Technical Efficiency of Rice Production and Food Insecurity in Sub-Saharan Africa: Evidence from Leading Rice Producing Countries.

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Abstract

Food insecurity has been a greater challenge to the LDCs which is increasing with global recession and the pandemics. This study examined the impact of technical efficiency of rice production on food insecurity in Sub-Saharan Africa using a quarterly data spanning the period 2017Q1 to 2021Q2. Data series sourced were subjected to the panel unit root test based on Augmented Dickey-Fuller framework. Result shows that all the variables are not stationary at level but stationary at first difference. Also, Johanson Co-integration test was conducted, and the result shows the non-rejection of the null hypothesis (series were jointly not co-integrated in the long run). We carried out the estimation based on traditional Panel VAR framework thereafter. Hausman Test lastly qualifies appropriateness of the Random Effect Model. In view of the results, it is established that with exception of technical efficiency index, all other explanatory variables have negative impact on Food Insecurity Experience Scale and it conforms the a priori expectation, while technical efficiency index of rice production is found out positive and significant determinant of the Food Insecurity Experience Scale at 41% which is against a priori expectation. Lastly, this study recommends that governments across the Sub-Saharan Africa should improve their rice farmers' technical efficiency through irrigation, further education, enlightments and increase in the farmers' contact with extension workers.

Keywords: Co-integration Test, Fixed Effect, Food Insecurity, Hausman Test. Panel VAR, Random Effect, Rice Production, Technical Efficiency and Unit Root Test.

Introduction

World's demand for agricultural products in general is expanding rapidly and the demand for food products is expected to continue growing globally for several decades ahead as a result of a combination of population growth, urban migration, rising per capita income and urbanization. Contemporary economists have shown that Public investment in agriculture coupled with investment in the supportive infrastructure will have considerable impact in poverty alleviation, rural led growth and food security.

Besides domestic food production in the region, it is obvious that governments in Sub-Saharan African countries sink a lot of resources in food importation. In fact, from 1970s to date, Sub-Saharan Africa consumes 34 million tons of milled rice yearly, of which 43% is imported

(Garba, 2019). Alas!, the food demand in the Sub-Saharan Africa still exceeds its total supply, which reflects emergence of food insecurity in the sub-continent (Food and Agricultural Organization [FAO], 2017). It is also very imperative to note that larger portion of the foreign exchange earned from the entire export in the Sub-Saharan African countries is being diverted to the importation of agricultural products, mainly the rice, despite the region's natural and comparative advantage in growing the rice. And this makes the trade balance to continuously becoming narrower over the years.

Given the limited financial resources available to the government, it is very important that specific policy instruments chosen to carry out food security policies should be well focused and effective. Also, with continuous declining of government resources partly as a result of economic recession and pandemics, the recommended United Nations' average food intake calorie of 2100kcal per person per day, is hard to be met. COVID-19 pandemic in particular, has greatly hampered the food supply chains to Sub-Saharan Africa, making it impossible for the imported rice to reach the continent (Ayanlade & Radeny, 2020). In the same study, Ayanlade and Radeny (2020), further reported that rice importation from Thailand, one of Africa's largest suppliers, have declined by 30% due to lockdowns, border closures and general limitations on supply chains in just over one year since the pandemic started. Consequently, many poor urban dwellers across the Sub-Saharan Africa, who traditionally struggle to afford staple foods, now have to contend with more expensive food as the price of the popular Indica White rice (both domestic and imported) has increased by 22% (Ndiame, 2021). Indeed, if immediate action is not taken with respect to the problems, the supply shortfalls further, and continue to worsening the food insecurity situation across the region.

It is against the backdrop, this study is designed to examine the impact of technical efficiency of rice production on food insecurity among selected Sub-Saharan African countries, utilizing a quarterly panel data across the countries from 2017Q1 to 2021Q2, making 30 quarters, which is scientifically and relatively large enough to capture and inform the required information. The study comprises of five (5) sections, after section one (introduction), section two is literature review and theoretical framework, section three is the methodology, and section four is result and discussions while section five is the conclusion and recommendations.

Literature Review

Overview of Rice Production in Sub-Saharan Africa

Rice is one of the most important food crops in Africa, where rice and the economic activities related to its production, processing, distribution, and consumption are widely considered a key for economic development, food security, and poverty reduction. In most of Sub-Saharan Africa, rice is the most-demanded staple food and the food product traded in the highest quantities (Nigatu, Hansen, Childs & Seeley, 2017). The West African sub-region is regarded as the biggest rice market in Sub-Saharan Africa, accounting for two-thirds of the region's rice demand with 50% imports, which represents about 20% of the total volume of rice traded globally (Terdoo & Feola, 2016).

Rice production in Sub-Saharan Africa is dominated by subsistence, smallholder farmers who have limited access to markets, no equipment other than hand-held tools and limited use of inputs. The average rice yield in the sub-continent is the lowest in the world (1.4 tonnes per hectare), when compared to Asia's average of 4 tonnes and more than 6 tonnes per hectare in China; with rice consumption increasing annually by 4.4 percent from 1961 to 2003 (Otenga & Sant'Annab, 2021).

Rice is the region's fourth most important cereal in terms of production (after sorghum, maize and millet), occupies 10% of the total land under cereals and contributes 15% of total cereal production in Sub-Saharan Africa. About 20 million farmers in Sub-Saharan Africa grow rice, with about 100 million people depending on it for their livelihoods (Garba, 2019). From 2013 to 2019, the region's rice production increased at an annual rate of 4.1 percent, compared to only 2.4 and 2.5 percent for maize and sorghum, respectively; Also, the rice is grown on 8.5 million hectares in Sub-Saharan Africa which is equivalent to 5.5 percent of the global rice area (Ndiame, 2021). Almost all of the region's 38 countries grow rice, but two countries, Nigeria and Madagascar, account for 60% of the entire rice land; Nine other countries grow rice on more than 100,000 hectares, including Guinea and Cote d'Ivoire (Otenga & Sant'Annab, 2021; Garba, 2019).

Africa is the only continent where the two species of rice, *Oryza glaberrima* (African rice) and *Oryza sativa* (Asian rice) are grown (Erhabor & Ahmadu, 2013). The most widely grown rice species, *Oryza sativa*, is high-yielding and responds well to inputs but not well adaptive to African condition (Dankoli, Ayambila & Abdulai, 2013). Hidayah (2018), reported that this rice was initially introduced in Africa about 450 years ago. The less well-known rice species, *Oryza glaberrima* was domesticated in the Niger River Delta over 3,500 years ago and it is well adapted to African farming condition but glossily has lower yield potential (Otenga & Sant'Annab, 2021).

Technical Efficiency/Inefficiency

Erhabor and Ahmadu (2013), defined technical efficiency as the measure of producer's success in achieving highest output using a given fixed inputs or raw materials. Therefore, the level of technical efficiency of a producer is directly characterized by the relationship between observed actual production and some expected threshold level of output. Rice farmer's technical efficiency is defined in this study by the ratio of their actual production to the potential or efficient output, usually by the production frontier. Therefore, technical efficiency in this study is particularly in line to the conceptualization of Erhabor and Ahmadu (2013).

Concept of Food Security/Insecurity

The concept of Food security and food insecurity are explained together in the literature. Food security is defined by (Amani, 2006), as the condition in which all individuals at all times and conditions have enough food for a most healthy and productive life. Therefore, Food security in this context, involves three components: food availability, food access, and food utilization.

Food availability implies sufficient production or imports to meet the food needs of the population. Food access refers to the ability of people to obtain food, either through their own production or by purchasing it with money earned from other activities. Food utilization means that the nutrient intake associated with food consumption is not impeded by inadequate nutritional information, poor sanitation, or problems in intra household distribution. Amani (2006), further submitted that food security does not necessarily always imply food self-sufficiency ,but in some context it is, since a household can be food secure if its income is high (and stable) enough to purchase its food requirements. But in remote areas with poor transportation infrastructure, households may be forced, however, to produce most or all of their food requirements. Therefore, in the context of this study food insecurity is the absence of stable and high income, and food insufficiency, and it is measured using the United Nations' Food Insecurity Experience Scale [FISC] developed since 1974.

Theoretical Framework

The theoretical anchor of this study is the Keynesian model of national income and output. According to this theory, national income is a function of the entire spending of the economic agents i.e. household expenditure on consumption, private investment expenditure and government expenditure. For the purpose of this study, the Four Sector Keynesian economy which incorporates both domestic and foreign government expenditures is modified, with Y representing rice output, C representing households' consumption of rice, I representing private spending on rice production, G representing government spending on domestic rice production and X-M representing government spending on rice importation. Thus:

$$Y = C + I + G + (X - M) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Empirical Literature

Ayanlade and Radeny (2020), conducted an empirical study on Covid-19 and food security in Sub-Saharan Africa: Implications of lockdown during agricultural planting seasons, using contents analysis and charts. The study found out that the local rice production and yields are very low in the sub-Saharan Africa compared to other parts of the world, which was partly attributed to the fact that rice is dominantly grown by smallholder farmers in the Sub-Saharan countries. The major weakness identified from this study is that it failed to offer conclusion and recommendation of any sort.

Boussard, Daviron, Gérard, and Voituriez, (2018), conducted empirical study on food security and agricultural development in Sub-Saharan Africa, using content analysis across the sub-Saharan African countries. The study found out that more than 50% of the Sub-Saharan African countries are above 10% malnutrient prevalent, inadequate average food availability is the result of insufficient domestic production and imports and poverty plays greater role toward food insecurity of the average households. In a similar study, Garoma, Admassie, Ayele and Bayene (2018), conducted a study on analysis of the significance of fishing on food security status of rural households around Lake Ziway and Langano in Ethiopia, using primary data collected among 344 rural households via questionnaire through purposive sampling technique. The study used descriptive statistics and Logit regression and found out that for food secured households, the available food energy was 31,244kcal, with 9, 283kcal for food insecure households. Also, there is a significant impact of fishing on food energy intake of the average households. Lastly, the study recommended for the promotion of income diversification opportunities, awareness promotion on family planning and in-depth investigation of households food security situation.

Nigatu, Hansen, Childs and Seeley (2017), conducted a study on Sub-Saharan Africa is projected to be the leader in global rice imports, content analysis was the major method used in the study. The study found out that growing economies, increasing urbanization, rising household incomes, improvements in infrastructure, and greater access to market outlets have all been responsible for the shift of rice from a luxury and holiday food to a major staple food and a growing source of calories in Sub-Saharan Africa, rice consumption is growing at a faster rate than rice production, and self-sufficiency unlikely in the medium term, rice imports are expected to continue to grow, filling the gap between consumption and production. Also, throughout the 10-year projection period, Sub-Saharan Africa is projected to be the largest rice importer in the world.

Also, Terdoo and Feola (2016), conducted a study on the vulnerability of rice value chains in Sub-Saharan Africa: A review. Specifically the study examined the existing evidence of the vulnerability of rice value chain to climate change and to the opening of global agri-food market in the Sub-Saharan Africa, as well as to discuss agriculture and rural development policies to their relevance for the vulnerability of the rice value chains. The study found out that there is a lack of research on the simultaneous impact of climate change and trade liberalization on rice value chains. Also, the major two debates in the literature on rice development are those on protectionism versus liberalization and those on value chains capacity and efficiency.

Nasrin, Lodin, Jirström, Holmquist, Djurf and Djurfeldt (2015), conducted a study on drivers of rice production: Evidence from Sub-Saharan African countries, focusing on Ghana, Malawi, Nigeria, Tanzania and Mozambique, covering the period 2002–2008. The study modeled production performance and changes in production amongst 317 rice-growing households across the selected countries, using multilevel and longitudinal data. The findings of the study shows that until 2002, production was driven by a combination of the three key processes considered while during the period 2002–2008, production increases were primarily associated with area expansion and commercial drivers. It also found out that in none of the periods considered, the share of the state budget allocated to agriculture had a significant effect on production and that recent developments do not give any obvious support for an As style state-driven Green Revolution in rice in Sub-Saharan Africa. Lastly, the study concluded that farmers need to have access to the new farm technology, and positive development of rice production would in turn contribute to an improvement of food security.

Gianessi (2014), conducted an empirical study on the importance of pesticides for growing rice in Sub-Saharan Africa, using content analysis and descriptive statistics. The study found out that rice farming is the most rapidly growing food commodity in Sub-Saharan Africa, grown as a subsistence crop by smallholders and largely consumed on the farm and recent years, its demand from urban consumers as a storable and easily prepared food has increased tremendously. Lastly the study recommended that greater use of pesticides on farms should be promoted among the rice farmers in Sub-Saharan Africa in order to achieve a meaningful increase in rice production.

From the empirical literature reviewed, it has come to the knowledge of this study that food security issue has been examined along with various variables like agricultural output, farmers characteristics, fishing, Covid-19, inflation, poverty, to mention but a few. But none of the previous studies attempted to see the impact of food production technical efficiency on the food insecurity. Therefore, this study in particular has taken a step forward to contribute into the literature by examining the impact of technical efficiency of rice production on food insecurity in Sub-Saharan Africa: Evidence from leading rice producing countries (Nigeria, Madagascar and Tanzania), using panel data covering 30 quarters.

Methodology

Type and Source of Data

This study is based on time series panel analysis and the data-type used in this study is quarterly data acquired from World Development Indicators, on country Food Insecurity Experience Scale, country expenditure on rice imports and country expenditure on domestic rice production across all the countries selected in the study (Nigeria, Madagascar and Tanzania). The data were generated in annual form but later broken into quarterly form in order to achieve the target of the study. Data on country rice production technical efficiency index were generated after running the Stochastic Frontier Model using STATA 14 while other estimations and tests were made on Eviews. The justification for the selection of the three countries is informed by their leading production performance in 2019 onward (Hilderink, Brons, Ordoñez, Akinyoade, Leliveld, Lucas & Kok, 2020) and data availability.

Method of Data Analysis

In this study inferential tools are utilized in the process of data analysis. This is done in two step pattern. In the first step, Stochastic Frontier is adopted following Garba (2019), to estimate the rice production technical efficiency index across the Sub-Saharan countries over the 30 quarters base on the justification that it is a linear regression model with a non-normal, asymmetric disturbance terms which is used to model efficiency in agricultural economics literature in such a way that output is a function of a set of inputs, inefficiency and the random error. In the second step, Static VAR model is adopted following Abdulkarim (2018), to measure the contribution of the rice production efficiency index on food security of the Sub-Saharan African countries over the quarter periods of the study.

Panel Unit Root Test: Panel unit root test in this study is conducted to determine the series stochastic properties of the data collected and it is very essential as it revealed the stationary status of the data. In this study, unit root test is adopted from the work of Garba, Ibrahim, Mustapha, Yantaba, Mubarak and Abdullahi (2021), in their study on Covid-19 and economic growth in West Africa: Evidence from some selected countries, who employed the Levin, Lin and Chu and In, Pesaran and Shin. Thus;

$$\Delta Y_{it} = \alpha_{it} + \rho Y_{ij-1} + \sum_{k-1}^{\propto} \emptyset \Delta Y_{ij-1} + \infty\pi + \Theta_t + \mu_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (i)$$

Panel Co-integration Test: The test for co-integration in this study is in line to Johanso Panel Co-integration, based on its multiple regression for the co-integration vector to vary across the sections of the panel series following the work of Zeb, Salar, Awan, Zaman and Shahbaz (2013), in their study on causal links between energy, environmental degradation and economic growth in selected SAARC countries: Progress towards green economy. Thus, it is specified as follow:

$$Y_{it} = \beta_{it} + \delta_i + \sum_{m=1}^{m} . \beta_{mi} + X_{mi,t} + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (ii)$$

Model Specification

Stochastic Frontier Model: Following Hidayah (2018), this study proposes multiplicative stochastic production function of the form:

$$Y_i = X_{it}\beta + \epsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

Where

Y_{it} = The rice output of the ith country over time, X_{it} = A vector of panel K inputs used by the ith country over time, β = A vector of parameter to be estimated, and ϵ_{it} = The panel farm specific composite residual term comprising a random error i.e. V_{it} and an inefficiency component i.e.U_{it}, thus:

$$\epsilon_{it} = (V_{it} - U_{it}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

$(i = 1,2,3, \ldots\ldots\ldots N), (t = 1,2,3, \ldots\ldots\ldots T),$

The two components of V_{it} *and* U_{it} are assumed to be independent of each other, where V_{it} is the two-sided normally distributed error term i.e.$V_{it} \approx N(0, \sigma_v^2)$ that captures the random effects outside the control of the farmer like fire, incidence of pests, e.t.c. and U_{it} is one-sided half-normal distributed efficiency component i.e. $U_{it} \sim |N(0, \sigma_u^2)|$due the farmer's level of education, farming experience, e.t.c. Dankoli, Ayambila and Abdulai (2013).

Transformation of the above equations to natural logarithm yields the Cobb Douglas specification with Maximum Likelihood Estimators in Battese and Coelli parameterization (1988). Thus;

$$In\ Y_{it} = \beta 0 + \beta 1\ In\ X_{it} + \epsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (v)$$

The importance of the Maximum Likelihood Estimation is not only for the estimation of parameters $\beta 0, \beta 1\ and\ \epsilon$ but also the two variances of $\sigma_v^2\ and\ \sigma_u^2$. which is used to measure the value of γ which is the contribution of technical efficiency of the total residual effect. Therefore, the value of γ lies between zero and one ($0 \leq \gamma \geq 1$).

$$TE_{it} = \frac{Y_{it}}{\exp(X_{it}+V_{it})} = \frac{\exp(X_{it}\beta+V_{it}-U_{it})}{\exp(X_{it}\beta+V_{it})} = \exp(-U_{it}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vi)$$

Where $0 < TE_i < 1$

Traditional Panel VAR: The Second model is the Panel VAR model in its multivariate static panel form adopted in the work of Garba et al. (2021), which is written more explicitly with the explanatory variables (X_{it}) expanded to include important determinants as in the following model:

$$Y_{it} = X_{it}\beta + \alpha_i + \epsilon_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (vii)$$

$$LogFIEScale_{it} = \beta 0 + \beta 1 LogTechEIndex_{it} + \beta 3 LogExpRiceImp_{it} + \beta 3 LogExpDRiceProd_{it} + \beta 3 LogValueForFoodAid_{it} + \epsilon_i \ldots\ldots (viii)$$

Result and Discussions

Table 1: Panel Unit Root Test Result

Country	Variables	T_μ	T_T	1st Difference
Nigeria	FIEScale	-0.7893	-2.6216	-8.1361**
	TechEffIndex	6.0007	2.5585	-8.0547*
	LogExpRiceImp	3.1352	2.1141	-3.2130***
	LogExpDRicePro	-2.5487	-2.4663	-5.1734*
Madagascar	FIEScale	-0.0774	-1.7483	-4.9495***
	TechEffIndex	5.6564	-2.2638	-5.0748**
	LogExpRiceImp	1.9728	0.0181	-3.8268*
	LogExpDRicePro	-3.0101	2.9093	-9.1523*
Tanzania	FIEScale	3.0104	-0.1034	-5.3989**
	TechEffIndex	-1.8975	-2.0129	-4.7575**

LogExpDRicePro	-1.7081	-1.4385	-10.7323*
LogExpRiceImp	6.1889	6.0141	-3.8686**

Note: $\boldsymbol{T_\mu}$ and $\boldsymbol{T_T}$ indicate the statistics are under the assumption of a constant and a constant with deterministic time trend respectively. The optimal lag length is selected using Schwartz Criterion (SC). *, ** and *** indicates 1, 5 and 10 percent level of significance.

Source: Researcher's Computation, using Eviews 9, 2021.

From Table 4.2, we can see that all the series, both at constant and constant with deterministic time trend are found non-stationary at level. But after taking their first difference, the series were found to be stationary at different level of significance, making the series an order one, I(1) process.

Table 2. Panel Johnson Co-integration Result

H_0	H_1	t-Statistics	5% Critical Value	Prob.
Nigeria				
Trace		Trace		
r=0	r>0	49.265	69.818	0.500
r≤ 1	r> 1	24.372	47.856	0.392
r=≤ 2	r> 2	11.269	29.797	0.879
Max value		Max value		
r=0	r>0	33.876	24.892	0.696
r≤ 1	r> 1	13.103	27.584	0.879
r=≤ 2	r> 2	07.556	21.131	0.928
Madagascar				
Trace		Trace		
r=0	r>0	18.072	22.299	0.175
r≤ 1	r> 1	21.063	28.588	0.335
r=≤ 2	r> 2	32.616	34.805	0.089
Max value		Max value		
r=0	r>0	14.784	21.131	0.304
r≤ 1	r> 1	21.705	27.584	0.235

r=≤ 2	r> 2	33.876	64.765	0.000
Tanzania				
Trace		Trace		
r=0	r>0	18.429	29.797	0.534
r≤ 1	r> 1	40.134	47.856	0.217
r=≤ 2	r> 2	69.818	104.900	0.045
Max value		Max value		
r=0	r>0	10.392	21.131	0.707
r≤ 1	r> 1	21.1039	27.584	0.270
r=≤ 2	r> 2	33.876	37.228	0.191

Source: Researcher's Computation, using Eviews 9, 2021.

From Table 3, we can see that in case of Nigeria, starting with null hypothesis of no co-integation, (r=0) among the variables, the trace statistics is 49.26 less than the 95 percent critical value of the trace statistic (critical value, 69.81). Hence, we cannot reject the null. In case of Madagascar, the trace statistics is 18.07 less than the 95 percent critical value of the trace statistic (critical value, 22.29). Hence, we cannot reject the null. Lastly, in case of Tanzania, the trace statistic is 18.42 less than the 95 percent critical value of the trace statistic (critical value, 29.79). Also, we cannot reject the null. Therefore, Johnson Panel Co-integration result shows that no long run associationship exists among the variables across the countries under study.

Table 3: Rice Production Efficiency Index

Class Interval of Efficiency Scores	Frequency	Percentage (%)
0.0785 – 0.1084	133	23
0.1085 – 0.1384	200	35
0.1385 – 0.1684	148	26
0.1685 – 0.1984	15	03
0.1985 – 1.0000	74	13
Total	570	100

Mean efficiency=0.128; Minimum efficiency=0.079; Maximum efficiency=0.228.
Source: Stata 11 Computation, 2021.

From the efficiency scores above, we can see that rice producing countries in the Sub-Saharan Africa were found to be 12.8 percent technically efficient only. Highest or maximum efficiency countries operate at 22.8 percent efficiency index whiles the least or minimum efficiency countries were found to operate at 7.9 percent efficiency index or level. Therefore, the average (mean) or most frequently occuring efficiency score among the rice procuncing countries in Sub-Saharan Africa is 12.8 percent. This finding contradicts that of Ifeanyichukwu, Ike, Akubuike and Felix (2016), in their study on analysis of technical inefficiency in rice production among farmers in Ezza South LGA of Ebonyi State of Nigeria.

The implication of the results obtained indicates that rice producing countries in Sub-Saharan Africa should strive effectively so as to improve their resources utilization due to the existence of about 77.2% efficiency gap to the optimum efficiency level of 100%. Therefore, an average rice producing country require 44% i.e. $1 - {}^{0.128}/_{0.228}$ *100 cost saving habit in order to attain the status of the highest or maximum efficiency.

Table 4. Hausman Test Result

Test Summary	Chi-Sq. Stat.	Prob.
Cross-Section Random	6.340698	0.0509

Source: Researcher's Computation, using Eviews 9, 2021.

From Table 5, we can see that the Probability Value of 51% (i.e 0.0509), is far above the 5 percent and it is significant enough. Therefore, we do not reject the 'Null' which says Random effect model is appropriate and conclude that it is the best in explaining the relationship between technical efficiency of rice production, government expenditure on domestic rice production, and government efficiency on rice importation on food security.

Table 5: Random Effect Result

Variable	Coefficient	Std. Error	t-Statistics	Probability
FIESScale(-1)	-0.5409	0.2309	2.3425	0.028
FIESScale(-2)	-0.4891	0.2210	2.2131	0.057
TechEfIndex(-1)	0.4047	0.0631	6.4136	0.000
TechEfIndex(-2)	0.4169	0.0980	4.2541	0.001
ExpDRicePro(-1)	-0.0293	0.0526	0.5570	0.031
ExpDRicePro(-2)	-0.1508	0.0760	1.9842	0.089
ExpRiceImp(-1)	-0.8772	0.0962	9.1185	0.000
ExpRiceImp(-2)	-0.8951	0.3890	2.3010	0.014
Constant	-27.7332	4.7988	5.7792	0.000
R Squared	0.5599			
f-Statistics	102.64			
Probability	0.000			

Source: Researcher's Computation, using Eviews 9, 2021.

From Table 5, we can see that R^2 of 0.5599 means that 56% variation in Food Insecurity Experience Scale is explained jointly by the explanatory variables and the probability value of 0.000 means that the model fit well in explaining the relation. Individually, all the explanatory variables are found to be negative determinant of the Food Insecurity Experience Scale with exception of the technical efficiency index of rice production. The estimated coefficients show that with one unit increase in the technical efficiency of the rice production across the Sub-Saharan countries, Food Insecurity Experience Scale will increase by 41%. This finding contradicts the a priori expectation may be due to that fact that rice production in Sub-Saharan Africa possesses very small average efficiency index of 12.8%; with one unit increase in government expenditure on domestic rice production; Food Insecurity Experience Scale will decrease by 15%. This finding conforms to the a priori expectation. Lastly, with one unit increase in government expenditure on rice importation, Food Insecurity Experience Scale will decrease by 89%.

Conclusion

This empirical study is based on the Keynesian flow of income and output to examine the impact of technical efficiency of rice production on food insecurity (proxied by the Food Insecurity Experience Scale) in Sub-Saharan Africa: Evidence from the leading rice producing countries (Nigeria, Madagascar and Tanzania), using a quarterly time series panel data covering 30 quarters (2017Q1 to 2021Q2). The result of this study based on Random Effect Model as suggested by the Hausman Test reveals that technical efficiency of rice production across the Sub-Saharan Africa is a positive determinant of Food Insecurity Experience scale, in such a way that with one unit increase in the rice production technical efficiency, Food Insecurity Experience Scale will decrease by 41%.

Recommendations

Based on the empirical findings of this study, it is recommended that governments across the Sub-Saharan Africa should improve the technical efficiency in rice production to meet up their efficiency gap of 77.2% by making farmers more technically efficient through further education, enlightenments and increasing farmers’ contact with extension workers.

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