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DIFFERENTIALS IN TECHNICAL INEFFICIENCY AMONG CHICKEN-EGG PRODUCERS IN EDO STATE, NIGERIA

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ABSTRACT
Empirical measure of output shot-fall from the production frontier for inefficient use of inputs in chicken-egg production is the concern of this study. The study was done in Edo state, Nigeria using medium-scale chicken-egg producers for the period between September 2016 and August 2017 production seasons in the three senatorial districts of the state. Data were collected from 120 producers selected using a three-stage sampling procedure and analysed using the stochastic frontier production approach. The results showed a stochastic error of 0.374 in production level of farmers in the state and efficiency factor of 0.15 with a huge gap for improving chicken-egg production level in the state by about 40% at the current levels of input use. Chicken-egg production across the state is input inelastic. Stock-size, feed and labour-hour increased chicken-egg production by 0.72%, 0.52% and 0.71% respectively while medication decreased production by 0.12% for 1% increase in these input in the short-run. Chicken-egg production in the state exhibits increasing return-to-scale of about 1.893. Hence, chicken-egg farmers in the state have the potential to increase their production level by efficient use of available inputs.

Keywords: Stochastic-frontier, efficiency, elasticities, returns-to-scale, and chicken-egg

Introduction

Chicken-egg supplies 17% of animal protein need of the Nigeria population (Oji and Chukwuma, 2007) and contributes about 15% of the total protein-intake per head (Ologbon and Ambali 2012). It is a good source of protein (Heise, Crisan and Theuvsen, 2015), more economical protein source for low-income earners (Aboki, Jongur and Onu, 2013) and has high level of acceptability across ethnic and religious backgrounds (Heise *et al*., 2015). Its production has been adjudged as cost-effective (Heise *ibid*) and one of the fastest means of meeting animal protein demand in Nigeria (Akpabio, Okon, Angba and Aboh, 2007).Yet, the inadequacy of chicken-egg supply to meet demand is a major challenge in Nigeria (Nmadu, Ogidan, and Omolehin, 2014). With chicken-egg production in Nigeria of about 0.3mmt in 2013 and local demand a little above 2mmt (NBS, 2014), there is a demand-supply gap of more than 1.7mmt (Folorunsho and Onibi, 2005; Yusuf and Malomo, 2007). The solution is not, possibly, to change most of the usual backyard farms for chicken-egg production to commercial chicken-egg farms (Effiong and Onyeweaku, 2008), nor is it to arbitrarily increase quantity of inputs (Yusuf and Malomo, 2007).

Resolving the challenges of achieving the highest level of output borders on the performance of chicken-egg farmers in using available resources, and behavior on how resources can best be utilized for substantial resource saving. Efficiency measurement is an important step to such calibration (Tijani *et al*., 2006; Yusuf and Malomo, 2007). Recent studies on poultry-egg production placed emphases on economic and technical efficiency with no particular poultry type (Adepoju, 2008; Adesiyan, Ashagidigbi, and Sulaimon, 2011; Tijjani and Sadiq, 2012; Ohajianya, Mgbada, Onu, Enyia, Henri-Ukoha, Ben-Chendo and Godson-Ibeji, 2013; Emokaro, Akinrinmola and Emokpae, 2016). Besides, a continuous research is required in chicken-egg production to meet the challenges and update available literature. This study, therefore, measured output shot-fall from the production frontier of a given technology, and inputs utilization in chicken-egg production. The study estimated the production frontier for medium chicken-egg production, examined the output gap of farmers from the production frontier of a given technology, and estimated the elasticities of production inputs and return-to-scale for medium-scale chicken-egg production in Edo State, Nigeria.

Methodology

The study was carried out in Edo state, Nigeria. 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 and population of 3.2million (National Population Commission, NPC, 2006). Chicken-egg production is prominent among other livestock production in the study area. The study focused on medium-scale chicken-egg producers, with 201-1000 birds, for the period between September 2016 and August 2017 production season in the three senatorial districts of the state. A three-stage sampling procedure was adopted in selecting farmers for the study. The first stage involved a purposive sampling of one Local Government Area (LGA) where chicken-egg production is dominant in each senatorial district. The LGAs were Oredo in Edo-South, Esan-Central in Edo-Central and Akoko-Edo in Edo-North. Simple random sampling technique was used in the second stage to select two wards each from the LGAs. To allow for representative sample of chicken-egg farmers for each ward, the sample-size estimator was used to determine the sample size for each ward following Ojogho and Ojo (2017). The sample-size estimator is given as:

$$n_i = \frac{z^2_{\alpha/2} s^2_i}{e^2 + \frac{z^2_{\alpha/2} s^2_i}{N_i}} \quad (1)$$

Where, $z_{\alpha/2} = z_{0.025} = 1.96$ from the standard normal distribution table at 95% confidence interval; $s^2_i = p(1-p)$, is the variance of the *i^th^* ward;N_i is the target population of the *i^th^* ward; p is the proportion of medium chicken-egg producers in the *i^th^* ward and $e = 0.03$ as margin of error corresponding to the 95% confident interval. A simple random sample of chicken-egg producers in each ward was selected from the list of the target population in the region developed from a pilot survey. The sample size of 45 producers were selected in Esan-Central LGA, 40 in Oredo LGA and 44 in Akoko-Edo LGA out of 55, 47 and 56 chicken egg farmers in the LGAs respectively making up a total of 129medium-scale chicken-egg farmers for the study. However, 120 copies of questionnaire were valid for analysis. The sample data set consists of output and quantity of four inputs (stock-size, medication, feed and fuel) for each of the 120 chicken-egg farmers.

Model Specification

Data collected were analysed using the stochastic frontier production approach, with the assumption that each chicken-egg producer potentially produce less than it might because of some degree of inefficiency and random shocks. The stochastic frontier approach has been adopted by many authors in the estimation of production efficiency (Nchare, 2007; Ogundari and Ojo, 2007; Idiong, Onyenweaku, Ohen, and Agom, 2007; Effiong and Onuekwusi, 2007; Amaza and Ogundari, 2008). The stochastic frontier production model is stated implicitly as:

$$q_{it} = f(\boldsymbol{z}_{it}, \boldsymbol{\beta})\xi_{it} exp(v_{it}) \quad (2)$$

Where $\boldsymbol{z}_{it}\boldsymbol{\beta},\ \xi_{it}$, and v_{it} are vectors of input, inputs parameters, technical efficiency and stochastic error respectively. With the assumption of a time-invariant production function that is linear in logarithm, and, $u_i = -\ln(\xi_i) = 1 - \xi_i$, as the inefficiency, the study estimated a production function given as:

$$\ln(q_i) = \beta_0 + \sum_{j=1}^{6} \beta_j \ln(z_{ji}) + (v_i) - (u_i) \quad (3)$$

Given that $u_i \geq 0$, $0 < \xi_i \leq 1$, $u_i \sim iidN^+(0, \sigma^2_u)$, $v_i \sim iidN(0, \sigma^2_v)$, $cov(u_i, v_i) = 0$, $cov(u_i, z_{ji}) = cov(v_i, z_{ji}) = 0$,$f(u_i + v_i) = \frac{2}{\sigma}\phi\left(\frac{v_i - u_i}{\sigma}\right)\Phi\left(\frac{-\lambda(v_i - u_i)}{\sigma}\right)$.

Where z_{ji} is the *j^th^* production input of the *i^th^* chicken-egg producer, β_j is the *j^th^* elasticity of production of the *j^th^* production input, $u_i$is a non-negative random variables representing inefficiency in production relative to the stochastic frontier, $v_i$is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmers , and measurements errors, $\phi(.)$is the standard normal probability density function, $\Phi(.)$ is the standard normal cumulative distribution functionwith parameterization, $\sigma^2 = \sigma^2_u + \sigma^2_v$ and $\lambda^* = \frac{var(u_i)}{var(v_i - u_i)}$ such that σ is the scale parameter of the composed error term and λ^* is commonly interpreted as the proportion of variation $(v_i - u_i)$due to inefficiency. The mean technical inefficiency and variance were determined using the estimators:

$$E(u) = \sigma_u \sqrt{\left(\frac{2}{\pi}\right)} \quad (4)$$

$$var(u_i) = \sigma^2_u \left\lfloor \frac{(\pi - 2)}{\pi} \right\rfloor \quad (5)$$

The inputs elasticities were computed using the first derivative of the production function in (3). The estimators are given as:

$$\frac{d\lfloor \ln(q_i) \rfloor}{d\lfloor \ln(z_{ji}) \rfloor} = \beta_j \quad (6)$$

The return-to-scale, φ, for medium-scale chicken-egg producers in the area is given as:

$$\varphi = \sum_{j=1}^{6} \beta_j \quad (7)$$

Results and Discussion

The results of the estimated stochastic frontier model are presented in Table 1. The result of the log-likelihood and inefficiency tests showed that there is inefficiency in medium-scale chicken-egg production in the study area, and that the model is a better fit compared to the model with only the constant term. Majority of the parameters in the model were statistically significant. In the pooled sample, stock-size, feed and labour-hour were significant at 1% while medication was significant at 5%. The levels of significance of the variables were the same in Edo-South (pooled sample for medium-scale chicken-egg production. All variables were significant Edo-central and Edo-northern for medium-scale chicken-egg production in the state). These imply that stock-size, medication, feed and labour-hour are important components of chicken-egg production in the Edo state. The parameters of technical inefficiency were significant in the state, except in Edo-South. The parameters were 0.359, 0.521, 0.860 and 0.161 in the State, Edo-Central, Edo-North and Edo-South respectively.

Table 2 shows the estimates of output-oriented technical efficiency and their corresponding input-oriented technical inefficiency of medium-scale chicken-egg production in the study area. The results showed that the overall mean technical inefficiencies of chicken-egg production is 0.286 in the state, 0.416, 0.686 and 0.128 in Edo-Central, Edo-North and Edo-South respectively. These imply that chicken-egg producers are producing outputs at 28.60%, 41.60%, 68.60% and 12.80% below from the production frontier in the state, Edo-Central, Edo-North and Edo-South respectively. Edo-North chicken-egg producers are the worst technically inefficient in the state. The state, Edo-Central, Edo-North and Edo-South are 71.40%, 58.40%, 31.40% and 87.20% technically efficient respectively. These indicate that chicken-egg producers are 71.40%, 58.40%, 31.40% and 87.20% technically efficient in chicken-egg at best practice given the current level of production inputs and technology in Edo State, Edo-Central, Edo-North and Edo-South respectively. It also indicates that Chicken-egg producers output could have been increased further by 28.60%, 41.60%, 68.60% and 12.80% at same levels of inputs if they are to operate within the frontier in Edo State, Edo-Central, Edo-North and Edo-South respectively. The low percentage output relative to inputs used in the state may be attributed to the low average technical efficiency of chicken-egg producers in Edo-North. Thus, there is still a huge gap for improving chicken-egg production level in the state since chicken-egg farmers output can still be increased further by more than 40% at the current levels of inputs. Similarly, there is still a huge gap for improving chicken-egg production level in the high potential chicken-egg farmers output, particularly in Edo-North, because chicken-egg farmers output can still increase egg production further by almost 70%, 45% and 30% respectively in Edo-North, Edo-Central and Edo State in general at the current levels of inputs. Chicken-egg producers in Edo-North district would continue to be able to utilize their resources in chicken-egg production more efficiently than farmers in the other two districts by producing almost 70% of chicken-egg at best practice.

The results of the returns-to-scale, also presented in Table 2, showed that pooled sample had a value of 1.893 while Edo-Central, Edo-North and Edo-South districts had returns-to-scale of 2.063, 1.578 and 0.862 respectively. For technically efficient chicken-egg farmers, these imply that 1% increase in all input use in chicken-egg production would lead to more than proportionate increase in chicken-egg production except for Edo-South with return-to-scale of less than 1. Edo-Central chicken-egg production doubled in output for a given percentage increase in all inputs. Edo-North chicken-egg production increased by 1.578, increased by 1.893 for the pooled sample but increased by 0.862in Edo-South. Hence, chicken-egg production in Edo-Central and Edo-North in particular and the State in general exhibits increasing returns-to-scale in chicken-egg production but decreasing returns-to-scale in Edo-South for efficient farmers.

Table 2 also shows the result of efficiency factor (input-oriented inefficiency) in chicken-egg production in the State. The results showed that, on average, chicken-egg producers used about 15%, 20%, 44% and 15% more input than necessary in the State, Edo-Central, Edo-North and Edo-South respectively due to technical inefficiency. This would imply that chicken-egg farmers in these regions incurred additional costs due to over-utilization of production inputs, and thus, would save cost if they would eliminate inefficiency by eliminating excess use of inputs. Assuming no allocative inefficiency, actual cost exceeds the minimum cost by 15%, 20%, 44% and 15% in the State, Edo-Central, Edo-North and Edo-South respectively due to technical inefficiency irrespective of the underlying production technology. The input-oriented inefficiency in the State, Edo-Central and Edo-North contrast with the 28%, 42% and 69% loss of output respectively under the output-oriented formulation, possibly, due to returns-to-scale at 1.893, 2.063 and 1.578 which are beyond unity, thus scaling-up the output-oriented inefficiency by the inverse of the estimated returns to scale. Chicken-egg producers in Edo-Central, Edo-North and the state are using more inputs than necessary in production. Thus, chicken-egg farmers in Edo-North and Edo-Central have the potential to increase their production level by using less of available inputs.

The results also show that there is variation in the productivity level of chicken-egg farmers in the state as shown by the respective variance of the composite error. In the decomposition of the total variance into its components, the contributions of the stochastic errors were 0.374, 1.00, 1.00 and 0.473 in Edo State, Edo-Central, Edo-North and Edo-South respectively. These imply that the difference in productivity in the state is largely due to the inefficiency component on the part of chicken-egg farmers in the state. Variation in chicken-egg output is accounted for by 47.30% inefficiency component of the producers in Edo-South district. Inefficiency of chicken-egg farmers in Edo-Central and Edo-North accounts largely accounts for the variation in productivity in the state.

The results of the input elasticities are presented in Table 3. The results show that all the elasticity parameters are significant. All input elasticities are significant in the three districts of the state. Chicken-egg production across the state is input inelastic. In Edo state, the input elasticities of stock-size, medication, feed and labour-hour were 0.716, -0.120, 0.518 and 0.714 respectively. These imply that 1% increase in stock-size, feed and labour-hour would increase chicken-egg by 0.72%, 0.52% and 0.71% respectively but decrease chicken-egg production by 0.12% for medication in the short-run. In Edo-Central, 1% increase in stock-size, feed, sawdust and labour-hour would increase chicken-egg production by 0.91%, 0.02%, 0.55% and 1.00% respectively but decrease chicken-egg production by 0.42% for medication in the short-run. In Edo-North, 1% increase in feed led to about the same proportionate increase in chicken-egg production in the short-run. A similar 1% increase in labour-hour in Edo-South led to more than proportionate increase in chicken-egg production. However, chicken-egg production is more than proportionate in increase for a given increase in all inputs except in Edo-South district of the state.

Conclusion

The study estimated differentials in technical inefficiency among chicken-egg producers in Edo State, Nigeria. Results showed that Chicken-egg producers in the state are producing below the frontier and under-utilizing resources. Chicken-egg production across the state is input elastic except for medication, but exhibited increasing returns-to-scale in all input used resulting in more than proportionate increase in chicken-egg production in the state. Chicken-egg producers in Edo-Central and Edo-North in particular and the State in general are using more input than necessary in production. Hence, chicken-egg farmers in the state have the potential to increase their production level by using less of available production inputs.

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Table 1: Estimates of the Stochastic Production Frontier parameters

Variables	Pooled sample	Central	North	South
In(stock)	0.716***	0.909***	0.381***	0.390***
	(5.73)	(4.132)	(7.620)	(5.000)
In(medication)	-0.120**	-0.421***	-0.191***	0.614***
	(1.980)	(-7.5180	(-6.586)	(4.490)
In(sawdust)	0.065	0.024***	0.100***	0.066
	(0.930)	(8.000)	(16.667)	(1.440)
In(feed)	0.518***	0.549***	1.082***	-0.004
	(4.170)	(12.200)	(4.260)	(-0.040)
In(labour)	0.714***	1.002***	0.206***	1.024***
	(5.600)	(4.008)	(6.059)	(8.170)
σ_v	0.465***	5.31e-09***	1.18e-08***	0.169*
	(6.940)	(16.036)	(2.879)	(1.817)
σ_u	0.359*	0.521***	0.860***	0.161
	(1.670)	(5.853)	(7.350)	(0.585)
σ^2	0.345***	0.271***	0.741***	0.055
	(2.899)	(2.914)	(3.668)	(0.917)
λ	0.772***	9.82e07***	7.28e07***	0.951***
	(2.891)	(11.034)	(6.222)	(.613)
Log-likelihood	-48.73	-1.262	-15.55	4.921
Wald χ^2 @5%	3881.12**	4.08e11**	2.25e11**	3934.16**

Source: Computed from Field Survey Data, 2017; ***significant at 1%; **significant at 5%; *significant at 10%, Values in the parentheses are t-ratios

Table 2: Estimates of the Output- and Input-oriented Technical Inefficiency Parameters, and Returns-to-scale

Parameters	Pooled sample	Central	North	South
σ_v^2	0.216	2.82e-17***	139e-16***	0.029
σ_u^2	0.129	0.271***	0.740***	0.026
σ^2	0.345	0.271	0.741	0.055
$E(u)$	0.286***	0.416***	0.686**	0.128***
$var(u_i)$	0.104	0.151	0.249	0.047
IO-TI	0.151	0.202	0.435	0.148
λ^*	0.374	1.000	1.000	0.473
Return-to-scale	1.893	2.063	1.578	0.862
Log-likelihood	-48.73	-1.262	-15.55	4.921
Wald χ^2 @5%	3881.12**	4.08e11**	2.25e11**	3934.16** Source:

Computed from Field Survey Data, 2017; ***significant at 1%; **significant at 5%; IO-TI is input-oriented technical inefficiency.

Table 3: Estimates of Input Elasticities in the study area

Variables	Pooled sample	Central	North	South
In(stock)	0.716***	0.909***	0.381***	0.390***
	(5.73)	(4.132)	(7.620)	(5.000)
In(medication)	-0.120**	-0.421***	-0.191***	-0.614***
	(1.980)	(-7.518)	(-6.586)	(-4.490)
In(sawdust)	0.065	0.024***	0.100***	0.066
	(0.930)	(8.000)	(16.667)	(1.440)
In(feed)	0.518***	0.549***	1.082***	-0.004
	(4.170)	(12.200)	(4.260)	(-0.040)
In(labour)	0.714***	1.002***	0.206***	1.024***
	(5.600)	(4.008)	(6.059)	(8.170)

Source: Computed from Field Survey Data, 2017; ***significant at 1%; **significant at 5%; Values in parentheses are t –ratios