, O. Z. (2020). Determinants of Rice Import Demand in Nigeria. *Journal of Applied Sciences and Environmental Management*, *24*(5), 923–931. https://doi.org/10.4314/jasem.v24i5.30