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Estimating Financing Gaps in Rice Production in Southwestern Nigeria

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Abstract

This study analyzed the financing gaps relative to production frontier of rice farmers in Southwestern Nigeria. A multistage sampling technique was used to collect cross sectional data from 360 rice farmers selected from three States in the region. A Cobb-Douglas stochastic frontier and an adapted form of Harrod-Domar (HD) Growth model was employed to determine the financing gap required for the farmers to be at the frontier level. The empirical results of the frontier model show that quantity of labour, quantity of rice as planting material and herbicides were statistically significant in explaining the variations in the efficiency of rice production in Nigeria. However, age, gender, farming experience, household size, access to credit, access to information, adoption of improved variety and location of rice farmers as sources of technical inefficiencies. As revealed by the result of the HD growth model, the average amount of credit per season that farmers had access to was, ₦38,630.56 while the mean financing in the form of credit required to produce at the frontier level was ₦193,626.50, showing a financing shortfall of about 80%. As unravelled by the result of the study, it can thus be concluded that technical efficiency of rice farmers can be improved by ameliorating access to timely credit and agricultural information for improving rice productivity. These findings suggest that filling the financing gap of smallholder rice farmers will improve rice productivity in Nigeria. The study, therefore, recommends that strengthening the existing technology by building farmers' capacity on farm management practices would be surest means of improving rice productivity growth in Nigeria. This would not only contribute to the intensification of rice production in Nigeria to meet its increasing rice demand, but also improve rice farmers' productivity and their households' incomes.

Keywords: Financing gaps; stochastic frontier and Harold-Domar Growth Model

Introduction

Rice is one of the most valuable cereal crops cultivated and consumed all over the world. It is a staple food in several African counties, Nigeria as an example and constitutes a large portion of the diet on a regular basis (Lu et al., 2018). Rice is cultivated in mostly all agro-ecological zones in Nigeria but on a relatively small scale. As asserted by FAO (2015), Nigeria is the continent's leading consumer of rice, one of the largest producers of rice in Africa and simultaneously one of the largest rice importers in the world. Rice is an important food security crop, it is an essential cash crop for it is mainly small-scale producers who commonly sell 80 per cent of total production and consume only 20 per cent. Farm productivity of staple crops, in developing nations such as Nigeria, is low due to traditional methods of farming, poor irrigation facilities, land fragmentation, the impact of climate change, misuse of modern agricultural technology, and less availability of credit (Chandio et al., 2017). Among the staple crops, rice has risen to a position of eminence in Nigeria. Rice is the most important staple food for about half of the human race (Akinbode, 2013). According to USDA (2016), the annual consumption of rice in Nigeria was about 5 million MT while quantity supplied was 2.7 million MT, with a demand-supply gap of about 2.3 million MT, which is today filled in by importation (Obih and Baiyegunhi, 2017). Nigeria still ranks third with Iraq (after the Philippines and China) in the group of major rice importing countries in the world.

Rice (*Oryza* spp. *L.)*, a grain cereal, is an important staple food for the world's human population, providing more than 20 per cent of the calories consumed worldwide (Kenmore, 2003). It has the second highest production worldwide, after maize (Mohanty et al., 2013). Rice is an important crop that has allured several studies in Nigeria. Some studies had focused on adoption of improved rice variety (Awotide *et al.*, 2013); consumption and marketing of rice (Obih & Baiyegunhi 2018) whilst others focused on resource use efficiency (Goni *et al.*, 2007; Ogundari, 2008) and technical efficiency (Ogundele & Okoruwa, 2006). A review of studies related to agricultural producers' efficiency shows there is a large body of literature dealing with farm level technical efficiency. According to Ogundele & Okoruwa (2006), efficiency measurement is imperative as success indicator and performance measure by which production units are evaluated, as well as an avenue to identify sources of production inefficiency. According to Fakayode (2009) where inadequate funds was considered as the greatest challenge limiting rice production, flooding was also considered as a challenge limiting rice production especially the upland smallholder rice farmers as found in Southwestern, Nigeria.

As argued by Guirkinger & Boucher, (2008), the significant adverse effects of credit constraints on farm productivity of smallholder farmers in the rural areas of developing countries such as Nigeria is alarming. Olomola & Gyimah-Brempong (2014) attributed the low productivity in the agricultural sector to the subsistence nature of agriculture and lack of credit availability. However, the influences of financing on technical efficiency of smallholder rice farmers have been given very little attention, which accordingly is the focus of this study. This study primarily focuses on assessing the financing gaps relative to production frontier of smallholder rice farmers in Southwestern Nigeria. It also investigates the socio-demographic factors that influence inefficiency in agricultural production among rice farmers. As a caveat for this study, the technical efficiency of rice smallholder rice farmers is estimated and an adapted form of the Harold-Domar(HD) growth model was employed to estimate the financing (credit) gap of smallholder rice farmers in southwestern Nigeria. The information on the financing (credit) gap can indicate to policymakers on how the intensification of rice production in Nigeria to meet its increasing rice demand, and also rice farmers' productivity and welfare can be improved.

Empirical framework

Harrod-Domar (HD) Model and Financing Gap Measurement

As posited by Easterly (1999), and recently applied by (Tang et al., 2018; Bermejo & Werner, 2018; van der Merwe & Dodd, 2019) Harrod-Domar growth model has been employed in international financing institutions (IFIs). Chenery and Strout (1966) gave the definitive statement of the Financing Gap model in their Two-Gap model that Aid will "fill the temporary gap between investment ability and saving ability." The usual ICOR formulation determines investment requirements for a given growth target. Easterly (1999) noted that the model has two important features viz. (A) investment requirements to achieve a given growth rate are proportional to the growth rate by a constant known as the Incremental Capital Output Ratio (ICOR) and (B) Aid requirements are given by the "Financing Gap" between the investment requirements and the financing available from the sum of private financing and domestic saving. And he referred to this model as "Financing Gap Model" for short, because, according to him, its most important use is to determine financing shortfalls. He further noted that (A) and (B) imply the following testable assumptions: (1) aid will go into investment one for one, and (2) there will be a fixed linear relationship between growth and investment in the short run. The constant of proportionality is one over the ICOR.

The shortcomings of the Harrod-Domar approach are well noted in the study of (Hussain, 2000). These, he stated, center on two closely related problems. The first is the inaccuracy of estimating the resource gap to achieve a target rate of growth and the second is the failure of the basic Harrod-Domar relationship to predict growth rates. With regard to the former, he noted that if the economy is working below capacity, which is typical in most developing countries such as Nigeria, the true value of the ICOR cannot be computed with any degree of precision, and definitely not with the precision suggested by the equations. Also, he noted that the Harrod-Domar approach assumes that all additional growth in income is attributed to the increments of capital. The approach overstates the productivity of capital and understates the ICOR based on the fact that other factors contribute to growth.

However, Geda *et al* (2009) observed that there are a number of considerations that still make the Harrod-Domar (HD) framework attractive for policy, which includes: 1) it deals with short-run planning problems, while most growth models that have theoretical appeal and some degree of sophistication deal with long-run growth. They noted that this distinction is very important in application because it is about an economy reaching its equilibrium or steady state over a certain period of time, or to be specific, zero per capita growth or GDP growing at the rate of population growth. (2) The lack of alternative models that can fit the needs of policymakers and practitioners like development banks, especially in dealing with short to medium-term financing needs. 3) The HD approach provides a useful benchmark – a first-order approximation to the complicated task of estimating financing needs for development. It allows a check on consistency across the macroeconomic balances as well as sectoral investment programmes. They finally concluded that HD may continue to be relevant when time and resources are limited.

In analysing the empirical validity of HD in the African context, Easterly (1999) found no empirical basis to support the 44 predictions of the HD in over 138 countries for the 1950-1992 period. In the same vein, (Bermejo & Werner, 2018) also found that the Spanish EU and euro entry have had no positive effect on growth. The findings call for a fundamental rethinking of methodology in economics. However, Geda et al (2009) were unable to replicate Easterly's findings. Setting aside issues of model specification and others, they attempted to re-examine these relationships for a sample of 12 African countries and their results actually suggested a strong support for HD predictions with the exception of two countries. They found significant relationships between growth and investment for the 10 countries when a constant is added in the OLS regression. They noted that this is because the HD model assumes no constant term in the relationship between growth and investment (proportionality) and that once they imposed a zero constant on the regressions, it turned out that all countries exhibit a strong and positive short-term relationship between investment and growth. They also found the relationship between aid and investment to be positive, and in most cases, significant. Although they agreed with the argument that HD ignores diminishing returns to aid, they however stated that the existence of diminishing returns implies that the straightforward HD projections will underestimate the actual resource requirements.

In summary, Geda et al (2009) stated that the African Development Bank (AfDB), as well as other institutions, continue to use various methodologies to estimate resource requirements for developing countries. They noted that any of these methodologies has its own limitations in relation to empirical application to country-specific and context-specific circumstances. However, they affirmed that estimates generated from simple models like the HD turn out to be very consistent with estimates generated by more sophisticated methodologies.

Conceptual and analytical frameworks

For this study, a stochastic frontier analysis (SFA) framework was used to assess the technical efficiency of rice production in the study area. The basic stochastic frontier production function of rice production can be expressed as;

$$Y_i = f(X_i;\beta)\exp(v_i - u_i) \quad (1)$$

Where Y_i denotes the quantity of rice produced by i^{th} farm $(i = 1,2,...N)$, X_i is a vector of production inputs of the i^{th} farm, and β is a $(kx1)$ vector of unknown parameters to be estimated. v_i is a stochastic noise distributed symmetrically with mean zero and unknown variance $N\left(0,\sigma_V^2\right)$ (Aigner, Lovell,andSchmidt 1977). u_i are systematic and non-negative random variables which are responsible for farmers technical inefficiency in production and are obtained by truncation (at zero) of normal distribution with mean $z_i\partial$, and variance σ^2. z_i is a vector of covariates explaining technical inefficiency associated with farm production and , δ is a vector of unknown parameters (Battese and Coelli, 1995).

In line with the frontier production function as specified in equation (1), the study define technical efficiency of the i^{th} rice farm as the ratio of the observed rice mean output, given the values of production inputs (X_i) and its assumed technical inefficiency effects (u_i), to corresponding potential output if there was non-existence of technical inefficiency $(u_i = 0)$ in rice production. The technical efficiency of a i^{th} farm can, therefore, be expressed as;

$$TE_i = \frac{f(Y_i / u_1, X_i)}{f(Y_i / u = 0, X_i)} = \exp(-v_i) \quad (2)$$

Where TE_i indicates technical efficiency score which is constraint within the interval (0, 1). The value of 1 indicates a fully technically efficient farm and the value of 0 implies a fully technically inefficient farm. Following the single stage approach proposed by Caudill and Ford (1993), the study parameterized the variance of the pre-truncated of the inefficiency error term u_i . This is to explore how socioeconomic and policy variables influence rice farmers' performance (Kumbahkar and Lovell, 2000). The inefficiency effect (u_i) can be specified as,

$$u_i = z_i\delta + \theta_i \quad (3)$$

Where z_i is *(mx1)* vector exogenous variables explaining rice farmers' technical inefficiency, such as age, farming experience, off-farm income, household size, membership in farmers' association), δ is *(1xm)* vector of parameters to be estimated, and θ_i is an error term of the inefficiency effect.

The Cobb-Douglas production function model used to represent the production of rice is specified as

$$\ln Q_i = \ln \beta_0 + \sum_{j=1}^{5} \beta_i \ln Z_i + (v_i - u_i) \tag{4}$$

Where Q_i represents value of rice output, Z_i represents the conventional inputs usually used in rice production namely, quantity of labour used, farm size, insecticides, herbicides and quantity of seeds planted.

For this study, four main hypotheses were tested, viz; (i). There is no inefficiency effect in rice production, (ii) the coefficients of the square values and the interaction terms in translog have zero values, (iii) exogenous factors are not responsible for the inefficiency term (u_i *),* and (iv) there is no heteroscedasticity in both the stochastic (v_i) and inefficiency error terms (u_i). The results of the four hypotheses were tested using the generalized likelihood-ratio test statistic specified as;

$$LR(\Omega) = -2[\{\ln L(H_0)\} - \{\ln L(H_1)\}]. \tag{5}$$

Harold-Doma Growth model

According to Geda et al (2009) regarding the continuous relevance and usefulness of the HD model in estimating financing gap, this study employed an adapted form of the HD model to estimate the financing (credit) gap of smallholder rice farmers in southwestern Nigeria. However in order to place all the producers on a desirable efficiency level (growth rate) and cater for the issue of efficient use of investment, the growth rate in the HD model is substituted with the production frontier. Thus, this study is based on the assumption that: credit amounts required by rice farmers to produce at the frontier level are directly proportional to the production frontier by a constant known as the Incremental Capital Output Ratio (ICOR). In the same vein, it is assumed that credit (finance) requirements of the farmers are given by the "Financing Gap" between the credit amount required to produce at the frontier level and the finance available to them at present.

$$Y^* = \frac{1}{c}\Phi \tag{6}$$

Where Y^* = Production frontier (Technical efficiency), $\frac{1}{c}$ is the reciprocal of the incremental capital output ratio (ICOR) given as $c = \frac{\Psi}{\phi}$, where Ψ is the annual investment in rice production and ϕ represents annual increase in output of rice produced Φ = amount required to produce at the frontier level. The ICOR is hypothesized to be a measure of the inefficiency with which credit is used. The adapted H-D model is thus hinged on the condition that the credit is used for the purpose of rice production. As posited by Bifarin *et al.* (2011), if production credit is invested on the farm, it is however, expected to lead to higher levels of output, but in case the credit is not accessed on time, it may, more often than not, lead to misapplication of funds. Hence, the expected impact of such funds will not be felt on the farm. If, however, the credit is invested in consumption purpose as peculiar to smallholder farmers, credit will likely not lead to an improvement in the efficiency level.

Study Area and Source of Data

The study was carried out in the southwestern part of Nigeria consisting of the Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States, collectively known as the South-West geographical zone of Nigeria. The area lies between the longitude 2^0 31^1 and 6^0 00^1E and the latitude 6^0 21^1 and 8^0 37^1N, with a total land area of about 77,818 km^2. It is bounded in the east by the Edo and Delta States, in the north by Kwara and Kogi States, in the west by the Republic of Benin and in the south by the Gulf of Guinea. The climate of South-West Nigeria is tropical in nature and characterized by wet and dry seasons. The mean temperature ranges between 21^0C and 34^0C, while the annual rainfall ranges between 150 mm and 3000 mm. The wet season is associated with the southwestern monsoon wind from the Atlantic Ocean, while the dry season is associated with the northeastern trade wind from the Sahara Desert. The vegetation in South-West Nigeria is made up of fresh water swamp and mangrove forest at the belt, the low land in forest stretching inland to the Ogun and part of the Ondo states, with the secondary forest stretching towards the northern boundary by the derived and southern Guinea savannas (Agboola, 1979).

A multistage sampling technique was used to select the respondents for the study from June to July, 2017. The first stage involved a typical case purposive selection of three states, Ekiti, Ondo and Osun states located in the same agro-ecological area. In the second stage, four local government areas (LGAs) were then selected from each state, based on the predominance of smallholder rice farmers in these areas, using a typical case purposive sampling. In the third stage, five villages were randomly selected from each of the four LGAs. Following Tesfahunegn et al. (2016), at 95% confidence level and 5% margin of error, the sample size for the study was determined using the sample determination formula as described by Cochran (1977), allowing for six smallholder rice farmers to be selected from each of the 5 villages earlier selected to give 360 respondents interviewed for the study. Data was collected by means of a pre-tested, well-structured questionnaire by trained and experienced enumerators who have good knowledge of the farming systems and speak the local language in collaboration with the Agricultural Development Programme (ADP) agents in each State. Information sought were on respondents' socio-economic characteristics, inputs and output in rice production and as well as the costs of and returns on rice production.

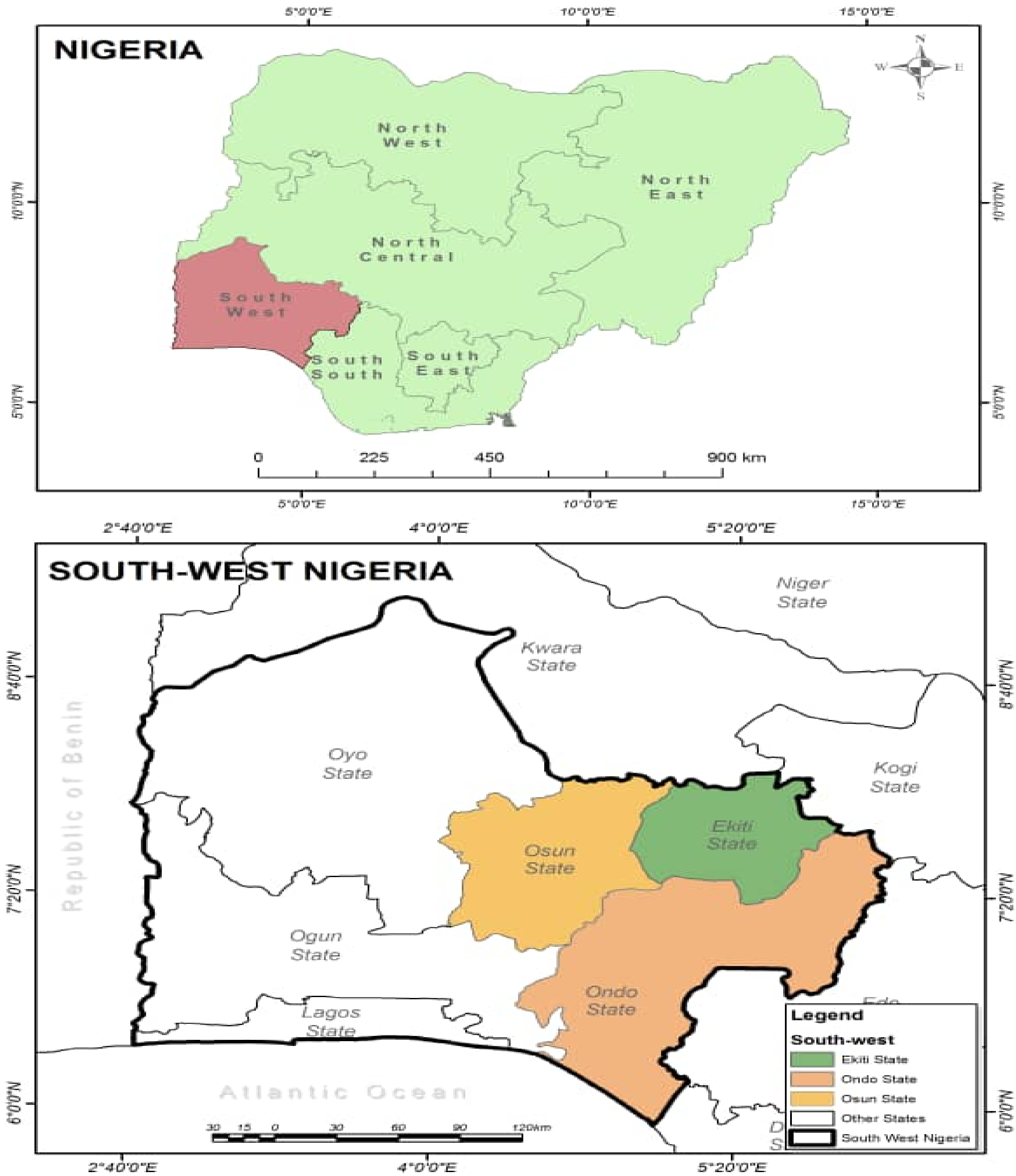

Fig 1: Map of Nigeria showing the study area.

Results and discussion

The descriptive statistics of the surveyed rice farmers are presented in Table 1. The results show that 52% of the smallholder farmers adopted at least one climate change adaptation strategy in response to the changes in climatic conditions; and that the household heads' average age and years of education are 47 and 6 years, respectively. On extension access, about

53% of the respondents have contact with extension agents. About 57% of the rice smallholder farmers have access to credit, which is a major determinant in choosing adaptation strategies. However, there are clear variations in terms of access to information, for example, about 36% of the farmers who adopted at least one strategy have access to information related to credit. The average farming experience of the farmers in the study area is 15 years. The result is in agreement with Hitayezu, Okello & Gor (2010), who posited that farmers' perception and efficient response to the economic conditions is directly related to their resource allocation ability, which is subsequently linked to their human capital endowment.

Table 1: Definitions and summary statistics of variables used in the model

Variables	Description of Variables	Mean	SD
Dependent	**Rice output/ha/year**	12207.61	5296.57
Explanatory variables			
Gender	1 if HH head is male, 0 if female	0.56	0.50
Age of the HH head	Age of HH head (years)	47.28	7.67
Marital status	1 if HH head is married, 0 if other/single/widowed	0.80	0.40
Educational status	Years of education of HH head	6.45	5.70
Household size	Number of HH size	4.66	1.24
Off-farm income	1 = if HH engages in any off-farm activity	0.54	0.50
Farming experience	Years of household experience in rice production	15.73	5.09
Access to credit	1 if HH has access to credit, 0 if otherwise	0.57	0.50
Farm size	Total land owned by HH, in hectares	7.37	3.04
Access to information	1 if HH gets climate change information, 0 if otherwise	0.36	0.48
Access to ext. contacts	1 if HH has access to extension, 0 if otherwise	0.53	0.50
Membership	1 if HH belongs to Farmers' Association	0.54	0.50
Location_Ekiti State	1 if HH is from Ekiti, 0 if otherwise	0.38	0.48
Location_Ondo State	1 if HH is from Ondo, 0 if otherwise	0.38	0.49
Location_Osun State	1 if HH is from Osun, 0 if otherwise	0.35	0.48

Test for model specifications

The result of the null hypothesis for the model is resented in Table 2. The null hypothesis of the frontier model was tested to ascertain the non-existence of technical inefficiency in the frontier of rice production in the study area. The null hypothesis was rejected as indicated by the *P-value*. This implies that the average response model does not fit the data well, as posited by the assumption of the stochastic frontier analysis model. As regards the functional form for the frontier model, Cobb-Douglas production function was chosen as the appropriate model as the model failed to reject the null hypothesis. The third null hypothesis test that none of the selected independent variables in the inefficiency effect model significantly explains farmers' technical inefficiency was also rejected in favour of the fact that at least one of the selected explanatory variables in the technical inefficiency model significantly explains the variation in farmers' technical inefficiency. Finally, the null hypothesis of homoscedasticity in both the stochastic and inefficiency variance of the error terms was not rejected, suggesting that the model is homoscedastic

Table 2: Test of null hypothesis

Hypothesis	P-value	Decision Rule
Frontier test	**0.005*** **	Frontier production appropriate
Inefficiency test	**0.000*** **	Inefficiency effect present
Functional form test	0.197	Cobb-Douglas appropriate
Heteroscedasticity test	0.8185	Heteroscedasticity not present

**** represents significant level at 1%*

The frontier estimates of the Cobb-Douglas stochastic frontier model

The maximum likelihood estimates of the parameters of the Cobb-Douglas stochastic frontier production functions are presented in Table 3. All estimated coefficients in the Cobb-Douglas model fall between zero and one, satisfying the monotonicity condition that all marginal products are positive and diminishing at the mean of inputs. These results are consistent with the estimates of Abdulai and Abdulahi (2016) who also found positive and significant effects of frontier variables on output of maize farmers in Zambia. The average technical efficiency of 70% suggests that an average smallholder rice farm in the sample requires about 30% additional resources to get to the frontier. In other words, a smallholder rice farmer lost an average of 30% of output due to technical inefficiency. The sum of first-order estimates of the production inputs which are referred to as the scale elasticity reveals decreasing returns to scale in the frontier model sum up to 0.57 suggesting that an average farm from the study area experiences a decreasing return-to-scale. The implication of the results shows that increasing all inputs by a certain proportion would result in a less than proportionate increase in output of the smallholder rice farmers in Nigeria. This could be attributed to the fact that scale inefficiency among farmers in developing countries, estimates of decreasing returns to scale seem consistent with expectation as agricultural production commonly exhibits decreasing returns to scale (Abdul-Rahaman ,2016; Khanal et al., 2018).

Table 3: Maximum likelihood estimates for parameters of the stochastic frontier production models for rice production

LNOUTPUT	Coef.	Std. Err.	P-Value
Log of farm size	0.400	0.402	0.921
Log of quantity of labour	0.052	0.022	**0.048****
Log of herbicides	-0.045	0.020	**0.088***
Log of volume of insecticides	0.001	0.002	0.592
Log of quantity of seed	0.171	0.091	**0.060***
Constant	1.399	0.400	**0.000*****
Inefficiency model			
Age	0.508	0.240	**0.034****
Gender	5.156	2.813	**0.067***
Farming experience	3.476	1.270	**0.006*****
Household size	-11.636	4.784	**0.015****
Access to credit	-18.609	10.956	**0.089***
Access to information	-13.231	6.033	**0.028****
Membership in cooperative	4.652	3.208	0.147
Access to improved variety	-19.919	6.951	**0.004*****
Location_Ekiti	1.297	3.138	0.679
Location_Osun	-15.420	5.932	**0.009*****
Location_Ondo	-20.535	8.033	**0.011****
Constants	-73.968	27.088	**0.006*****
δ^2	-4.558	0.075	**0.000*****
Prob > chi2			**0.0842***
Log likelihood	306.07221		
Wald chi2(5)	9.70		
Mean efficiency score	70		

****, ** and * represent significance level at 1%, 5% and 10%, respectively*

The coefficient of labour as measured in man-day is positive and statistically significant in increasing the rice output. In line with Hazell et al., (2007), labour intensification in the agricultural sector improves growth in the rural economy. The implication of the result shows that rice output increases as the quantity of labour is increases. The plausible implication of the significance of labour for rice output is not unexpected since smallholder farmers rely heavily on manual labour with farming operations in developing countries such as Nigeria are resource-constrained. This finding is in line with the study conducted by Mensah and Brümmer (2016) who reported an increasing effect of labour supply on the output of mango producers in some selected regions in Ghana. Huy and Nguyen, (2019) also found an increasing effect of labour in their study on cropland rental market and farm technical efficiency in rural Vietnam.

Weeds remain a major challenge to increasing crop output as they compete with the crop plants for nutrients and water among others. The coefficient of herbicides is negative and statistically significant in reducing the productivity of a rice in the study area. The negative and significant coefficient of the value of herbicides indicates an inverted U-shaped response function. The implication of the results shows that a continuous increase in the quantity of herbicides while the value would at a point decrease rice yield. This indicates that, after a certain point in the production process, a higher quantity of herbicides is not beneficial in increasing rice productivity. Another plausible explanation could be over-application, inappropriate use or application of unapproved herbicides which subsequently increases input cost that reduces expenditures on other inputs without positive contribution to the productivity of rice (Danso-Abbeam and Baiyegunhi, 2017). This stage of negative contribution of herbicides to the productivity of rice production is marked as the irrational stage (stage III) of production.

The coefficient of quantity of seed planted was positive and statistically significant in increasing the efficiency of rice production in the study area. This implies that as the quantity of rice planted increases by 1%, the output of rice increases by 17%. This result corroborates the study of Ogundari (2008) who also found an increasing effect of quantity of rice planted on rice output in his study on the resource-productivity, allocative efficiency and determinants of technical inefficiency of rainfed rice farmers in Nigeria.

Determinants of technical inefficiency in rice production

Household characteristics

The results show that the age of the rice farmer exerts a positive significant effect on inefficiency of rice farming in Nigeria. This implies that as the age of smallholder rice farmers increases, the level of inefficiency also increases. This is expected as relatively, the positive sign for age indicates that older farmers are less efficient as against the young farmers who energetic and would also want to take risk of trying innovation in farming practices which may increase their production efficiency (Alwarritzi et al., 2015). This finding is in line with the study of Villano and Flemming (2005), suggesting that self-satisfaction among relatively old farmers has the propensity to decrease their probability of adopting new farming practices, therefore, lowering their productive efficiency level.

The coefficient of gender shows a positive sign and statistically significant at 10%. This result implies that male farmers tend to be less efficient compared to their female counterparts. This is in line with the study of Kinkingninhoun-Meˆdagbe´ et al. (2010) who estimated technical efficiency indices between men and women and the result of the study shows that women are on average more technically efficient than men. Further, the number of years of experience in rice production was expected to reduce technical inefficiency. Result of this study shows that farming experience positive and statistically significant in increasing the technical inefficiency of smallholder rice farmers in the study area. This could be attributed to the conventional nature of some experienced farmers. Some farmers are so satisfied with their rudimentary method of farming such that they find it difficult to switch to new farming practices, hence, reduce productive efficiency. This finding is in consonance with Danso-Abbeam and Baiyegunhi, (2017) who also found a negative relationship between farming experience and technical efficiency among cocoa farmers in Brong-Ahafo region of Ghana. Conversely, Khanal et al. (2018) suggested that the more experienced household heads can better manage agricultural activities and adapt to new farming practices than less experienced ones, thereby increasing the technical efficiency of agricultural production.

The result of this study shows that the estimate of household size is negatively signed and statistically significant in reducing the smallholder rice farmers' inefficiencies. This implies that the technical inefficiency of the respondents decreases as the household size increases. The plausible explanation for this could be attributed to the ability of the household to supply surplus family labour as argued by Gautam and Andersen (2016). As posited by Ahmed and Melesse (2018), household size is an indicator of labour availability as measured in terms of adult equivalent A large family size implies the availability of labour by a family who can actively engage in farming activities and facilitate the adoption of adaptation measures against climate change effects (Uddin et al., 2014) which ultimately increases the technical efficiency of rice production among rice farmers in South-west, Nigeria.

Institutional factors

According to Alfred and Xiao, (2013) and supported by Quaye et al., (2014), supply and access to capital are critical to improving agricultural production and economic growth. As posited by the International Finance Corporation (IFC), about 84% of small and medium-sized enterprises (SME's) including smallholder farmers in Africa are either un-served or underserved, representing a financial gap of USD 140-170 billion. Easing potential credit constraints through the timely granting of credit reduces the opportunity costs of some capital-intensive climate change adaptation strategies (Binam et al., 2004). A negative and statistically significant relationship found between access to credit and technical inefficiency implies that overcoming credit constraints is likely to enhance the productive efficiency of smallholder rice farmers in South-west, Nigeria. The significant coefficient for credit indicates that access to enough and timely credit is a significant factor in bridging the financing gap and ultimately improves agricultural productivity. These results are in agreement with the findings of Chandio et al. (2017) who posited that institutional credit facilitates and increases the productivity of the farmers. It is also in line with the findings of Bozoglu and Ceyhan (2007) who posited that credit use increased technical efficiency among vegetable farmers in Samsun province, Turkey. As argued by Abdulai and Abdulai, (2016), visits by extension agents to the famers was used to account for access to information from institutional sources. Access to extension is expected to improve famers' level of exposure to information on farm practices and farm inputs. Access to extension is measured as whether farmer had contact with an extension agent on the production methods within the past three production seasons. The coefficient of access to information is negative and statistically significant in reducing inefficiency of rice production. This implies that access to information from extension agents and other sources of information improves the efficiency of rice production in Nigeria. This is in consonance with the study of (Donkor et al., 2018) in their study on efficiency of rice production in Ghana concluded that if agricultural innovation systems is incorporated by the policymakers to facilitate the dissemination of knowledge from researchers to extension agents and then to the agricultural producers, rice production efficiency will be improved. Access to information about agricultural related activities would improve the productivity of farmers (Khanal et al., 2018). The variable representing access to climate change information is negative and statistically significant with inefficiency in rice production. This implies that farmers with better access to information are more efficient as compared with others with inadequate access to information. The smallholder rice farmers with better access to agricultural information more progressive and therefore exhibited greater efficiency. The coefficient of use of improved seeds was negatively signed and statistically significant with the smallholder rice farmers' inefficiency in rice production. This is in agreement with the findings of Bhat and Bhat, (2014) and Dessale, (2019) who found a positive relationship between improved planting varieties and technical efficiency. It means that the tendency for any smallholder rice farmers to increase his/her production depends on the type and quality of improved seed available at the right time of planting.

Location variables

The location dummies are included to capture managerial and environmental differences among farms located in different States (Danso-Abbeam and Baiyegunhi, 2017). Location variable is expected to have an impact on technical efficiency of rice farmers in the South-west, Nigeria. It is assumed that farmers located in the same region apply similar managerial techniques due to their proximity and are have a similar physical environment, soil quality. The coefficients for the district dummies for the farmers located in Osun and Ondo States are negatively signed and statistically significant in reducing inefficiency in rice production. The negative sign indicates that smallholder rice farmers located in both Osun and Ondo exhibit higher efficiencies in rice production. This is in consonance with the study of Otitoju and Enete (2014) on climate change adaptation strategies and farm-level efficiency in food crop production in South-western, Nigeria.

Table 4: Financing Gap Analysis

Financing gap(₦[1])	**Frequency**	**Percentage**
20000-100000	48	13.33
101000-200000	145	40.28
201000-300000	130	36.11
301000-400000	23	6.39
401000-500000	13	3.61
501000-600000	1	0.28
Total	**360**	**100**
Variables	**Mean**	**Standard deviation**
Credit amount received	**38630.56**	**47577.03**
Credit amount required (Financing gap)	**193626.5**	**100944.7**

Financing gap estimation

Access to finance is often seen as one of the major impediments in agricultural production disproportionately (Ayyagari et al., 2012), and lack of data has made it very difficult to determine the exact size of the financing gap (Peer et al., 2013). This lack of access to credit from the traditional financial sector is alarming in a situation where the poor represent the

[1] $1 is equivalent to ₦365

largest share of the population in many African countries and that the informal sector represents an integral part of the economy in these countries. A large number and variety of microfinance institutions have been established in recent years in Africa to serve the unsatisfied demand for financial services—particularly in the informal sector. Following Ayanwale et al., (2018), to estimate the financing gap experienced by smallholder rice farmers, a target production increase for each rice producer was set through the technical efficiency of the farmer first determined using the stochastic frontier function. Thereafter, the current efficiency of the farmer, the corresponding quantity of rice produced at the current efficiency and the target efficiency or expected increase in efficiency due to credit availability were used to estimate the quantity of rice expected to be produced at the target efficiency which is the frontier efficiency in this study area. The difference in rice quantity at the current efficiency and that at the target efficiency is then taken as the desired increase in production due to finance availability. Using an adapted version of Harrod-Domar (HD), the financial amount required to produce at the target efficiency was estimated. Thereafter, the amount currently being used by the farmers is subtracted from the estimated finance at the target efficiency and the difference is taken as the financing gap of each farmer. This represents the external financing (in form of credit) that would be required by smallholder rice farmer. In doing this, it is assumed that: 1) majority of the rice producers were not producing at the frontier level and that the immediate concern was to provide finance in form of credit that will impact positively on their technical efficiencies to cause increase in production at a higher efficiency level (frontier level)compared to the present situation. 2) Credit amount required by each smallholder rice farmer to attain the technical efficiency at the frontier level is proportional to the production frontier (technical efficiency) by a constant known as the Incremental Capital Output Ratio (ICOR). 3) Credit (finance) requirement of each smallholder rice farmer is given by the gap between the credit amount required to produce at the frontier level and the finance used to produce at their present level of efficiency.

Table 4 shows the estimated financing gap of smallholder rice farmers in the study area. The table reveals that 13.33% of the respondents have financing gap of not more than ₦100,000. Also, about 40% of the farmers experienced financing gap of not more than ₦200,000 while about 36% experienced financing gap of not more than ₦300,000. This implies that two-third (76%) of the smallholder rice farmers would require an amount between ₦200,000 and ₦300,000 to produce at the frontier level. In addition, the table showed that to produce at the frontier level, only about 10 % would require an amount greater than ₦400,000. This suggests that majority (76%) of the smallholder rice farmers would require not less than or equal to ₦250,000 to fill the financing gap being presently experienced and be able to produce at the frontier level with other necessary conditions for production being in place. As further revealed in Table 4, the mean credit amount per season that farmers had access to was, ₦38,630.56 while the mean financing in the form of credit required to produce at the frontier level was ₦193,626.50, showing a financing shortfall of about 80%. The implication of these results as posited by (Ojo et al., 2019) show that to improve the productivity of rice farmers, government and development partners should work together to improve the conditions of access of rice farmers to suitable agricultural credit, including the policy incentives aimed at lowering the cost of borrowing in the Nigerian agricultural sector.

Conclusion and policy recommendations

This study primarily focuses on assessing the financing gaps relative to production frontier of smallholder rice farmers in Southwestern Nigeria. It also investigates the socio-demographic factors that influence inefficiency in agricultural production among rice farmers. As a caveat for this study, the technical efficiency of rice smallholder rice farmers is estimated and an adapted form of the Harold-Domar (HD) growth model was employed to estimate the financing (credit) gap of smallholder rice farmers in southwestern Nigeria. However, age, gender, farming experience, household size, access to credit, access to information, adoption of improved variety and location of rice farmers as sources of technical inefficiencies. As revealed by the result of the HD growth model, the average amount of credit per season that farmers had access to was, ₦38,630.56 while the mean financing in the form of credit required to produce at the frontier level was ₦193,626.50, showing a financing shortfall of about 80%. As unravelled by the result of the study, it can thus be concluded that technical efficiency of rice farmers can be improved by amelioarating access to timely credit and agricultural information for improving rice productivity. The growth of smallholder farmers is usually hampered by limited access to credit especially by banks despite their significant contributions to economic development. These findings suggest that filling the financing gap of smallholder rice farmers will improve rice productivity in Nigeria. The study, therefore, recommends that in order to improve rice production efficiency to meet the geometric increase in demand, location specific policy interventions are necessary to improve the efficiency of rice production in Nigeria. The potential gains intrinsic in the current domestic rice cultivation, processing, and consumption policy makes it critical that the current federal administration retain and sustain the policy.

Agricultural innovation systems perceptions should be incorporated by the policymakers to facilitate the dissemination of knowledge from researchers and academics, to extension agents and then to the agricultural producers. A necessary addition should be developed to the assistance already being provided under Nigeria Incentive-Based Risk Sharing System for Agricultural Lending (NIRSAL) in the form of loan guarantees and other risk-sharing incentives, such as a regulatory environment that supports the modern contractual obligations that are characteristic of well-functioning agricultural financing. This would not only bridge the financing gap but also improve the intensification of rice production in Nigeria to meet its increasing rice demand, and also improve rice farmers' productivity and their households' incomes. The transformation of the agricultural finance system will also involve upgrading farmers' risk management capacity in terms of prevention, mitigation, and adaptation strategies.

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