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EFFECT OF RICE TOTAL FACTOR PRODUCTIVITY (TFP) ON RICE OUTPUT IN NIGERIA

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ABSTRACT— This study critically examined the effects of Total Factor Productivity on rice output in Nigeria. Data for this study such as land area, labour, capital and rice output from 1961 to 2020 were collected from various sources such as World Bank online statistical depository, United States Department of Agriculture Economic Research Service [26], [8], [16]. Data were analysed using descriptive such as mean and graph and inferential statistics such as Ordinary Least Square Regression model. Result from the study showed that although there is a positive trend in rice TFP in Nigeria over the years, the average rice TFP is regressive (i.e., less than 1). Furthermore, rice TFP (coefficient = 12.282; p<5%) had statistically significant effect on rice output. The study therefore recommended that promoting the adoption of modern technologies and improving management practices, policymakers can help enhance TFP and increase rice output, thereby improving food security and promoting economic development.

KEYWORDS: Total Factor Productivity, Rice output, Error Correction Model, Malmquist Productivity Index, Nigeria.

1. INTRODUCTION

Rice is a vital staple food for millions of Nigerians, and its cultivation plays a significant role in the country's agricultural sector. The cultivation of rice has played a vital role in ensuring food security and poverty reduction in many developing countries [2]. Despite the government's efforts to improve rice production through policies such as the Agricultural Transformation Agenda, rice output in Nigeria remains far below the nation's demand [18]. One of the critical factors affecting rice output is total factor productivity (TFP), which refers to the efficiency of input use in agricultural production [15].

TFP according to [10] is a measure of the efficiency with which inputs (land, labour, capital, and other resources) are transformed into outputs. Several factors influence TFP in rice production, including technology adoption, research and development, human capital, infrastructure, and institutional factors. Technology adoption, especially modern rice varieties, has been identified as a critical factor in improving TFP and increasing rice output [24]. Research and development (R&D) also play a crucial role in enhancing TFP by improving technology adoption and disseminating best practices [23]. Additionally, human capital, such as education and training, can enhance TFP by improving farmers' knowledge and skills [13].

Studies have shown that TFP plays a crucial role in agricultural productivity, including rice output [1], [20]. In Nigeria, previous research has focused on the determinants of rice productivity, such as farm size, inputs, and technology adoption [19], [21] but no research has Benn conducted on the effect of TFP on rice output.

However, there is a need to investigate the impact of TFP on rice output in Nigeria, as this will provide insight into the factors that affect rice production efficiency and inform policy decisions aimed at improving rice production in the country.

Therefore, this study seeks to examine the effect of TFP on rice output in Nigeria, using secondary data from 1961 to 2020. The specific objectives are to;

i. describe the trend of rice TFP in Nigeria from 1961 to 2020; and
ii. examine the effect of rice TFP on rice output in Nigeria

The null hypothesis of this study is stated as follows;

H_{01}: There is no significant effect of rice TFP on rice output in Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study area under consideration is the Federal Republic of Nigeria, which is a West African country with a landmass of 923,768 square kilometers. It is located between latitudes 4° and 14°N and longitudes 2° and 14°E, as reported by the [25] World Factbook. Nigeria shares borders with Niger to the north, Benin to the west, Chad and Cameroon to the east, and the Gulf of Guinea (Atlantic Ocean) to the south. Nigeria is richly endowed with land, natural resources, and a large workforce, as reported by the [17].

2.2 Data Collection

Data for this study such as rice input and output data from 1961 to 2020 were collected from the United States Department of Agriculture Economic Research Service [26], [8], [16].

2.3 Data Analysis

Data were analysed using descriptive such as means and graphs and inferential statistics such as Ordinary Least Square Regression model. The TFP index of rice was generated using the Malmquist Data Envelopment Analysis (DEA) software version 2.0. Test for stationarity, causality, cointegration, serial correlation, heteroscedasticity, normality and stability were carried out using the E-views software version 10.

2.4 Description of Variables

The variables used in this study are briefly described in Table 1.

Table 1. Description of variables

Variable name	Description	Unit
Dependent variables		
Output	Total annual rice output	Metric tonnes
Independent variables		
Rice TFP	Total Factor Productivity of rice	
Rice input variables		
Land	Total area of land for rice production	Hectares
Labour	Number of persons involved in rice production	Persons
Capital	Amount of total capital stock for fertilizer, chemicals, machineries etc.	Nigerian naira ($1USD = ₦460)

Source: Author's computation (2023)

2.5 Empirical Models

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2.5.1 Rice Total Factor Productivity (Malmquist Productivity Index)

The Malmquist Productivity Index for rice TFP in this study was generated using the Data Envelopment Analysis (DEA) software 2.0. Land, Labour and Capital were used as the input variables while rice production in metric tonnes was used as the output variable.

According to [9], the Malmquist index divides TFP into Technical Change (TC) and Technical Efficiency Change (EC) based on the constant return to scale (CRS) assumption. It also accounts for technological inefficiency. EC can be further subdivided into pure technical efficiency change (PE) and scale efficiency change (SE) if returns to scale are variable. Assuming that there are *k* decision-making units (DMU), where *k* = 1, 2, . . ., *K*, the input and output vectors of each period are $x^{k,t} = (x_1^{k,t}, x_2^{k,t}, \dots, x_N^{k,t}) \in R_+^N$ and $y^{k,t} = (y_1^{k,t}, y_2^{k,t}, \dots, y_N^{k,t}) \in R_+^M$ respectively, where *t* = 1, 2, . . ., *T*. Therefore, the input-oriented Malmquist index can be expressed as (1) under the CRS assumption.

$$M_i^k(x^{k,t+1}, y^{k,t+1}, x^{k,t}, y^{k,t})$$
$$= \frac{D_i^{k,t+1}(x^{k,t+1}, y^{k,t+1})}{D_i^{k,t}(x^{k,t}, y^{k,t})} X \left[\frac{D_i^{k,t}(x^{k,t+1}, y^{k,t+1})}{D_i^{k,t+1}(x^{k,t+1}, y^{k,t+1})} X \frac{D_i^{k,t}(x^{k,t}, y^{k,t})}{D_i^{k,t+1}(x^{k,t}, y^{k,t})}\right]^{\frac{1}{2}}$$
$$= EC_i^k XTC_i^k = PE_i^k XSE_i^k XTC_i^k \ldots\ldots (1)$$

$\frac{D_i^{k,t}(x^{k,t+1}, y^{k,t+1})}{D_i^{k,t+1}(x^{k,t+1}, y^{k,t+1})}$ in (1) measures the EC of DMU *k* from period *t* to *t* + 1, indicating the impact of EC on TFP for a corresponding period, and EC can be further divided into PE and SE. The section in the square bracket measures TC of DMU *k* from period *t* to *t* + 1, which indicates the impact of advancement of production technology frontiers on TFP for a corresponding period.

Rice production in Nigeria as an independent DMU and create the optimal frontier of rice production in the country for periods under the same technical conditions. It is followed by a comparison of the relationship between the coordinates of rice production point of each DMU and the position of the optimal frontier.

The technical efficiency of a DMU is at the highest level if the rice production point of the DMU is just on the frontier, and if the point is within the frontier, then the DMU is characterized by technical inefficiency. Meanwhile, with the time factor taken into consideration as mentioned earlier, the rice production point of a DMU can be compared with the mapping point of the optimal frontier and thus decompose rice TFP into TC and EC. Therefore, if TC = 1 for a DMU, this means there is no technical change or innovation for the DMU from *t* to *t* + 1, whereas TC > 1 (or TC < 1) indicates technical progress (or setback). Similarly, EC > 1 (EC < 1) implies there is technical efficiency gain (loss) for the DMU from *t* to *t* + 1. Likewise, *M*= 1 indicates that rice TFP in the DMU from *t* to *t* + 1 stays unchanged; *M*> 1 (*M*< 1) denotes an increase (decline) of rice TFP.

2.5.2 Unit root test

Augmented Dickey-Fuller (ADF) was used to ascertain whether or not the series are stationary. The testing procedure for the ADF is stated as follows:

$$\Delta X_t = \beta_0 + \beta_2 X_{t-1} + \beta_i \sum X_{t-1} + \sum\nolimits_i \ldots\ldots (2)$$

Where,

X_t = individual explanatory variables at time, t;

β_o = constant

Δ = the difference term.

The unit root test was then undertaken for the null hypothesis, t ≠0.
The computed value test statistic was compared with the pertinent critical value for the ADF_t. If the statistics is greater (in absolute value) than the critical value at 5% or 1% level of significance, then the null hypothesis of μ≠0 would not be accepted and no unit root is present. Once this is established, the test for co-integration was carried out.

2.5.3 Test for co-integration

Johansen maximum likelihood test was carried out to show if there is a long-run equilibrium relationship between the dependent and the independent variables, this is shown below:

$$\Delta OUTPUT_t = \beta_0 + \beta_1 TFP_{t-1} + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where;
TFP_t, = Total Factor Productivity of rice
$OUTPUT_t$ = Output of rice (metric tonnes)
β_0 refer to intercepts; β_1 is the parameter to be estimated U_t is random term while t denotes the year.

2.5.4 Effect of rice TFP on rice output in Nigeria

The model is expressed in implicit form as shown in equation below:

$$OUTPUT_t = f\left(TFP_{t,}U\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

The functional form is expressed in the explicit form as:

$$OUTPUT_t = \beta_0 + \beta_1 TFP_t + U_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

β_0 refer to intercepts; β_1 to β_n are parameters to be estimated U_t is random term while t denotes the year.

3. RESULTS

3.1 Descriptive Statistics

The descriptive statistics of the variables in this study is presented in Table 2. The result revealed that the mean value of Rice TFP was 0.953. This result indicates that the average TFP of rice for the period under review was regressive because it is less than 1. The mean value of rice output was 2,655,720 tonnes. The result showed that the average labour force was 15,960 persons, average area of land used for rice was 1,331,275 hectares and average capital stock was ₦4.5 billion ($9.7 million).

The result of the kurtosis of a distribution which measures the peakness (the tallness or flatness) of the series revealed that rice TFP and rice output had kurtosis values of 8.947 and 3.245 respectively. This result implies that TFP and rice output were leptokurtic which implies that these values had positive kurtosis (peaked-curve or more higher values).

The result of the Jarque-Bera test statistics which measures the difference of the skewness and kurtosis of the series with those from the normal distribution revealed that rice TFP (Jarque-Bera 141.691; P-value <5%) and rice output (Jarque-Bera 9.329; P-value <5%) had abnormal distribution. On the other hand, land (Jarque-Bera 5.270; P-value >5%), labour (Jarque-Bera 5.493; P-value >5%) and capital (Jarque-Bera 2.926; P-value >5%) had normal distributions.

Table 2. Descriptive statistics

Statistics	Rice TFP	Rice Output	Land area	Labour	Capital
Mean	0.953	2655720	1331275	15960.13	4.50E+09

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Median	0.969	2626000	1579420	14616.24	4.47E+09
Max	1.054	8435000	3088496	21778.00	8.22E+09
Min	0.702	133000.0	149000	12269.04	1.76E+09
Std. Dev.	0.063	2314847	980208.6	2724.134	1.83E+09
Skewness	-2.308	0.958072	0.230	0.469	0.334
Kurtosis	8.947	3.244602	1.623	1.851	2.149
Jarque-Bera	141.690	9.329	5.270	5.492	2.926
Prob.	0.000	0.009	0.071	0.064	0.232
Sum	57.176	1.59E+08	79876470	957607.6	2.70E+11
Sum Sq. Dev.	0.236	3.16E+14	5.67E+13	4.38E+08	1.98E+20
Obs.	60	60	60	60	60

Source: Author's computation (2023)

3.2 Unit Root Test

The econometric approach is, first, to test for the time series properties of the variables using Augmented Dickey-Fuller (ADF) unit root test. The unit root test result presented in Table 3 shows that all the variables are integrated of orders 1 (first difference).

Table 3. Unit root test

Variable	**Level difference**	**Prob**	**First diff**	**Prob**	**Order of integration**
Rice TFP	-6.234	0.000	-14.011	0.000	I(1)
Rice Output	2.304	0.999	-4.116	0.002	I(1)
Land	0.913	0.995	-10.66	0.000	I(1)
Labour	1.131	0.997	-6.250	0.000	I(1)
Capital	2.346	1.000	-8.586	0.000	I(1)

Source: Author's computation (2023)

3.3 Trend of TFP of Rice in Nigeria from 1961 to 2020

The result in figure 1 shows the trend of rice TFP in Nigeria from 1961 to 2020. The study showed that TFP of rice in Nigeria for the period under review has a positive slope. The regression equation stated as:

RTFP = – 3.286 + 0.002*t + ei……………………………………………………………….(6)

Where;

RTFP = Rice Total Factor Productivity

t = time (year)

ei = error term

This equation suggests that a percentage change in year will lead to 0.002% change in rice TFP in Nigeria. The result from the study further revealed that rice TFP had a value of 0.718 in the year 1961 before hitting its lowest value of 0.702 in the year 1962. TFP of rice increased to 1.026 in the year 1978 but thereafter experienced a fluctuating trend till it got to its highest peak of 1.054 in the year 2009.

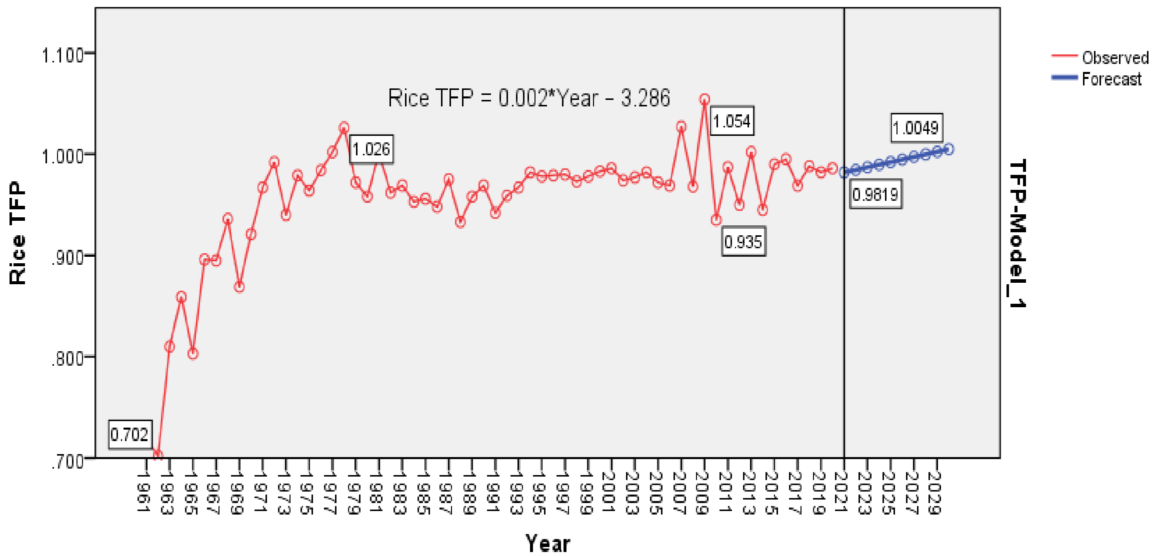

Figure 1: Trend of TFP of Rice in Nigeria from 1961 to 2020

3.4 Effect of rice TFP on rice output in Nigeria

3.4.1 Lag Order Selection Criteria for the Effect of rice TFP on rice output in Nigeria

The result of the lag order selection criteria for the effect of rice TFP on rice output in Nigeria is presented in Table 4. The study showed that the lag order selected for this model was lag 2. This is because most of the selection criteria were significant at 5% level of probability at lag 2.

Table 4. Lag Order Selection Criteria for the Effect of rice TFP on rice output in Nigeria

VAR Lag Order Selection Criteria
Endogenous variables: DRICE OUTPUT DTFP
Exogenous variables: C
Date: 02/17/23 Time: 00:12
Sample: 1961 2020
Included observations: 56

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-1145.185	NA	2.13e+15	40.970	41.043	40.998
1	-1135.840	17.689	1.76e+15	40.780	40.997*	40.864
2	-1128.521	13.331*	1.56e+15*	40.661*	41.023	40.801*
3	-1126.453	3.618	1.68e+15	40.730	41.236	40.926

* 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

3.4.2 Cointegration Test for the Effect of rice TFP on rice output in Nigeria

The cointegration test for the effect of rice TFP on rice output in Nigeria is presented in Table 5. It was revealed that both unrestricted trace co-integrating rank test and unrestricted max-eigen cointegrating rank test confirmed the presence of co-integrating equation. Hence, there is a long run relationship between the dependent variable (rice output) and the independent variable (rice TFP).

Table 5. Cointegration Test for the Effect of rice TFP on rice output in Nigeria

Date: 02/17/23 Time: 00:14
Sample (adjusted): 1964 2020
Included observations: 57 after adjustments
Trend assumption: Linear deterministic trend
Series: DRICE OUTPUT DTFP
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.568	62.073	15.495	0.000
At most 1 *	0.221	14.213	3.841	0.000

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.568	47.860	14.264	0.000
At most 1 *	0.221	14.213	3.841	0.000

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

3.4.3 Pairwise Granger Causality Tests for the Effect of rice TFP on rice output in Nigeria

The result of the pairwise granger causality tests for the effect of rice TFP on rice output in Nigeria is presented in Table 6. This study rejects the null hypotheses that rice TFP does not granger cause rice output (F-stat. 1.177; p-value >5%) and rice output does not granger cause rice TFP (F-stat. 1.993; p-value >5%). Thus, the study makes a case of bidirectional relationship arguing that rice TFP granger causes rice output and rice output granger cause rice TFP for the period under review.

Table 6. Pairwise Granger Causality Tests for the Effect of rice TFP on rice output in Nigeria

Pairwise Granger Causality Tests

Date: 02/17/23 Time: 00:16
Sample: 1961 2020
Lags: 2

Null Hypothesis:	Obs	F-Statistic	Prob.
DTFP does not Granger Cause DRICE OUTPUT	57	1.177	0.316
DRICE OUTPUT does not Granger Cause DTFP		1.993	0.147

3.4.4 Regression Analysis for the Effect of rice TFP on rice output in Nigeria

The result in Table 7 presents the effect of rice TFP on rice output in Nigeria from year 1961 to 2020. The result reveals that the R^2 of 0.408 (41%) shows the extent to which the rice TFP predict rice output was 41%. The adjusted R^2 of 0.378 showed that 38% of the variance in the rice output was accounted for by rice TFP. From the result in Table 4.31 it is observed that rice TFP (coefficient = 12.282; p<5%) had a positive influence on rice output and was statistically significant at 5% level of probability.

The Error Correction Model (ECM) coefficient of -0.454 indicates that ECM(-2) is well specified and the diagnostic statistics are good. The negative sign shows the short run adjustment of the independent variable to the dependent variable. The ECM term also shows a 45% speed of adjustment towards equilibrium. This implies that 45% of disequilibrium caused by exogenous shocks or short run fluctuations in the previous period is corrected in the current year.

The result in Table 7 further reveals that the F-statistics value of 7.073 was significant at 1% level of probability. This implies that the independent variable in the model jointly explained the dependent variable and was statistically significant. The Durbin-Watson test for autocorrelation had a value of 1.904 which lies within the range of 1.5 to 2.0. Thus, there was no case of autocorrelation in the model.

Test of hypothesis: Rice TFP (coefficient = 12.282; p<5%) had statistically significant effect on rice output. Therefore, the null hypothesis which stated that there is no significant effect of rice TFP on rice output in Nigeria is hereby rejected.

Table 7. Regression Analysis for the Effect of rice TFP on rice output in Nigeria

Dependent Variable: DRICE OUTPUT				
Method: Least Squares				
Date: 02/17/23 Time: 00:24				
Sample (adjusted): 1964 2020				
Included observations: 57 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DTFP	12.282**	5.559	2.209	0.037
ECM(-2)	-0.454***	0.129	-3.509	0.001
C	135251.100	53981.250	2.506	0.015
R-squared	0.408	Mean dependent var		139947.400
Adjusted R-squared	0.378	S.D. dependent var		448870.600
S.E. of regression	406908.500	Akaike info criterion		28.722
Sum squared resid	8.94E+12	Schwarz criterion		28.829
Log likelihood	-815.570	Hannan-Quinn criter.		28.764
F-statistic	7.073	Durbin-Watson stat		1.904
Prob(F-statistic)	0.002			

*** and ** significant at 1% and 5% level of probability respectively

3.4.5 Serial Correlation Test for the Effect of rice TFP on rice output in Nigeria

The result in Table 8 shows the Breusch-Godfrey Serial Correlation LM Test. The result revealed that the F-statistic (1.305; p >5%) and the observed R-squared (2.724; p>5%) were not statistically significant at 5% level of probability. This result therefore implies that there is no serial correlation problem in the model. Therefore, the error terms are not serially correlated and the predictions based on the regression estimates are thus efficient.

Table 8. Serial Correlation Test for the Effect of rice TFP on rice output in Nigeria

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.305	Prob. F(2,52)	0.280
Obs*R-squared	2.724	Prob. Chi-Square(2)	0.256

3.4.6 Heteroskedasticity Test for the Effect of rice TFP on rice output in Nigeria

The Breusch-Pagan-Godfrey Test for Heteroskedasticity as shown in Table 9 was carried out to check if the error term in the model exhibits constant variance. The result from the study revealed that the F-statistic (0.691; p >5%) and the observed R-squared (1.422; p>5%) were not statistically significant at 5% level of probability. Thus, the violation of the assumption that there is presence of heteroscedasticity in the model. This further suggests that the regression result is valid.

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Table 9. Heteroskedasticity Test for the Effect of rice TFP on rice output variables in Nigeria

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.691	Prob. F(2,54)	0.506
Obs*R-squared	1.422	Prob. Chi-Square(2)	0.491
Scaled explained SS	1.712	Prob. Chi-Square(2)	0.425

3.4.7 Normality Test for the Effect of rice TFP on rice output in Nigeria

The result in figure 2 shows that the Jarque-Bera statistics of 1.856 was not significant at 5% level of probability thus it is therefore agreed that the residuals in the equation are normally distributed.

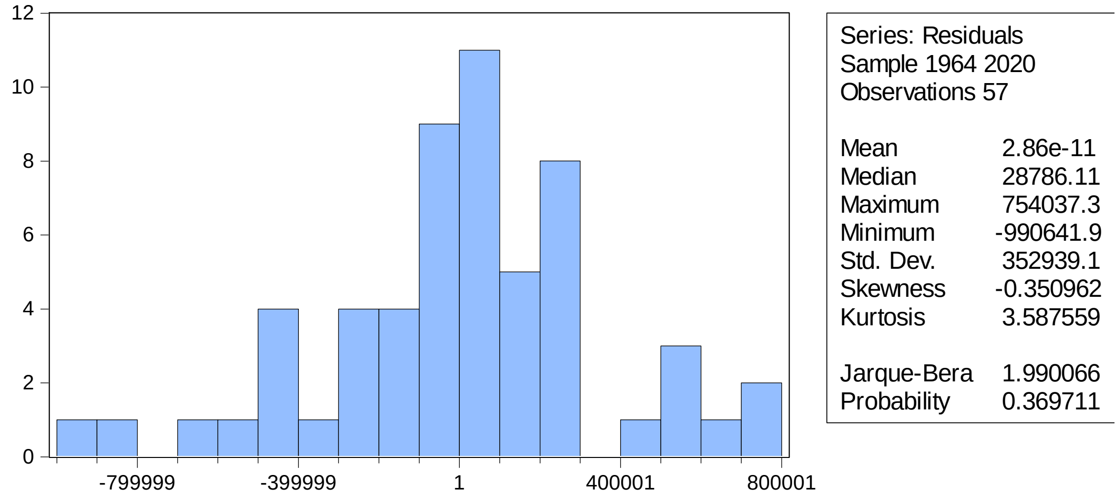

Figure 2. Normality Test for the Effect of rice TFP on rice output in Nigeria

3.4.8 Stability Test for the Effect of rice TFP on rice output variables in Nigeria

The result in figure 3 shows the Cumulative Sum (CUSUM) test which was performed to determine the appropriateness and stability of the model. The result from the study revealed that the plot of the CUSUM stayed within the 5% critical bounds which implies that the parameters of the model do not suffer from any structural instability. Thus, all the coefficients in the model are stable.

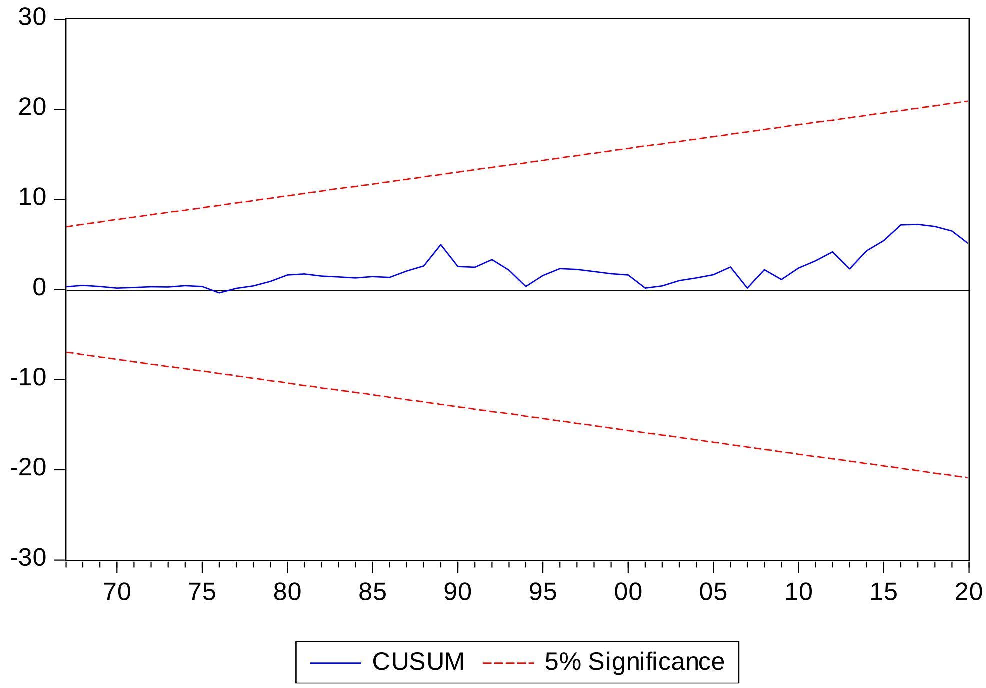

Figure 3. Stability Test for the Effect of rice TFP on rice output in Nigeria

4. DISCUSSION

Total Factor Productivity (TFP) is an important measure of agricultural efficiency and productivity, and rice is a staple food in Nigeria. According to the World Bank, Nigeria's rice production has been growing steadily over the years, with an average annual growth rate of 3.5% from 2000 to 2019 [27]. However, the trend in rice TFP in Nigeria has been mixed over the years. Between 1960 and the early 1980s, TFP in the Nigerian rice sector increased due to government support and investment in irrigation infrastructure and research and development [3]. However, from the late 1980s to the early 2000s, rice TFP in Nigeria declined due to a combination of factors, including poor infrastructure, limited access to credit, low levels of technology adoption, and inadequate government support for research and development [11]. In recent years, there have been efforts by the Nigerian government and other stakeholders to improve the productivity of the rice sector through policies such as the Anchor Borrowers' Program and the Presidential Fertilizer Initiative [22]. As a result, there has been an increase in rice TFP in Nigeria in recent years, although the exact magnitude of the increase is not clear.

The result of the forecast also suggested an upward trend of rice TFP in Nigeria from 2021 to 2030. This result implies that if the combination of input in rice production and climatic variables are sustained or improved on, this will lead to rice TFP growth in the year 2030. This result is in line with that of Adedeji and Owolabi (2016) who reported that the trend of rice TFP witnessed an overall positive trend over time for the sampled states in Nigeria. Overall, while the trend in rice TFP in Nigeria has been mixed over the years, recent efforts to improve productivity in the sector offer hope for future growth.

The result of this study makes a case of bidirectional relationship arguing that rice TFP granger causes rice output and rice output granger cause rice TFP for the period under review. According to [6], [12], TFP and output are interrelated but the causality between them is not straightforward and can be bidirectional. On one hand, TFP can affect output as it is a measure of how efficiently inputs are being used to produce output. Higher TFP implies that a given set of inputs is producing more output, indicating increased efficiency. Therefore, an increase in TFP can lead to an increase in output. On the other hand, output can also affect TFP.

When output increases, the firm may invest in new technology or process improvements, which can increase TFP. Increased output can also result in economies of scale, which can improve efficiency and productivity [6], [12].

From the result of the study, it is observed that rice TFP (coefficient = 12.282; $p<5\%$) had a positive influence on rice output and was statistically significant at 5% level of probability. The statistics suggest that a percentage increase in rice TFP will increase rice output by 12.282%. This means that any increase in the level of efficiency of resource allocation will or can cause an increase in rice output in Nigeria. according to Economic Accounts for Agriculture (EAA, 2023), TFP reflects output per unit of some combined set of inputs such that an increase in TFP reflects a gain in output quantity which is not originating in from an increase of input use. As a result, TFP reveals the joint effects of many factors including land, labour, capital, new technologies, efficiency gains, economies of scale, managerial skill, and changes in the organization of production.

Several studies have shown that improvements in agricultural TFP can lead to an increase in agricultural output. One study by [4] analysed the effect of agricultural TFP on maize yield in Uganda. The study found that a 1% increase in agricultural TFP led to a 0.36% increase in maize yield. Similarly, another study by [14] examined the impact of TFP on rice production in Nepal and found that an increase in TFP by 1% led to an increase in rice output by 0.53%. In addition to the impact of TFP on output, there is also evidence to suggest that agricultural output can affect TFP. One study by [7] analysed the relationship between agricultural output and TFP in China from 1985 to 2012. The study found that agricultural output had a positive impact on TFP, with a 1% increase in agricultural output leading to a 0.14% increase in TFP. Another study by [5] analysed the relationship between agricultural output and TFP in Nigeria. The study found that agricultural output had a positive and significant impact on TFP, indicating that increases in agricultural output can lead to improvements in TFP. Overall, these studies suggest that there is a positive relationship between agricultural TFP and output, with improvements in TFP leading to an increase in agricultural output and increases in agricultural output also leading to improvements in TFP.

5. CONCLUSION AND RECOMMENDATIONS

This study critically examined the effects of rice TFP on rice output in Nigeria. Specifically in this study, it was established that although there is a positive trend in rice TFP in Nigeria over the years, the average rice TFP is regressive (i.e., less than 1). Overall, the findings of this study suggests that TFP is a critical determinant of rice output, and improvements in land allocation, labour, capital, technology, management practices, and other factors can enhance TFP and increase rice output. The results of this study have important implications for policymakers and farmers in countries that depend on rice production. The study therefore recommends that promoting the adoption of modern technologies and improving management practices, policymakers can help enhance TFP and increase rice output, thereby improving food security and promoting economic development. Second, investing in human capital can also enhance TFP and improve farmers' productivity. Third, improving infrastructure and institutional factors such as property rights, access to credit, and market information can enhance TFP and increase rice output.

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