Cost Impact of Inefficiency in Small-scale Paddy Rice Production in Edo State, Nigeria

by O. Ojogho and S. O. Imade

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Date: **30-06-2021**

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Abstract

Small-scale farmers with farm holdings of less than 1 ha cultivate most of the rice produced in Nigeria but with output below 60% irrespective of interventions by Nigeria government. Empirical studies attribute the low output to technical inefficiency with implicit assumptions of cost-minimising behavior and allocative efficiency among rice farmers. This study examined cost of inefficiency in Edo State paddy rice production on micro-data from 175 smallholder paddy rice farmers using the primal system error component Cobb-Douglas cost frontier specification. The study found statistical significant evidence against cost-minimising behavior, with systemic allocative inefficiency in the form of over-utilisation of rice seed by 3.60%, fertilizer by 13.70% and under-utilisation of herbicide by 9.4%, resulting in a 33.50% increase in actual production cost. Economic inefficiency accounted for 41.90% of the frontier cost consisting of 8.4% (20%) and 33.50% (80%) respectively due to technical inefficiency and input-misallocation. Demand for labour, farm size, fertilizer and herbicide decreased by 8.1%, 6.2%, 5.8% and 14.2% respectively while rice seed increased by 5.2% without systemic allocative inefficiency in production. However, demand for labour, farm size and herbicide decreased to 49.1%, 32.4%, 158% respectively but rice seed and fertilizer increased by 54.5% and 37.6% respectively given systemic allocative inefficiency. Hence, there is no cost-minimising behavior in paddy rice production while increased cost of production is more of mistakes in production inputs allocation. Costs in small-scale paddy rice production can be reduced through a more efficient input allocation.

Keywords: *frontier, inefficiency, input-share, input-demand, cost*

Introduction

Rice is the world third most produced and consumed cereal after maize and wheat (Food and Agriculture Organization, FAO, 2012) providing more than 20% of caloric needs of millions of people on daily basis (Yang & Zhang, 2010). It is the fifth-most common consumed food after tubers, vegetables, beans, and other cereals. Nigeria is the leading consumer of rice in Africa (FAO, 2015; Lu et al.. 2018). It has become the staple dietary household food item in Nigeria (Ojogho & Alufohai, 2010b, Kanu & Ugwu, 2012, Johnson et al.. 2013) especially among lower-middle and low-income groups. However, the increase in demand for rice in Nigeria has not been accompanied by a sizeable increase in rice production, resulting in the widening of the local demand-supply gap (Damisa et al.. 2013).

With over 96% of African farmers as smallholders (Kanu et al. 2014), and over 70% in Nigeria, who are less productive compared to world standards resulting in lower yields (FAO 2014; Larson et al. 2014) with yield differences of up to 80% (van Ittersum et al. 2013) as compared to other farms elsewhere, the demand-supply is likely to widen. As at 2013, rice consumption in Nigeria was growing at 7.2% while production was growing at average annual rate of 6.1%. In 2016, the annual consumption was about 5 million MT while quantity supplied was 2.7 million MT, leaving a demand–supply gap of about 2.3 million MT (United State Department of Agriculture, USDA, 2016), which is filled in by importation (Obih & Baiyegunhi, 2017). The local demand for rice and allied products was projected to rise to 7.2 million metric tons by 2018, with local production of milled rice projected to reach only 3.7 million metric tons. Experts say that the enormous difference in yields between on-farm and research stations cannot be explained by differences between farm field and research station settings alone (Tittonell and Giller, 2013)., rather attribute it to inefficiency on the part of rice farmer.

Aigner, Lovell and Schmidt (1977) and Meeiisen and van den Broeck (1977) have independently proposed a methodology for econometric estimation of frontier functions. In recognition of that, empirical studies on rice production efficiency in the literature have employed such approach to estimate the inefficiencies associated with paddy rice production (Idiong et al., 2007; Hoang & Yabe, 2012; Galluzzo, 2013; Baten et al., 2014; Chiona et al., 2014) using either production and cost or profit frontier construct on the assumption that the primary objective of rice farming households is any of output-maximization, cost-minimisation, revenue-maximisation and profit-maximisation (Akudugu, et al., 2012). Similarly, scholars in Nigeria have followed the same approach to estimate either the technical or allocative inefficiency in paddy rice production (Ojogho & Alufohai, 2010a; Okeke et al., 2012; Bamiro & Aloro 2013; Kadiri et al., 2014; Ogundele & Okoruwa, 2014). These are poor standards to measure producer performance since either no behavioural objectives is imposed, or with behavioural objective assumptions without the associated system of cost-minimising input demand equations, revenue-maximising out supply equations, or profit-maximising output supply equations. Any comparison of producer performance base on efficiency estimates obtained from such models must be treated with caution. These are the issues earlier identified by Tijani & Adesiyan, 2006) and (Yusuf & Malomo, 2007). In addition, these studies have implicitly imposed a strong assumption that all firms are allocatively efficient. The difficulty, it appears, is due to inability to disentangle costs of technical and allocative inefficiency from the cost function. A more recent perspective chronicled changes that, in broad outline, parallel those that have occurred, pinning low output to high production cost differentials in input misuse (Chandio et al., 2017). In addition, Kumbhakar and Wang (2006) shows that failure to include the cost of allocative inefficiency explicitly in the cost function biases the estimates of the cost function parameters, returns to scale, input price elasticities, and cost-inefficiency.

Taking a clue from Lai and Kumbhakar (2019) and Kumbhakar et al. (2020), this study estimates both technical and allocative inefficiency, input-demand and the costs therefrom in paddy rice production from the primal system approach that consists of the optimal input choice rule, the first-order conditions (FOCs) under Cobb-Douglas frontier paramentization, but using cross-section micro-data, disentangling technical inefficiency and allocative inefficiency from the estimation of the cost function. This specification distinguishes the study from other studies that concern allocative efficiency estimation and that allows unbiased estimates of the allocative efficiency. The study provides up-to-date inefficiency estimates and cost therefrom in rice production for financing-gap policy thrust in Nigeria. Moreover, to the extent that technical and allocative inefficiency have different causes, a determination of which of the two constitutes the main source of inefficiency can be very useful.

Data and Empirical Procedure

The data for the study were drawn from a target population of 321 rain-fed paddy rice farmers in Edo state, Nigeria for the 2018 production season. The State lies between latitude 05° 44'N and 07° 35'N and longitude 06° 04'E and 06° 43'E with a total land-mass of 17,802 km^2. It shares boundary with Kogi in the North, Delta in the South, Ondo in the West and Anambra in the East. The state has a tropical climate, characterized by wet and dry seasons. The wet season occurs between April and October with a break in August, while the dry season is from November to March with a cold harmattan spell between December and January. The mean annual temperature is about 25℃ in the rainy season and about 28℃ in the dry season. The annual rain-fall regime ranges from tropical rainforest in the South to derived guinea savannah in the North. The State has about six out of the 18 Local Government Areas (LGAs) with high comparative advantage in rice production.

A three-stage sampling procedure was adopted in selecting paddy farmers for the study. The first stage involved a simple random sampling of three LGAs where rice production is dominant in the State out of the six LGAs with high comparative advantage in rice production. The LGAs were Esan-central, Esan-west and Owan-east LGAs of the state. Simple random sampling technique was used in the second stage to select two communities each from the LGAs. Following Ojogho and Ojo (2017b), at 95% confidence level, the sample size for the study was determined using the sample determination formula as described by Cochran (1977), allowing for representative sample of smallholder rice farmers for each community in the study area. The sample-size estimator is given as:

$$n_i = \frac{z^2_{\alpha/2} s^2_i}{e^2 + \frac{z^2_{\alpha/2} s^2_i}{N_i}} \qquad [1]$$

where $z_{\alpha/2} = z_{0.025} = 1.96$ from the Standard Normal Distribution Table at 95% confidence interval, s^2_i is the quantity of output variance for rice production of the ith community developed from a pilot survey, N_i is the target population of the ith community and $e = 0.03$ as margin of error corresponding to the 95% confidence interval.

A simple random sample of rice producers in each community was then taken. The sample size were respectively 75 out of 103 in Esan-central, 84 out of 121 in Esan-west and 72 out of 97 in Owan-east LGAs of the state making a total 217 rice farmers out of 321 target population of rice farmers as presented in Table 1. Using structured questionnaires, the study collected data on rice production from a random sample of 217 smallholder rice farmers. The questionnaire used was designed to contain questions on quantities of inputs and outputs, and their respective prices. The subsample for analysis consisted of valid data from 175 rice farmers on output of rice, total cost of rice production, and prices and quantities of five rice production inputs (farm size, seed planted, fertilizer, herbicide, and labour). Output is quantity of rice produced (Kg) during the 2018 production season; fertilizer is the actual consumption (Kg) used in production; labour is the labour-force measured in total employee man-hours (total employees x 8 working hours); rice seed is the actual consumption (Kg) in rice production, farm size (ha) is the size of farm cultivated to rice; the prices of production inputs were measured as the sum of the transactions costs incurred by a rice farmer and the market prices per unit.

Table 1: Sampling Frame and Sample Size

LGAs	Sample size, n_i	Target population, N_i	Variance, s_i^2	Communities	Sample size, n_i	Target population, N_i	Variance, s_i^2
Esan-central	75	103	0.065	Idoa	29	33	0.060
				Ewu	36	42	0.059
Esan-west	84	121	0.064	Ekpoma	35	40	0.066
				Iruekpen	38	44	0.064
Owan-east	72	96	0.067	Uokha	38	45	0.061
				Ihievbe	43	51	0.063

Source: Field Survey, 2018

The results of the pre-survey in Table 1 suggest homogeneity in rice production output in the study area. This could be on the assumption that paddy rice farmers in the study area apply similar managerial techniques due to their proximity and are have a similar physical environment, soil quality. Data collected from the LGAs were, therefore, pooled in the analysis.

The study makes the behavioral assumption that the rice producers seeks to minimize the cost of producing the desired rice output, subject to a stochastic production frontier constraint, a given level of output and input prices. Secondly, that output and input prices are exogenous with the levels of inputs as choice variables. Finally, the study assumed a time-invariant production function that is linear in logarithm. Data collected were, therefore, analysed using the self-dual single-output Cobb-Douglas parametization with both technical and allocative inefficiency of the primal cost system approach.

The stochastic frontier production model, associated $(T-1)$ first-order conditions of the cost minimization, or allocative inefficiency are stated generically as:

$$\ln q_i = \ln f(\mathbf{z}, \boldsymbol{\beta}) + v_i - u_i \quad [2]$$

Following Kumbhakar et al. (2020), allocative inefficiency was modelled as nonfulfillment of the first order conditions (FOCs) of cost minimization while the FOCs were used to take care of endogeneity of inputs.

$$\ln f_j - \ln f_i - \ln(\omega_i) + \ln(\omega_1) = \xi_i, \forall j = 2,3 \ldots J \quad [3]$$

$$\ln s_j - \ln s_1 - \ln(\omega_i z_j) + \ln(\omega_1 z_1) = \xi_i, \forall j = 2,3 \ldots J \quad [4]$$

Equation [2] given explicitly as:

$$\ln q_i = \alpha_0 + \beta_1 \ln lb + \beta_2 \ln fsz + \beta_3 \ln sd + \beta_4 \ln fer + \beta_5 \ln hb + v_i - u_i \quad [5]$$

where T, q_i, $\mathbf{z}$, ω_1, ω_i, $\boldsymbol{\beta}$, u_i, v_i, s_i, s_1, $\xi_i(\gtreqless 0)$, fsz, lb, sd, fer, and hb are number of inputs, rice output of the i^{th}, farmer, vector of inputs, unit cost of the numeraire input (labour), unit cost of the j^{th} input, vector of technology parameters, output-oriented technical efficiency, stochastic error, cost share of the j^{th} input, cost share of the numeraire input, input allocative inefficiency for the input pair (j, labour), size of land planted to rice, the quantity of labour, the quantity of rice seed planted, the quantity of fertilizer used, and quantity of herbicide used respectively. Input j was then considered over-used relative to labour if $\xi_i < 0$ or underused relative to labour if $\xi_i > 0$. A producer was considered allocatively efficient if and only if $\xi_i = 0, j = 2,3..., J$

The impact of technical and allocative inefficiency on input demand was then obtained as:

$$\ln z_j = a_j + \frac{1}{r}\sum_{i=1}^{J} a_i \ln\omega_i - \ln\omega_i + \frac{1}{r}\ln y + \frac{1}{r}\sum_{i=2}^{J} a_i\xi_i - \xi_j - \frac{1}{r}(v-u), j = 2,...,J \quad [6]$$

$$\ln z_1 = a_1 + \frac{1}{r}\sum_{i=1}^{J} a_i \ln\omega_i - \ln\omega_1 + \frac{1}{r}\ln y + \frac{1}{r}\sum_{i=2}^{J} a_i\xi_i - \frac{1}{r}(v-u) \quad [7]$$

where $r = \sum_{i=1}^{J} a_i$ is the degree of homogeneity, and $a_j = \ln a_j - \frac{1}{r}[a_0 + \sum_{i=1}^{J} a_i \ln a_i]$, $\ln x_{j(neo)} = a_j + \frac{1}{r}\sum_{i=1}^{J} a_i\ln\omega_i - \ln\omega_i + \frac{1}{r}\ln y$ is the neoclassical input demand function independent of production uncertainty, technical inefficiency, and allocative inefficiency, $\ln x_{j(allo)} = \frac{1}{r}\sum_{i=2}^{J} a_i\xi_i - \xi_j$ is part due to input allocative inefficiency, $\ln x_{j(u)} = \frac{1}{r}u$ is the part due to output-oriented technical inefficiency, and $\ln x_{j(v)} = -\frac{1}{r}v$ is the part due to disturbance error. The impact of technical and allocative inefficiency on production costs were obtained as:

$$\ln C^a = a_0 + \frac{1}{r}\ln y + \frac{1}{r}\sum_{i=1}^{J} a_i\ln\omega_i - \frac{1}{r}(v-u) + (E - \ln r) \quad [8]$$

where $a_0 = \ln r - \frac{a_0}{r} - \frac{1}{r}[\sum_{i=1}^{J} a_i \ln a_i]$, and $E = \frac{1}{r}\sum_{j=2}^{J} a_j\xi_i + \ln[a_1 + \sum_{j=2}^{J} a_j e^{-\xi_j}] - \ln r$

The minimum neoclassic cost function frontier, the contribution of technical inefficiency, input allocative inefficiency and production uncertainty to total cost of rice production were computed respectively as:

$$\ln C^0(\cdot) = a_0 + \ln\left[\sum_{i=1}^{J} a_i\right] + \sum_{i=1}^{J} a_i\ln\omega_i + a_y \ln y \quad [9]$$

$$\ln C_u = (\ln C^a - \ln C^a|_{u=0} = a_y u \geq 0) \quad [10]$$

$$\ln C_\xi = (\ln C^a - \ln C^a|_{\xi_i=0}\forall j) = \sum_{j=2}^{J} a_j\xi_i + \ln[a_1 + \sum_{j=2}^{J} a_j e^{-\xi_j}] - \sum_{j=1}^{J} a_j \quad [11]$$

$$\ln C_v = (\ln C^a - \ln C^a|_{v=0} = -a_y v \gtreqless 0), \text{ for } v \gtreqless 0 \quad [12]$$

The parameters were estimated using the Maximum Likelihood (ML) method with sfbook program written for use in STATA by Kumbhakar et.al., (2015), given that $u_i \geq 0$, $u \sim iidN^+(0,\sigma_u^2)$, $v \sim iidN(0,\sigma_v^2)$, $cov(u_i, v_i) = 0$, $cov(u_i, z_{ji}) = cov(v_i, z_{ji}) = 0$, $cov(u_i, \Sigma) = 0$, $cov(v_i, \Sigma) = 0$ $E(\xi_i) = 0$ and $u_i = -\ln(u_i) \cong 1 - u_i$, as the inefficiency, the joint distribution of $(v_i - u_i)$ and ξ_i is $f(v_i - u_i, \xi_i) = g(v_i - u_i).h(\xi_i)$ where $g(v_i - u_i) = \frac{2}{\sigma}\phi\left(\frac{v_i - u_i}{\sigma}\right)\Phi\left(\frac{-\sigma_u(v_i - u_i)}{\sigma_v\sigma}\right)$, $\phi(.)$ is the standard normal probability density function, $\Phi(.)$ is the standard normal cumulative distribution function with parameterization, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $h(\xi_i)$ is the multivariate probability density function for ξ_i with likelihood function, $L = g(v_i - u_i).h(\xi_i).|J|$ and $|J|$ is the determinant of the Jacobian matrix, $|J| = \frac{\partial(v_i - u_i, \xi_2, \xi_3, \xi_4, ..., \xi_J)}{\partial(\ln z_1, \ln z_2, \ln z_3, ..., \ln z_J)}, \forall j = 1,2,3...J$. The system was estimated first without systematic allocative inefficiency, $\xi \sim MVN(0,\Sigma)$, and second with systematic allocative inefficiency to test for over-usage of any input relative to some input, $\xi \sim MVN(\rho,\Sigma)$, with the parameter estimates of former serving as starting values for estimation of the latter. The zero means of ξ implied no systematic tendency to over- or under-utilize any input relative to labour. The mean impact of technical inefficiency on output was obtained after the Jondrow et al. (1982) formula to determine observation-specific estimates of the impact of technical inefficiency on output from parameter estimates while allocative inefficiency for the input pair (j, labour) was obtained from the residuals of the first-order conditions formulae. So, rice producer was technically inefficient if it operated beneath its stochastic production frontier, and was allocatively inefficient if it operated off its least cost expansion path.

Results and Discussion

The results of the estimated stochastic frontier models are presented in Table 2. All the parameters in the models are statistically significant. The parameters of technical inefficiency were significant across all models. The inefficiency parameters were respectively 0.381, 0.073, 0.071 and 0.093 for the Ordinary Least Square (OLS), Stochastic Frontier (SF), SF without systematic allocative inefficiency and SF with the first order conditions with error term allowed to have a nonzero mean.

The mean of the efficiency index from the OLS estimation results indicates that, on average, output is about 62% of the maximum potential level with about 38% inefficiency. The result of the stochastic production frontier indicates that, on average, output is about 93.11% of the maximum potential level with average inefficiency of 7.29%. This implies that the best performing rice farmer used fewer resources in producing the same amount of output as compared to the average rice farmer in the sample. It indicated that the average rice farmer could have used 7.29% less production inputs, if it had used the method adopted by the most efficient rice farmer. In other words, if the average rice farmer operated at the same efficient level as the most efficient rice farmer in the sample, 7.29% of the production resources in producing the same amount of output would have been saved. The implication of this result is that the SF parametric approach under normal half-normal assumption of the one-sided error term revealed that paddy rice farm households should reduce the use of inputs by only 7.29% and will still be able to attain the current level of output.

Also presented in the Table 2 is the result of the likelihood test for existence of non-zero allocative inefficiency. The result showed that the critical value of the statistic at the 1% significance level was 5.412. Given that the model's test statistic is 79.525 with a mixed chi-square value of 5.412 at one degree level of freedom and 1% level of significance, the result indicates an outright rejection of the null hypothesis of zero allocative inefficiency. This finding implies that models that exclude allocative inefficiency do not provide precise information on the level of such component that is present. The results of the primal system without systematic error (zero allocative inefficiency) in the allocative inefficiency show that, on average, rice farmers in Edo state, Nigeria produce around 6.70% to 7.08% less than their maximum potential rice output due to technical inefficiency. With systematic error (non-zero allocative inefficiency) in the allocative inefficiency, the results of the primal system show that, on average, rice farmers in Edo state, Nigeria produce around 8.70% to 9.30% less than their maximum potential rice output due to the technical inefficiency.

Table 2: Parameter Estimates of the Production Function and Primal Cost System, and their associated Standard Errors

Parameters	Production Function Model		Primal System Model	
	OLS Model	Stochastic Frontier Model (SF)	Without Systemic Error	With Systemic Error
β_1	0.141*** (0.024)	0.141*** (0.022)	0.085*** (0.005)	0.192*** (0.026)
β_2	0.033*** (0.021)	0.035*** (0.021)	0.042*** (0.002)	0.081*** (0.023)
β_3	0.467*** (0.014)	0.465*** (0.014)	0.511*** (0.013)	0.469*** (0.015)
β_4	0.227*** (0.018)	0.228*** (0.018)	0.283*** (0.013)	0.276*** (0.021)
β_5	0.085*** (0.022)	0.082*** (0.022)	0.023*** (0.001)	0.152*** (0.026)
α_0	8.709*** (0.018)	8.781*** (0.032)	8.711*** (0.046)	8.775*** (0.037)
R-squared	0.922			

Efficiency	0.619***	0.931***	0.933***	0.913***
	(0.078)	(0.024)	(0.020)	(0.034)
Inefficiency	0.381***	0.073***	0.071***	0.093***
	(0.078)	(0.027)	(0.022)	(0.039)
σ_u^2		0.008	0.008	0.013***
		(0.006)	(0.006)	(0.004)
σ_v^2		0.012***	0.016***	0.014***
		(0.003)	(0.004)	(0.003)

Log-likelihood test of non-zero *allocative* inefficiency: 79.525*** , χ^2 =5.412 @1%

Authors' computation from Field Survey Data, 2018; ***significant at 1%; **significant at 5%; Values in the parentheses are standard error

The results of the allocative inefficiency are presented in Table 3 with labour as numeraire. The parameters indicate the systematic allocative inefficiency arise from the use of the corresponding production input in a non-cost minimizing mix. All parameter estimates differ significantly from zero with systemic error. This implies that, at the sample mean, the proportion in which the inputs are used is systematically inefficient. With all values are less or greater than zero, rice producers in the state are allocatively inefficient. The mean allocative inefficiency values ξ_{fsz}, ξ_{sd}, and ξ_{fer} for farm-size, seed and fertilizer relative to labour are respectively -0.019, -0.113, and -0.019 while ξ_{hb} for herbicide is 0.010 given zero means for allocative inefficiency. The value for seed planted to rice relative to labour-use was significantly different from zero. That creates doubt about the specification that the mean of ξ_{sd} is zero. However, this implies that seed planted to rice is over-use relative to labour. Given non-zero mean of allocative inefficiency, the mean allocative inefficiency values ξ_{fsz}, ξ_{sd}, and ξ_{fer} for farm-size, seed and fertilizer relative to labour were respectively -0.167, -1.036, and -0.863 while ξ_{hb} for herbicide was 1.094 with respective standard errors of 0.044, 0.066, 0.046, and 0.045, and were significantly) different from zero. These confirmed that there are in fact systematic deviations from the cost minimizing input ratios, and that the specification that the means are non-zero is more appropriate. Incidentally, the likelihood ratio test statistic for testing the hypothesis of non-zero allocative inefficiency is 79.53 with a χ^2 p -value of 5.41. The mean values were negative for farm-size, seed and fertilizer, and positive for herbicide. It means that $\exp(\xi_{fsz}) = 0.846 < 1$, $\exp(\xi_{sd}) = 0.355 < 1$, $\exp(\xi_{fer}) = 0.422 < 1$, and $\exp(\xi_{hb}) = 2.986 > 1$. These mean that farm-size, seed and fertilizer are under-used relative to labour while there is excessive used of herbicide relative to labour for the paddy rice producers in the State. It is evident from the results that input misallocation of any form either from under-utilization of farm-size, seed and fertilizer relative to labour, or excessive use of herbicide relative to labour will have impact on input use and increase cost of paddy rice production in the State. Hence, the labour/farm-size, labour/seed, and labour/fertilizer ratios are on average lower than the cost minimizing ratios while labour/herbicide ratio is on average greater than the cost minimizing ratio. In words, farm-size/labour, seed/labour and fertilizer/labour ratios are, on average, 17%, 103% and 86% lower, respectively, than the cost minimizing ratios while herbicide/labour is, on average, 109% higher, than the cost minimizing ratios. These imply that the proportion in which herbicides are used is above optimum, while that of farm size, seeds planted to rice and fertilizer is below optimum. Thus too much is spent on herbicide, and too little is spent on farm-size seed planted to rice and fertilizer.

Table 4: Summary Statistics for Farm-size, Seed, Fertilizer and Herbicide *allocative inefficiency* Relative to Labour

Parameters	without Systemic Error				with Systemic Error			
	Mean	Std. dev.	Min.	Max.	Mean	Std. dev.	Min.	Max.
$\xi_{fsz,lb}$	-0.019	0.582	-1.532	1.358	-0.167***	0.582	-1.681	1.210
$\xi_{sd,lb}$	-0.133**	0.800	-1.602	2.128	-1.036***	0.800	-2.506	1.224
$\xi_{fer,lb}$	-0.019	0.608	-1.172	2.006	-0.863***	0.608	-2.016	1.162
$\xi_{hb,lb}$	0.010	0.599	-2.105	2.166	1.094***	0.599	-1.021	3.250

Authors' computation, ξ_{fsz}, ξ_{sd}, ξ_{fer} and ξ_{hb} are *allocative* inefficiency due to farm-size, seed, fertilizer and herbicide respectively.

Observation-specific values showed that about 45% of the rice farmers over-used seed planted to rice relative to labour and farm-size, 37% over-used rice seed relative to labour and fertilizer, while about 76% of the rice farmers over-used rice seed relative to labour, farm-size and fertilizer, allowing for zero means in allocative inefficiency. Allowing for non-zero means in allocative inefficiency, however, observation-specific values showed that about 17% of the rice farmers over-used rice seed relative to labour and farm-size, 35% over-used rice seed relative to labour and fertilizer, while about 93% of the rice farmers over-used rice seed relative to labour, farm-size and fertilizer, allowing for non-zero means of allocative inefficiency. Hence, land planted to rice, the quantity of labour used and the fertilizer applied by rice farmers in the state are less than commensurate the quantity of seed planted to rice.

Table 3: Summary Statistics of Input Demand due to *Technical Inefficiency* and *Allocative Inefficiency*

Variables	Actual Demand	Without Systemic Error			With Systemic Error		
		Optimum Demand	*Technical Inefficiency*	*Allocative Inefficiency*	Optimum demand	*Technical Inefficiency*	*Allocative Inefficiency*
	Mean	**Mean.**	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
lnlb	0.172 (0.438)	0.175 (0.515)	0.248 (0.513)	0.094 (0.477)	0.580 (0.423)	0.659 (0.423)	0.089 (0.421)
lnfsz	0.500 (0.495)	0.487 (0.485)	0.561 (0.482)	0.425 (0.513)	0.744 (0.395)	0.823 (0.392)	0.420 (0.480)
lnsd	0.895 (0.756)	0.765 (0.465)	0.839 (0.466)	0.817 (0.732)	0.267 (0.381)	0.346 (0.385)	0.812 (0.749)
lnfer	0.257 (0.553)	0.241 (0.552)	0.288 (0.553)	0.183 (0.537)	-0.198 (0.472)	-0.118 (0.476)	0.178 (0.540)
lnhb	-0.313 (0.440)	-0.299 (0.520)	-0.227 (0.517)	-0.369 (0.493)	1.190 (0.426)	1.267 (0.423)	-0.390 (0.424)

Authors' computation; standard deviation values in parentheses

Table 3 presents the input demand due to technical and allocative inefficiency. Technical inefficiency increased demand for all inputs by about 7.4% allowing for zero means in allocative inefficiency while the increase is about 8.0% when allocative inefficiency is allowed to have non-zero mean. This is attributable to the fact that, being neutral with respect to input usage, its impact is uniform across input demands. Allocative inefficiency of rice farmers decreased demand for labour, farm size, fertilizer and herbicide by 8.1%, 6.2%, 5.8% and 14.2% respectively but increase demand for seed planted to rice by 5.2% when allocative inefficiency is allowed to have zero mean. However, the decrease in demand for labour, farm size and herbicide were respectively 49.1%, 32.4%, 158% but increased demand for seed planted to rice and fertilizer by 54.5% and 37.6% respectively when allocative inefficiency is allowed to have non-zero mean. These imply that rice farmers are over-using labour, farm size and herbicide compared with fertilizer and seed planted to rice given the maintained hypothesis of non-zero allocative inefficiency.

Table 4 presents the cost of input misallocation alongside the cost of technical inefficiency, the sum of which represents the cost of economic inefficiency. The results showed that, without systemic allocative inefficiency, the cost of economic inefficiency is at 17.60% where the larger share is due to allocative inefficiency, at 9.80% compared to technical inefficiency at 7.80%. Roughly under half of this is due to failure to produce maximal rice from labour, farm size, fertilizer, seed planted and herbicide as decision input variables, and slightly over half is due to failure to choose input-mix correctly.

Table 4: Summary Statistics of *Technical Inefficiency* and *Allocative Inefficiency* on Cost of Rice Production

Variable	Without Systemic Error				With Systemic Error			
	Mean	**% Inc**	**Min.**	**Max.**	**mean**	**% Inc**	**Min.**	**Max.**
Optimal cost	8585.38 (3859.16)		2037.38	24843.27	6806.52 (2564.98)		2269.774	17223.55
Technical Inefficiency	9228.82 (4122.67)	0.078 (0.026)	2556.63	26411.5	7356.16 (2740.47)	0.084 (0.038)	2718.47	17657.06
Allocative Inefficiency	9394.30 (4394.14)	0.098 (0.108)	2279.75	27654.58	9350.01 (4422.76)	0.335 (0.1723)	2671.45	27559.96

Authors' computation; standard deviation values in parentheses

With non-zero mean allocative inefficiency an increase in cost due to technical inefficiency was 8.4%, while allocative inefficiency increased cost, on average, by 33.5%, amounting to 41.90% as cost of economic inefficiency. As a result, cost is, on average, a total of 41.9% above the frontier level with about 80% of this due to allocative inefficiency with systematic allocative inefficiency, and about 20% due to technical inefficiency. The high estimated share due to allocative inefficiency and a consequent percentage increase in cost of allocative inefficiency with systemic error should be of concern to researchers who use the stochastic frontier framework and do not disentangle technical inefficiency and allocative inefficiency from the estimation of the cost function. In effect, not doing so imposes a very strong assumption that smallholder paddy rice farmers are fully allocatively efficient, which is rejected by estimates of the study that show that allocative inefficiency is more important than technical inefficiency.

Conclusion and Policy Implication

The study used micro-data from 175 paddy rice farmers in Edo state to benchmark the cost of technical and *allocative* inefficiency in paddy rice production from the maximum likelihood estimation of the primal system that consists of the optimal input choice rule, the first-order conditions (FOCs) under cost minimization and the production technology, disentangling technical inefficiency and *allocative* inefficiency from the estimation of the cost function. The system was estimated first without systematic *allocative* inefficiency and second with systematic *allocative* inefficiency to test for over- and under-usage of any input relative to labour with the parameter estimates of former serving as starting values for estimation of the latter. The output of the estimation includes estimates of the shape and location of the frontier parameters, and measures of the average technical and *allocative* inefficiency in the sample and the cost therefrom. It also considered the two important economic efficiency components cost drivers in paddy rice production in Edo State, Nigeria, namely, technical inefficiency and input misallocation. The non-zero *allocative* inefficiency model best described the dataset with more than 40% of the frontier cost lost to inefficiency. Rice farmers in the State under-use farm-size, seed and fertilizer relative to labour while there is excessive used of herbicide relative to labour for the paddy rice producers in the State. Of these cost drivers, *allocative* inefficiency emerged as the more important, contributing approximately 33.50% to increase in cost, compared to 8.40% for technical inefficiency out of the 41.9% cost of economic inefficiency. Hence increased cost of paddy rice production in Edo state, Nigeria is attributable more to *allocative* inefficiency than to technical inefficiency. The proportion in which variable inputs are allocated is, at the mean, inefficient, and costs could therefore be reduced through a more efficient allocation of inputs.

The study shows why it is important for the paddy rice farmers to focus on implications of technical inefficiency, input misallocation, and the cost therefrom as these are important output, productivity and profit drivers in the rice sub-sector in agricultural sector of the Nigerian economy. Understanding and addressing the impact of technical and *allocative* inefficiency can significantly reduce economic inefficiency costs for the rice farmers. For example, the results indicate over-utilisation of rice seed and fertilizer. Apart from factors specific to rice farmer that will likely explain why there is no optimal combination of inputs relative to a more *allocatively* efficient farmer, or those exogenous to farmers, that are possible drivers in misallocation of rice production inputs, there is the attendant increase in cost of production due to over-utilisation of inputs like rice seed and fertilizer Besides, rice farmers are price-taker since they operate in competitive market. So, if there is large uncertainty in the price of herbicide, pesticide and rice seed, for example, there would a resultant uncertainty in production cost. That gives reason for the use of financial derivatives to hedge away risk that may arise from undesirable unanticipated increase in the price of these variables. Alternatively, in periods of high demand uncertainty, farmers without systemic *allocative* inefficiency may be wary of hiring new workers and thereby invest in labour to commensurate with the other production inputs. The level of technical and allocative inefficiency of rice farmer in the state explains the low productivity especially in terms of yield. Reducing the inefficiency in rice production would produce the targeted yield/productivity growth for 2015 to 2025 under the 7% per annum proposed for Nigeria in order to double productivity, increase domestic food production with significant stabilization of agricultural product prices, and reduce food import.

Furthermore, the study found statistical significant evidence against cost-minimising behavior by paddy rice farmers in the state implying that there are no potential cost savings in expanding rice outputs. This provides scope for consolidation of rice farms in the sub-sector in line with the view of policy makers who advocate for stronger incentives to encourage cluster rice farming. Besides the cost reductions that potentially emanate from decrease in the demand for labour, farm size and herbicide with systemic *allocative* inefficiency, the results of the study shows that increased cost of production is more of mistakes in production inputs allocation. This strengthens the case for strong need of a more robust readily available and affordable technology, knowledge and inputs technology that could improve paddy rice production resulting in high economic efficiency and profitability. It also supports the case for that a good number of rice farms are demanding efficiency enhancement solutions in the aspect of seeds, agrochemicals and production facilities, given the Nigeria fast growing population projected to reach over 250 million in 2030.

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