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Effect of Private Investment and Exchange Rate on Rice Output in Nigeria: A Bivariate Analysis

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Abstract

Studying the effects of exchange rate fluctuations on crop output can provide valuable insights into the relationship between exchange rates and agricultural performance. This research focused on how private investment and exchange rates specifically impact rice production. The study employed a Vector Error Correction Model (VECM), Impulse Response, and Variance Decomposition to achieve its objectives. The findings revealed that both foreign direct investment (FDI) and gross domestic private investment significantly affect rice output. Additionally, exchange rates and labor also have a significant impact on rice production. The analysis showed that rice output responds negatively to a unit shock in exchange rates and similarly negative responses to shocks in FDI, gross domestic investment, and labor. The study concluded that FDI, gross domestic investment, exchange rates, and labor contributed to rice output during the examined period. To attract foreign partners and

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enhance agricultural output, the study suggests implementing tax incentives and improving security. Furthermore, re-evaluating the exchange rate could encourage the importation of agrochemicals, genetically modified seeds, farming equipment, and other inputs, thereby boosting the agricultural subsector. These policies would influence production incentives and, consequently, the allocation of resources across sectors.

Keywords: Private Investment, Exchange Rate, Variance Decomposition, Rice Output, Impulse Response

INTRODUCTION

Private investment, both domestic and foreign, is a crucial driver of agricultural growth in Nigeria. As noted in [5], private investment in agriculture can significantly boost crop yields and overall productivity. The influx of capital, modern technology, and improved farming practices associated with private investment can substantially impact crop output. Private investment has the potential to bring transformative changes to the agricultural sector. By analyzing the effects of private investment on rice output, policymakers and stakeholders can identify specific areas where investment is most needed, guiding the formulation of policies and strategies to attract and channel private investment into critical agricultural subsectors such as rice production, storage, processing, and marketing. Additionally, understanding the impact of private investment on rice output can help identify barriers or constraints that hinder investment inflows and develop targeted interventions to address them.

Exchange rates also play a pivotal role in determining the competitiveness of Nigerian agricultural products in the global market. Fluctuations in exchange rates can influence the prices at which agricultural goods are exported, affecting the overall output of these crops. Research by [11] has highlighted the importance of exchange rate stability for enhancing agricultural exports. Studying the effects of exchange rate movements on crop output can provide valuable insights into the dynamics between exchange rates and agricultural performance. This knowledge can guide the design of appropriate exchange rate policies, trade facilitation measures, and risk management strategies to mitigate the adverse effects

of exchange rate volatility and enhance the competitiveness of Nigerian rice in global markets.

While many studies ([7], [8], [15], and [9]) have explored the influence of private investment and exchange rates on economic output, there is a noticeable research gap regarding crop-specific analysis. Most studies ([12], [16], [6], [1], [13], and [10]) offer a broad overview of the impact on the agricultural sector as a whole, without focusing on the effects on individual crops. This research gap calls for a more detailed examination of how private investment and exchange rates specifically affect rice output. Addressing this gap will provide a more nuanced understanding of these factors' impact on particular crops in Nigeria, aiding policymakers, investors, and farmers in making informed decisions and implementing strategies tailored to individual crops. This approach ultimately promotes agricultural sustainability, economic growth, and food security in the country.

Understanding the interplay between private investment and exchange rates is essential for a comprehensive analysis of their effects on rice output in Nigeria. While private investment can enhance agricultural productivity, exchange rate fluctuations can either amplify or dampen its impact. Therefore, an in-depth analysis of these factors is crucial for policymakers, investors, and stakeholders to make informed decisions and develop strategies that promote sustainable crop production and economic growth in Nigeria. Considering the crop-specific dynamics is crucial due to the diverse nature of crops grown in Nigeria and their varying responses to investment and exchange rate fluctuations. Different crops have distinct agronomic requirements, market dynamics, and sensitivities to external factors, making it imperative to discern how private investment and exchange rates uniquely affect each crop's output. For instance, the impact on staple crops like rice may differ significantly from that on cash crops like cocoa or rubber.

This study aims to examine the effects of private investment and exchange rate fluctuations on the output of rice in Nigeria, shedding light on the relationship between these factors and providing valuable insights for policymakers and agricultural stakeholders. The findings offer practical recommendations for enhancing crop production in Nigeria.

MATERIALS AND METHODS

Method of Data Collection

Secondary data spanning 42 years (1980-2021) were obtained from the World Bank database, the Food and Agriculture Organization, the United Nations Conference on Trade and Development (UNCTAD), the Central Bank of Nigeria (CBN), and the National Bureau of Statistics (NBS).

Techniques of Data Analysis

VECM (vector error correction model), Impulse response and Variance decomposition were used to achieve the objective of this study

Models Specification

VECM model for the effect of private investment on agricultural subsector output

To estimate the relationship between the variables when cointegration is found, the corresponding vector error correction equation was estimated as follows:

$$lnAG_{t-i} = \beta_0 + \beta_1 lnFDI_{t-i} + \beta_2 lnDI_{t-i} + \beta_3 lnLb_{t-i} + ECT_{t-i} + \varepsilon_t$$

Where

AG_{t-i} = Output of selected crops (Rice, cassava, Cocoa, Groundnut, and Sesame) output (tons)

FDI_{t-i} = foreign direct investment (Naira)

DI_{t-i} = Domestic Private Investment (Naira)

Lb_{t-i} = labour (number of persons involved in the agriculture sector)

ECT_{t-i} = Error correction Term

ε_t = error term

A priori expectation, β_1, β_2 and $\beta_3 > 0$

Foreign direct investment is expected to have a positive effect because it involves the injection of capital (a factor of production) and the transfer of new technology into a business, which enhances production and increases output.

Gross domestic private investment is expected to have a positive effect because it provides inputs, infrastructural facilities, finance, and other resources that facilitate production, thereby increasing output.

Labor is expected to have a positive effect as it is an essential factor of production; without labor, production cannot take place. Labor can be skilled, semi-skilled, or unskilled.

Effect of exchange rate on selected crops output

$$lnAG_{t-i} = \beta_0 + \beta_1 lnEX_{t-i} + \beta_2 lnLb_{t-i} + \beta_3 lnPAG_{t-i} + ECT_{t-i} + \varepsilon_t$$

AG_{t-i} = Output of selected crops (Rice, cassava, Cocoa, Groundnut, Sesame) output (tons)

EX_{t-i} = Exchange rate

Lb_{t-i} = labour (Number of person involved in the agriculture sector)

PAG_{t-i} = Public Agricultural spending (Naira)

ECT_{t-i} = Error correction Term

ε_t = error term

A priori expectation, $\beta_1 < 0, \beta_2$ and $\beta_3 > 0$

The exchange rate is expected to have a negative impact because a high exchange rate increases the cost of inputs (such as fertilizer, seeds, and agrochemicals), making them less affordable for many farmers. This can result in crop failure due to a lack of nutrients or susceptibility to pests and diseases. Labor is expected to have a positive impact since it is a crucial factor of production; without labor, production cannot occur. Labor can be skilled, semi-skilled, or unskilled. Public agricultural spending is also expected to have a positive impact, as increased spending in agriculture typically leads to higher production levels.**3.**

RESULTS AND DISCUSSION

Stationarity Test (Unit Root Rest)

The results of the stationarity test are shown in Table 1. The findings indicate that all the variables became stationary at their first differences, meaning they are integrated of order one (1(1)).

Table 1: Augmented Dickey-Fuller Unit Root Test Result

Variables	Level		First difference		Decision
	t-statistic	Probability	t-statistic	Probability	
Rice	-1.13	0.6910	-9.31	0.0000	1(1)
Public Agric	-1.06	0.7162	-5.64	0.0001	1(1)
Exch Rate	-1.87	0.3407	-5.16	0.0002	1(1)
FDI	-1.25	0.6393	-5.17	0.0002	1(1)
GDPI	-1.35	0.5949	-5.17	0.0010	1(1)
Labour	-0.00	0.9522	-9.75	0.0000	1(1)

***,** and*indicate stationary at 1%, 5% and 10% level of significance respectively

Source: Data analysis (2023)

Co-integration between private investment and rice output

The results of the co-integration test between private investment and rice output are presented in Table 2. The trace statistic (64.37) exceeds the critical value (63.87), indicating a long-run relationship between private investment and rice output, with one co-integration equation. This finding suggests that private investment and rice output are co-integrated, implying a long-term relationship between the two. The presence of co-integration means that private investment and rice output follow the same long-run trend, causing private investment to move in tandem with rice output over time.

Table 2: **Unrestricted Co-integration Rank Test Result on Rice output**

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.556621	64.37836	63.87610	0.0453
At most 1	0.476903	35.91180	42.91525	0.2095
At most 2	0.238129	13.23222	25.87211	0.7199
At most 3	0.100652	3.712989	12.51798	0.7832

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

* denotes rejection of the hypothesis at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values
Source: Data analysis (2023)

Co-integration test between exchange rate and rice output

The results of the co-integration test between exchange rate and rice output are presented in Table 3. The trace statistic (30.92) exceeds the critical value (24.27), indicating a long-run relationship between exchange rate and rice output, with one co-integrating equation. This implies that exchange rate and rice output are co-integrated, suggesting a long-term relationship between them. The presence of co-integration means that exchange rate and rice output follow the same long-term trend, causing the exchange rate to move in line with rice output over time.

Table 3: Unrestricted Co-integration Rank Test Result on rice output

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.417776	30.92351	24.27596	0.0063
At most 1	0.203611	11.99199	12.32090	0.0567
At most 2	0.108599	4.023646	4.129906	0.0532

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: Data analysis (2023)

Effect private investment on rice output

The results of the analysis on the effects of private investment on rice output are presented in Table 4. The findings reveal one co-integrating equation. The coefficient of determination (R^2) was 0.698, indicating that 69.8% of the variation in rice output was explained by factors such as rice output, foreign direct investment (FDI), gross domestic private investment (GDPI), and labor from the previous year.

Specifically, the coefficient for FDI (-0.76) was negative and not statistically significant, which does not align with a priori expectations. The results further indicate that, in the long run, labor and GDPI were the only variables significantly impacting rice output in Nigeria. The coefficient for labor (24.17) was positive and significant at the 1% level, suggesting that rice farming is predominantly conducted by an active workforce with the energy and capability to work. This finding aligns with the conclusions of [5], who also found that labor contributes positively to agricultural growth in Nigeria.

The coefficient for GDPI (-1.44) was negative and significant at the 1% level, which also contradicts a priori expectations. This implies that a unit increase in GDPI would decrease rice output by 1.44%. This could be attributed to government policies during the structural adjustment periods that artificially reduced rice and fertilizer prices relative to global prices. The government's involvement in the importation, distribution, and marketing of rice, combined with the non-transfer of actual costs to consumers, led to lower prices for domestically produced rice. This depressed farm gate prices and discouraged domestic private investors, resulting in a negative coefficient for GDPI. This finding is consistent with [14], who found that increasing domestic private investment reduced agricultural growth in Nigeria.

In the short run, FDI was the only variable that significantly affected rice output. The coefficient for FDI (-0.88) was negative and significant at the 1% level, indicating that a unit increase in foreign direct investment would reduce rice output by 0.88%. This reduction could be due to rigid and unattractive macroeconomic policies, such as fiscal and monetary policies, implemented by the Nigerian government. These policies might include increased corporate taxes, reduced government spending on essential infrastructure (e.g., roads, electricity, healthcare, water supply), and unstable exchange and interest rates. These conditions can discourage foreign investors, as no company wants to operate at a loss due to increased taxation, additional costs to provide basic amenities, and volatile financial rates. The inconsistent trends in rice growth are also attributed to various inconsistencies in rice production policies and investment opportunities, particularly during the pre-ban and post-ban periods of rice imports. This finding contrasts with [10], who found that FDI increases agricultural growth in Nigeria.

Table 4: Effect Private Investment on Rice Output

Cointegrating Eq:	CointEq1			
D(LNRICE(-1))	1.000000			
D(LNLABOUR(-1))	24.17***			
	[6.58]			
D(LNGDPI(-1))	-1.44***			
	[-2.61]			
D(LNFDI(-1))	-0.76			
	[-0.42]			
C	-0.59			
Error Correction:	D(LNRICE,2)	D(LNLABOUR, 2)	D(LNGDPI,2)	D(LNFDI,2)
CointEq1	-0.003	-0.06***	0.14	0.01
	[-0.07]	[-5.77]	[2.09]	[0.50]
D(LNRICE(-1),2)	-0.70***	0.04	0.14	0.04
	[-6.18]	[1.36]	[0.77]	[0.75]
D(LNLABOUR(-1),2)	-0.070	0.18	-1.82**	-0.13
	[-0.11]	[1.05]	[-1.75]	[-0.43]
D(LNGDPI(-1),2)	-0.08	-0.07***	-0.17	0.13***
	[-0.84]	[-2.75]	[-1.00]	[2.75]
D(LNFDI(-1),2)	-0.88***	-0.06	-0.02	-0.58***
	[-2.84]	[-0.72]	[-0.03]	[-3.74]
C	-0.00	-2.42E-06	0.00	-0.00
	[-0.26]	[-0.00]	[0.17]	[-0.23]
R-squared	0.698	0.755	0.253	0.401
Adj. R-squared	0.644	0.711	0.120	0.294
Sum sq. resids	0.729	0.058	2.100	0.184
S.E. equation	0.161	0.045	0.273	0.081
F-statistic	12.943	17.291	1.903	3.760
Log likelihood	17.064	59.983	-0.910	40.456
Akaike AIC	-0.650	-3.175	0.406	-2.026
Schwarz SC	-0.381	-2.906	0.675	-1.757
Mean dependent	-0.001	0.000	0.008	-0.000
S.D. dependent	0.270	0.085	0.292	0.096
Determinant resid covariance (dof adj.)		2.04E-08		
Determinant resid covariance		9.38E-09		
Log likelihood		121.2718		
Akaike information criterion		-5.486578		
Schwarz criterion		-4.229575		

***, ** and * are significant at 1, 5 and 10% respectively values in bracket are t statistics
N.B values in bracket are t-statistics
Source: Data analysis (2023)

Effect of exchange rate on rice output

The results of the analysis on the effect of exchange rate on rice output are presented in Table 5, which shows one cointegrating equation. The coefficient of determination (R^2) for the cointegrating equation was 0.5885, indicating that 58.85% of the variation in rice output could be explained by the previous year's rice output, exchange rate, labor, and public agricultural spending.

In the long run, the variables that significantly affected rice output were exchange rate, public agricultural spending, and labor. Specifically, the coefficients for labor (18.67) and public agricultural spending (0.71) were positive and significant at the 1% level. This suggests that a unit increase in labor and public agricultural spending would increase rice output by 18.67% and 0.71%, respectively. Increased public spending, which could include the construction of new roads connecting towns and rural areas, provision of piped water, electricity, irrigation systems, and agricultural inputs, would likely boost rice output in Nigeria. This finding aligns with [4], who found that government expenditure positively and significantly impacts agricultural output in Nigeria.

The coefficient for exchange rate (-0.75) was negative and significant at the 5% level, consistent with a priori expectations. Therefore, the null hypothesis stating that the exchange rate has no significant effect on rice output in Nigeria is rejected. The negative coefficient indicates that a unit increase in the exchange rate would decrease rice output by 0.75%. This decrease could be attributed to unfavorable monetary policies by the Central Bank of Nigeria (CBN). In the short run, however, none of the variables significantly affected rice output during the period under review. These findings contrast with [3], who found a positive relationship between exchange rate and agricultural sector output in Nigeria.

Table 5: Effect of Exchange Rate on Rice Output

Cointegrating Eq:	CointEq1
D(LNRICE(-1))	1.000000
D(PUBLIAGRIC(-1))	0.71***
	[5.60]
D(LNLABOUR(-1))	18.67***
	[6.91]
D(LNEXCRATE(-1))	-0.75**
	[-2.51]
C	-0.57

Error Correction:	D(LNRICE,2)	D(PUBLICAGRIC,2)	D(LNLABOUR,2)	D(LNEXCHRATE,2)
CointEq1	-0.03	-1.39***	-0.08***	-0.29***
	[-0.44]	[-4.91]	[-4.13]	[-3.28
D(LNRICE(-1),2)	-0.74***	1.74***	0.03	0.23
	[-6.01]	[3.41]	[1.05]	[1.47]
D(PUBAGRIC(-1),2)	0.01	-0.11	0.02***	0.05
	[0.41]	[-0.83]	[2.69]	[1.32]
D(LNLABOUR(-1),2)	0.20	14.25***	0.18	6.37***
	[0.23]	[3.99]	[0.73]	[5.73]
D(LNEXRATE(-1),2)	-0.02	0.32	-0.01	-0.19**
	[-0.23]	[0.89]	[-0.51]	[-1.74]
C	-0.00	0.01	0.00	0.00
	[-0.09]	[0.09]	[0.01]	[0.10]
R-squared	0.588	0.666	0.664	0.705
Adj. R-squared	0.515	0.607	0.604	0.653
Sum sq. resids	0.994	16.682	0.080	1.621
S.E. equation	0.188	0.771	0.053	0.240
F-statistic	8.009	11.200	11.086	13.438
Log likelihood	11.805	-36.139	54.609	3.490
Akaike AIC	-0.341	2.478	-2.859	0.147
Schwarz SC	-0.072	2.748	-2.590	0.416
Mean dependent	-0.001	0.006	0.000	0.003
S.D. dependent	0.270	1.231	0.085	0.408

Determinant resid covariance (dof adj.)	2.31E-06
Determinant resid covariance	1.06E-06
Log likelihood	40.82602
Akaike information criterion	-0.754472
Schwarz criterion	0.502531

*****,** and*indicate stationary at 1%, 5% and 10% level of significance**
NB: values in bracket are t-statistics
Source: Data analysis. (2023)

Impulse response on the effects of private investment on rice output

The results of the unit shock of private investment on rice output over time are illustrated in Figure 1. The graph indicates that rice output responds positively to itself from the first year to 2.5 years, negatively from 2.5 years to 5 years, positively from 5 years to 7.5 years, and again negatively from 7.5 years to 9.5 years, continuing negatively until the 10th year. This pattern implies that rice output increases by 1% during periods of positive response and decreases by 1% during periods of negative response, both in the long and short run.

Furthermore, the graph shows that rice output responds positively to a unit shock in labor and gross domestic private investment in both the short and long run. This means that a unit increase in labor and gross domestic private investment is associated with a 1% increase in rice output. Conversely, rice output responds negatively to a unit shock in foreign direct investment from the first to the second year, but then positively from the second year to the tenth year. This suggests that foreign direct investment initially decreases rice output by 1% during the negative response period and increases it by 1% during the positive response period.

Impulse response analysis illustrates how a dynamic system reacts to external changes or shocks. In this context, positive shocks, such as increased investment in rice, lead to an increase in rice output, while negative shocks, such as decreased investment, lead to a decrease in output. This demonstrates a correlation between investment and rice output.

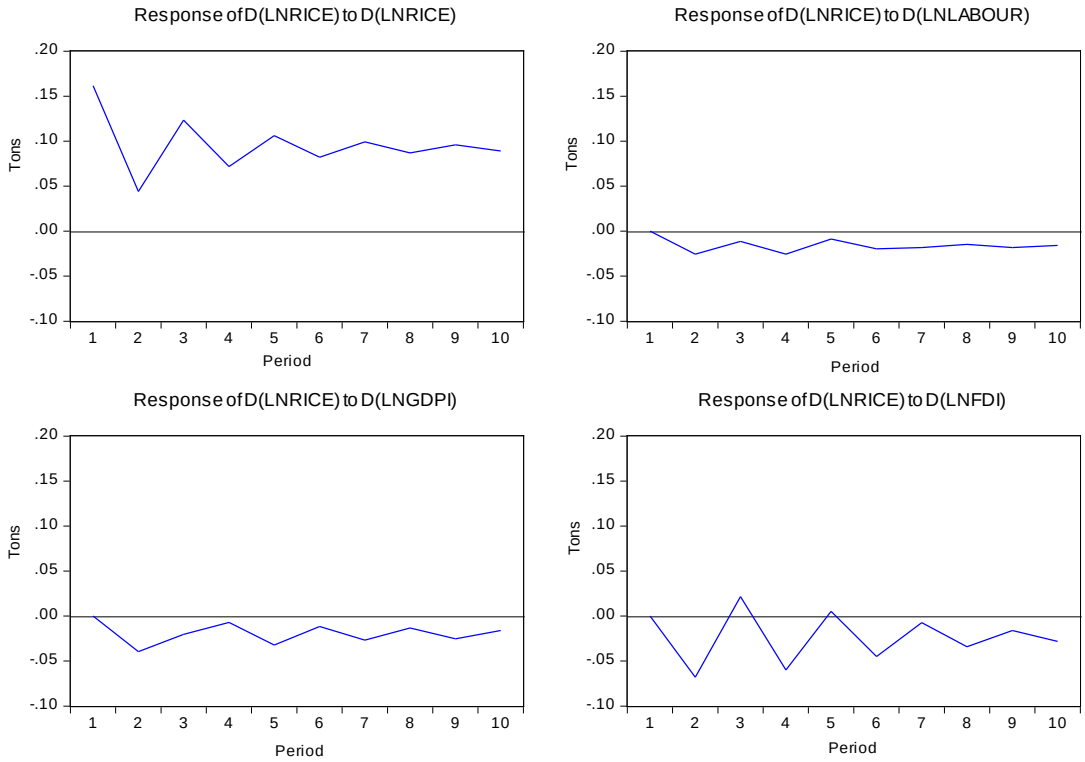

Figure 1: Response of rice to a unit shock in private investment

Impulse response for the effects of exchange rate on rice output

The results of the unit shock of exchange rate on groundnut output over time are depicted in Figure 2. The graph shows that groundnut output responds positively to its own unit

shock in both the short and long run. This means that a unit increase in the output of groundnut in the previous year leads to a 1% increase in groundnut output in both time frames.

The graph also indicates that groundnut output reacts negatively to unit shocks in labor and exchange rate in both the short and long run. This suggests that a unit increase in labor or exchange rate in the previous year results in a 1% decrease in groundnut output in both time periods.

Additionally, the graph reveals that groundnut output responds negatively to a unit shock in public agricultural spending in the short run, but positively in the long run. This implies that a unit increase in public agricultural spending decreases groundnut output in the short run but increases it in the long run.

Impulse response analysis demonstrates how a dynamic system reacts to external changes or shocks. Specifically, a positive shock, such as an increase in the exchange rate, leads to a decrease in groundnut output, whereas a negative shock, such as a decrease in the exchange rate, results in an increase in output. This indicates a correlation between exchange rate fluctuations and groundnut output.

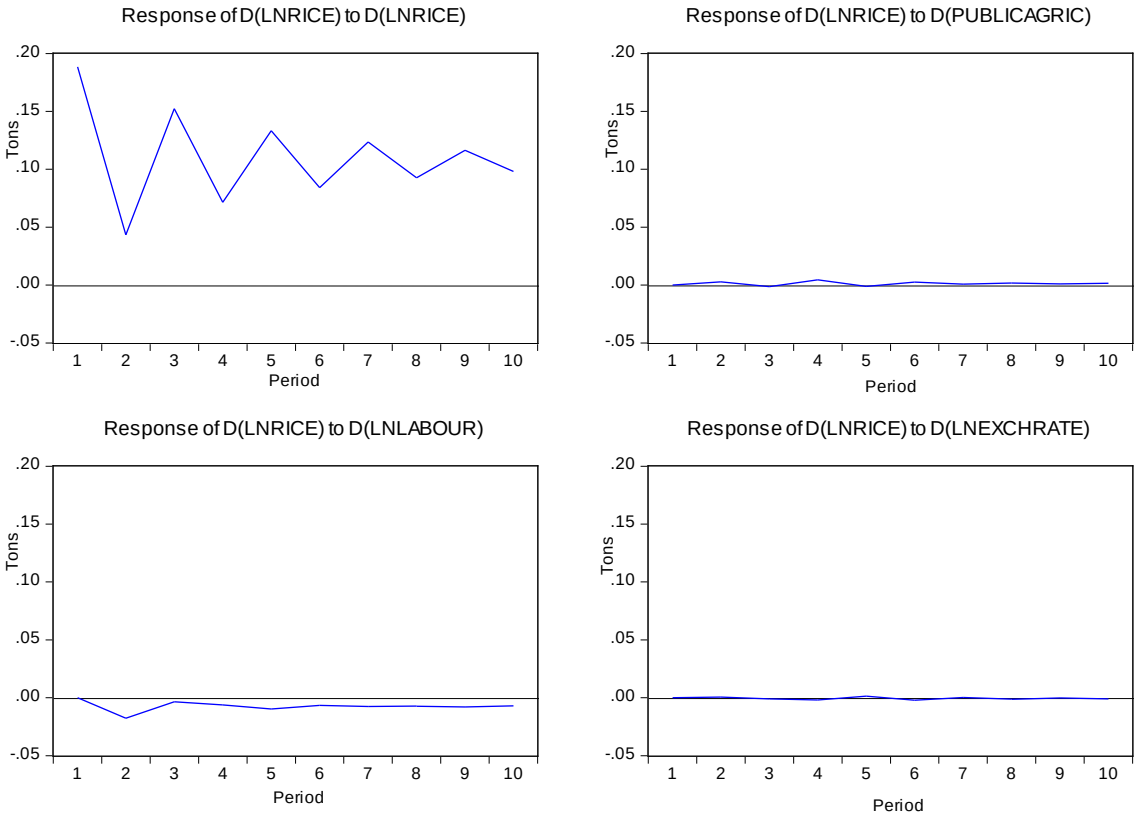

Figure 2: Response of rice to a unit shock in exchange rate

Variance decomposition on effects of private investment on rice

The results of the contribution of private investment to rice output are shown in Table 6. In the long run (10 years), rice output contributed 83% to itself, labor contributed 2%, Gross Domestic Private Investment (GDPI) contributed 4%, and Foreign Direct Investment (FDI) contributed 11%. In the short run (5 years), rice output contributed 82% to itself, labor contributed 2%, GDPI contributed 4%, and FDI contributed 12%.

Table 6: Variance Decomposition of private investment on Rice Output

Period	S.E.	RICE	LABOUR	GDPI	FDI
5	0.269959	81.79114	2.076000	4.194127	11.93874
10	0.349137	82.78017	2.484073	4.084881	10.65088

Source: Data analysis (2023)

Variance decomposition on effect of exchange rate on rice output

The results of the contribution of exchange rate to rice output are detailed in Table 7. In the short run (5 years), rice output contributed 99% to itself, while the exchange rate contributed 0.5%, labor contributed 0.5%, and public agricultural spending contributed 0.03%. In the long run (10 years), rice output contributed 99% to itself, with the exchange rate contributing 0.01%, labor contributing 1%, and public agricultural spending contributing 0.03%. The low contribution of the exchange rate to rice output is attributed to the fact that high exchange rates discourage importation, limiting farmers' access to essential farm inputs.

Table 7: Variance Decomposition of effect of exchange rate on Rice Output

Period	S.E.	RICE	PUBLICAGRIC	LABOUR	EXCHRATE
5	0.289717	99.41900	0.035746	0.536815	0.008443
10	0.371883	99.44245	0.031524	0.516084	0.009947

Source: Data analysis (2023)

CONCLUSION

The study revealed that both Foreign Direct Investment (FDI) and Gross Domestic Private Investment (GDPI) significantly impact rice output. Additionally, the exchange rate and labor also have a significant effect on rice production. The findings indicated that rice output responds negatively to unit shocks in exchange rate, FDI, GDPI, and labor. Despite this, all these factors—FDI, GDPI, exchange rate, and labor—contributed to rice output during the period under review.

Based on these conclusions, the following recommendations are made:

1. **Enhance Foreign Investment**: To leverage the significant impact of FDI on rice output, it is recommended to implement tax incentives and strengthen security measures to attract and retain foreign investors.

2. **Reevaluate Exchange Rate Policies**: The exchange rate should be reassessed to promote the importation of agrochemicals, genetically modified seeds, and farming equipment. These measures are expected to boost agricultural sector output by improving production incentives and resource flow across sectors.

3. **Encourage Domestic Investment**: To stimulate domestic private investment, which also significantly affects rice output, it is advised to offer incentives such as single-digit interest rates and input subsidies, including fertilizer.

Conflicts of Interest: The authors declare no conflict of interest. The funding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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