

# A comparative analysis of the profitability and technical efficiency of vegetable production under two farming systems in Nigeria



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## Abstract:

Increasing agricultural productivity enhanced by versatile production systems is critical for sustainable food security and economic development. The study aims to compare the profitability and technical efficiency of vegetable production and factors influencing the technical efficiency of vegetable production between inorganic and organic farming systems in Imo State, Nigeria. Primary data were collected using structured questionnaires comprising 100 vegetable farmers using a multistage sampling procedure. The budgetary analysis and stochastic production frontier model were used to estimate the profitability and the technical efficiencies of the enterprise. An average farmer realized ₦277,445.24 and ₦190,506.04 per hectare as profit from inorganic and organic vegetable production and can potentially earn ₦4.40 and ₦2.89 on every Naira invested, respectively. However, the inorganic farming system achieved significantly higher returns than the organic farming system. The mean technical efficiencies for organic and inorganic vegetable farmers were 89.57% and 75.64%, respectively. Farm size, labour and the quantity of seeds were the crucial factors that affected the technical efficiency under both farming systems. Also, age, years of education and farming experience were the significant variables that influenced the technical inefficiency of inorganic farmers, whereas years of education and household size significantly influenced the technical inefficiency of organic farmers. This study advocates for subsidized inputs for organic farmers to compensate for their lower yields and policies that would attract young people to vegetable farming to increase the production level.

**Keywords:** comparative analysis; profitability; stochastic frontier; vegetable

## INTRODUCTION

The introduction and usage of chemicals produced from fossil fuels into the farming system transformed and enhanced agricultural yield and productivity. Many were amazed by the intense transformation of the effects of these chemical aids on their farming activities and enterprises (Gandhi, 2014). Initially, soil contained various healthy compositions for great productivity (FAO, 2015); any damage brought about by chemicals such as fertilisers, pesticides, herbicides, fungicides and other synthetic compounds was hardly noticeable (Meena et al., 2020). It is a recognisable technology spread across the world as it was considered the revolution in agriculture (Pretty and Bharucha, 2015; Allongue, 2018). In recent times, the output and health benefits of organic farming have been marvellous (Seufert and Ramankutty, 2017; Chait, 2019). This came to existence due to the conventional knowledge about inorganic farming methods coupled with a host of problems, including health-related diseases like cancer, pollution, degradation of soil and water, and impact on domestic animals (Özkara et al., 2016).

In Africa, especially in developing countries such as Nigeria, organic farming is an ancient agronomic practice (Adebayo and Oladele, 2014). Organic farming can be explained as agricultural practices in natural ways. Over the years, it has been believed that the conventional or inorganic system of farming is

more proficient in its output than the organic system (Panhwar et al., 2019). Yield differences may be due to a less productive technology or lower technical efficiency in production on organic farms, or both. Measured differences in productivity and efficiency may also be influenced by self-selection in the choice of production technology and thus not entirely attributable to organic standards. Efforts have been made to increase food productivity in Africa for the teeming population through innovative and sustainable farming systems (Osabohien et al., 2018). One of the alternative systems gaining prominence is organic farming. Today there exist widespread concerns that conventional agriculture is not sustainable in the long term (Tal, 2018). This is attributed mainly to the effect of artificial fertilisers and synthetic pesticides on the soil resulting in phenomena such as pesticide resistance and soil degradation; for example, erosion, acidity, salinity and compaction. The availability of information on the benefits and profitability of converting to organic farming could encourage farmers to produce vegetables organically (Röös et al., 2018). Therefore, knowing how profitable it is to produce vegetables organically is essential to reduce the amount of chemicals we consume and limit the havoc caused in our environment (Tuck et al., 2014).

In agricultural production, the efficiency with which the farmers put the farm inputs to use and the available technology are important (Mechri et al., 2017; Finger et al., 2019). The efficiency of any farm is measured for the following reasons; first, it is a success indicator and performance evaluator. Second, measuring the efficiency and separating its effects from the production environment determine the sources of the inefficiency. Third, it helps decision makers to monitor the performance of the unit under study (Bhatt and Bhatt, 2014). Also, identifying the most profitable technology is important. Profitability as the difference between the cost incurred and revenue generated should be checked in line with the technology used. Even though organic farming is better for a sustainable environment, profitability should also be compared with conventional practice (Alawode and Abegunde, 2015). The technology that is not profitable cannot survive in a market-oriented production, given the limited resources and the number of competing alternatives. The number of studies devoted to the question of how profitable organic agriculture is when compared to non-organic management is enormous; however, long-term studies analysing the development of profits in comparative studies are much less numerous (Specht et al., 2014). Regrettably, the geographical distribution of these studies is skewed towards developed countries and certain cash crops (e.g. soya bean, wheat, maize). However, a general trend can be identified when considering economic comparisons made in the last three decades (Kahan, 2013).

The idiosyncratic feature of this study is the methodology adopted and the study area, considering that the Imo State vegetable production has improved significantly over the last year. Therefore, the identification of the foundational issues concerning the sources of inefficiency is essential to the implementation of policies enacted to improve performance. This process would enable the formulation of policies about the factors targeted at raising the present efficiency level of vegetable farmers operating under inorganic and organic farming systems. A succinct understanding of these relationships is expected to provide the working tools for policymakers. In other words, it would encourage a designed program towards expanding vegetable production in Imo State in particular and in the nation at large. The necessity to compare the economic analysis of organic, inorganic and integrated technologies of vegetable production is hence the focus of this study. The specific objectives of this study are to:

- i. estimate the yield of organic and inorganic vegetable farmers;
- ii. compare the budgetary analysis of organic and inorganic vegetable production;
- iii. estimate the technical efficiency of vegetable farmers under the inorganic and organic farming systems.

The hypothesis guiding this research work is:

Ho = There is no significant difference in the profitability of vegetables produced organically or inorganically;

Ha = There is a significant difference in the profitability of vegetables produced organically or inorganically.

## MATERIALS AND METHODS

### *Description of the study area*

The study was conducted in Owerri, the capital of Imo State, Nigeria. Imo State is one of the five states of Southeast Nigeria. The Owerri municipal includes one community (Owerri Nchi Ise) and comprises five villages, including Amawom, Umuororonjo, Umuonyeche, Umuodu and Umuoyima. It is located between latitudes 5° 29' north and longitudes 7° 2' east with a population of 1,401,873 and approximately 100km<sup>2</sup> in the area (NPC, 2006). Owerri is known for the tropical wet climate according to the Koppen-Geiger system. The rainy season begins in April and lasts until October (Climate and Weather, 2019), with annual rainfall varying from 1500 mm to 2200 mm (Kalu et al., 2014). The average annual temperature is above 20°C, with an annual relative humidity of 75 per cent. The primary occupation in the study area is agriculture which comprises the cultivation of crops and rearing of animals. The predominant crops grown in Owerri, Imo State, are oil palm, rice, melon, cocoa, rubber, maize and vegetables. Consumable crops such as yam, cassava, cocoyam and maize are produced in large quantities.

### *Sampling techniques and sampling size*

The population of this study comprises vegetable producing farmers in the Owerri municipal council area. A multistage sampling technique was used to select 100 vegetable farmers in the study area. The first stage was the purposive selection of the five villages in the Owerri municipal council area. The council area has the advantage that its communities and villages are proximal to the Federal University of Technology, Owerri. Hence, the council area communities are expected to benefit more relatively and directly from the university's extension and rural outreaches than communities in the other areas in the state. The second stage involved the simple random sampling of 20 vegetable farmers from the sampled five villages to make a total of 100 respondents. The data were then separated based on organic and inorganic farming for comparison.

### *Methods of data collection*

Primary data were collected from the farmers through a questionnaire complemented by an interview. The interview was conducted in English, and in some cases, questions were interpreted in the respondent's local language for their better understanding. During the course of this study, several precautions were taken to ensure the protection of the rights of respondents to the questionnaire and interview. No questionnaire administration or interview began without the receipt of informed consent from each respondent. The data collected include socioeconomic characteristics of the vegetable farmers, the quantity and cost of various inputs employed in production, values of vegetables harvested and the yield of various vegetables cultivated.

### *Analytical techniques*

Data were analysed using descriptive statistics (such as mean, tables and percentages), the t-test, the budgetary and stochastic production frontier model. Descriptive statistics were used to describe the socioeconomic characteristics of the farmers. The independent t-test was used to know the significant difference between the mean yield of the two groups, i.e. organic and inorganic farming. The budgetary techniques were employed in estimating the cost, returns, gross margin, net income (profit) and measures of profitability (such as profit per Naira invested) while the stochastic production frontier was used to analyse the technical efficiency of the vegetable enterprise in the study area.

### *The t-test estimation*

In order to examine the differences in terms of variables that contribute to the calculation of vegetable yield among the farmers who practise organic farming and those practising inorganic farming, the t-

test was conducted on various major costs. The rationale was to assess where the difference arises at the gross margin level. The vegetable yield was calculated by using the following formula:

$$(1) Yield = \frac{Y}{A}$$

where (Y) represents the output, and (A) represents the area of land farmed. The statistic  $t_{yield}$  (experimental t value) is then estimated thus:

$$(2) t_{yield} = \frac{|\bar{x}_0 - \bar{x}_i|}{s_{0i} \sqrt{\frac{1}{n_0} + \frac{1}{n_i}}}$$

$t_{yield}$  value is compared with the critical value ( $t_{critical}$ ) corresponding to the given degree of freedom N in the present case  $N = n_0 + n_i - 2$  and the confidence level chosen. The selection criteria are that if  $t_{yield} > t_{critical}$  then  $H_0$  is rejected, else  $H_a$  is retained.

### Budgetary analysis

The mathematical specification of the budgetary techniques leading to the estimation of costs, returns, gross margin, net income (profit) and measures of profitability is as stated:

Profit ( $\pi$ ) on vegetable enterprise = Gross Margin (GM) – Total Fixed Cost (TFC).

The computation of gross margin is given as:

$$(3) \Pi_j = [(P_y)Q_y]_j - \sum_{i=1}^n [(P_{xi}X_i) + TC]_j$$

where:

$\Pi_j$  is the gross margin of the  $j^{th}$  farmer;

$[(P_y)Q_y]_j$  is the total revenue for the  $j^{th}$  farmer;

$[(P_{xi})X_i + TC]_j$  is the total variable costs of the  $j^{th}$  farmer, which include the operational costs in the whole enterprise such as input costs, costs of labour (both skilled and unskilled) and transport costs.

T is the transaction costs.

$P_y$  is the output price received by the  $j^{th}$  farmer.

$Q_y$  is the output of the  $j^{th}$  farmer.

On the other hand,  $P_x$  is the input price paid by the  $j^{th}$  farmer for the  $i^{th}$  input or service and  $X_{ij}$  is the quantity of the  $i^{th}$  input or service used by the  $j^{th}$  farmer.

### Fixed cost (TFC)

In order to estimate the fixed cost, the depreciated values of fixed items were estimated as follows:

Fixed (depreciated) Cost

$$(4) (\text{₦}) = \frac{PV - SV}{N}$$

where PV is the purchase value (₦), SV is the salvage value, N is the life span (in years).

The Total Fixed Cost (TFC)

$$\sum_{d=1}^H P_{xd} X_{jd}$$

where H is the number of fixed items with d indexing each fixed input.

### Profitability

This is a measure of the performance of the vegetable enterprise. It was estimated using the returns to investment as stated in equation (5)

$$(5) \text{ Returns to Investment (ROI)} = \frac{\text{Total Revenue}}{\text{Total Cost}}$$

RI is the amount of money that would be generated on a Naira invested in the business. The higher the rate of return, the more profitable an enterprise is during the period under consideration.

### Technical efficiency of vegetable farmers

The stochastic production frontier (using the Cobb-Douglas functional form) was used to determine the technical efficiency or inefficiency of vegetable farmers in the study area. The stochastic production frontier model (Coelli, 1995) was adopted to specify the relationship between the input and output level of vegetable production in the study area. The production frontier model without a random component is written as:

$$(6) y_i = f(x_i; \beta). TE_i$$

$y_i$  = the observed output of the  $i^{\text{th}}$  vegetable farmer in kg;

$x_i$  = the vector of the input used by the  $i^{\text{th}}$  vegetable farmer (farm size, labour, seed, manure/fertiliser, pesticide) and their relevant explanatory variables associated with the production of the  $i^{\text{th}}$  vegetable farmer;

$f(x_i; \beta)$  = the production frontier (Battese and Tessema, 1992);

$\beta$  = the vector of the unknown parameter associated with explanatory variables in the production function to be estimated;

$TE_i$  = the technical efficiency defined as the ratio of observed output to maximum feasible output.

A stochastic component that describes random shocks affecting the production process is added. These shocks are not directly attributable to the farmers or the underlying technology. The shock that may come from changes in weather or an economic adversity ( $v_i$ ) denotes the shock effect and each farmer faces a different shock effect. The stochastic production frontier then becomes:

$$(7) y_i = f(x_i; \beta). TE_i . (v_i)$$

$TE_i$  is assumed to be the stochastic variable with a specific distribution common to all farmers. Thus,  $TE_i = (-u_i)$  where  $u_i \geq 0$ . The function then becomes:

$$(8) y_i = f(x_i; \beta). \exp(-u_i). (v_i)$$

Assuming that  $(x_i; \beta)$  takes the log-linear Cobb-Douglas form, the model is then written as:

$$(9) \ln y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i - u_i$$

where:

$y_i$  = the output of vegetable harvested by the farmer (kg);

$\beta_n$  = regression coefficients to be estimated;

$x_i$  = input variables used in vegetable production;

$v_i$  = the 'noise' component (i.e. stochastic disturbance term).  $v_i$ 's are assumed to be independently and identically distributed  $N(\mu, \sigma_v^2)$  random errors (Battese and Tessema, 1992);

$u_i$  = the non-negative technical inefficiency component.  $u_i$ 's are assumed to be independently and identically distributed non-negative truncations of  $\mu$  and  $\sigma^2$ , (Battese and Tessema, 1992);

$v_i$  and  $u_i$  together constitute a compound error term;

$\ln$  = the natural logarithm;

For inorganic farmers, equation (4) is expanded as:

$$(10) \ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + e$$

where:

$X_1$  = land size (ha);

$X_2$  = labour (manday);

$X_3$  = seeds (kg);

$X_4$  = fertiliser (kg);

$X_5$  = pesticide (litre).

For organic farmers, equation (4) is expanded as:

$$(11) \ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + e$$

where:

$X_1$  = land size (ha);

$X_2$  = labour (manday);

$X_3$  = seeds (kg);

$X_4$  = manure (kg);

$e$  = the error term (assumed that it is truncated normal at zero  $N-(\mu, \sigma u^2)$ ).

Determining the factors affecting technical inefficiency for both groups (inorganic and organic), the following mathematical expression was used:

$$(12) TE_i = \infty_0 + \infty_1 Z_1 + \infty_2 Z_2 + \infty_3 Z_3 + \infty_4 Z_4 + \infty_5 Z_5 + \infty_6 Z_6 + e_i$$

where:

$Z_1$  = age (in year);

$Z_2$  = gender (1 for female, 0 for male);

$Z_3$  = marital status (1 for married, 0 otherwise);



$Z_4$  = educational level (number of years of education);

$Z_5$  = household size (number);

$Z_6$  = years of farming experience (in year);

$\alpha_1 - \alpha_6$  = parameters to be estimated;

$TE_i$  = technical efficiency.

In this study, parameters of the stochastic frontier production function were estimated using the maximum likelihood estimation method using STATA version 12, which also estimated the variance parameter in terms of parameterisation:

$$(13) \sigma^2 = \sigma_v^2 + \sigma_u^2$$

$$(14) \gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$$

$$(15) \gamma = \sigma_u^2 / (\sigma^2)$$

Gamma ( $\gamma$ ), which is the variance ratio, has a value between zero and one ( $0 < \gamma < 1$ ) (Battese and Tessema, 1992). The parameter  $\gamma$  is the total output attained at the frontier attributed to technical efficiency (Battese and Tessema, 1992), explaining the total variation in the output from the frontier level attributed to technical efficiency. Thus  $1 - \gamma$  measures the technical inefficiency of vegetable farmers.

## RESULTS AND DISCUSSION

### *The average yield of organic and inorganic vegetable farmers*

The distribution of the average yield of vegetable farmers across the farming systems is presented in Table 1. The average yields of vegetables were 6,287.19 kg/ha and 4,856.93 kg/ha under the inorganic and organic farming systems, respectively. The results showed that the average yield of vegetables under the inorganic farming system was significantly higher than the yield of vegetables under the organic farming system ( $p < 0.01$ ).

### *Budgetary analysis of vegetable production under inorganic and organic farming systems*

Budgetary analysis of vegetable production under organic and inorganic systems is presented in Table 2. The cost structure of vegetable production under inorganic and organic farming systems is explained. The labour cost accounted for about 36.2% and 80.3% of the total variable cost of production under the inorganic and organic farming systems, respectively. The average cost of organic manure was about ₦3,984.5, whereas inorganic fertiliser cost an average of ₦7,404.76. As reported earlier, organic farmers did not use pesticides on their vegetable farms, while the cost of pesticides for vegetable farmers under the inorganic farming system was ₦3,787.71. The cost of seeds was significantly higher under the inorganic farming system (₦3,952.38) than under the organic farming system (₦2,072.41 at the  $p < 0.01$  significance level). Transportation costs and costs of implements were significantly higher under the inorganic vegetable farming system at  $p < 0.01$  than under the organic vegetable farming system.

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**Table 1.** The average yield of vegetables across farming systems

	Inorganic vegetable production (kg/ha)	Organic vegetable production (kg/ha)	t-statistics
Average yield	6,287.19 <sup>a</sup>	4,856.93 <sup>a</sup>	4.412
Maximum yield	24,800	18,120	
Minimum yield	860	750	
Total yield	264,061.96	281,701.71	

Source: Author's computation, 2018, <sup>a</sup> means that there is a significant difference.

The total variable costs (TVCs) were significantly higher under the organic vegetable farming system than under the inorganic vegetable farming system and accounted for approximately 46.27% of the total cost incurred. The inorganic farming system achieved significantly higher total revenues generated from vegetables than the organic farming system ( $p < 0.01$ ). This is contrary to the findings of Alawode and Abegunde (2015), who found that the revenue from vegetable production under the organic farming system was significantly higher than under the inorganic farming system. Similarly, the net revenue was significantly higher under the inorganic farming system than under the organic farming system.

The results further revealed that the gross margins realised from both inorganic and organic farming systems were profitable, but the inorganic farming system had significantly higher returns than the organic farming system ( $p < 0.01$ ). The estimated returns on investment were (4.40) and (2.89) under the inorganic and organic farming systems, respectively. The result revealed that both systems were profitable, but the inorganic farming system had significantly higher returns on investment than the organic farming system ( $p < 0.01$ ). This indicated that an average farmer could realise about 4.40 Naira and 2.89 Naira on every Naira invested in vegetable production under the inorganic farming system and the organic farming system, respectively.

#### *Estimates of the stochastic frontier production parameter under inorganic and organic farming systems*

The maximum likelihood estimates (MLEs) of the Cobb-Douglas stochastic production model are presented in Table 3. The estimates of sigma-square ( $\sigma^2$ ) were 0.017 and 0.0357 for inorganic vegetable farming and organic vegetable farming, respectively. This indicates a good fit and correctness of the distribution assumption specified. The variance ratio gamma ( $\gamma$ ), which measures the effect of technical efficiency in the variations of the observed output, had values of 0.8189 and 0.7893 for inorganic and organic vegetable farming systems, respectively. This implies that 81.89% (inorganic farming system) and 78.93% (organic farming system) of the difference between the observed and maximum production frontier outputs occurred due to differences in the producer's level of technical efficiency. The



estimated chi-squares were large and significantly different from zero at 1%, indicating goodness of fit (best fit) and the correctness of the specified distribution assumptions for the decomposed error term.

**Table 2.** The costs and returns of vegetable production under inorganic and organic farming systems

	Inorganic vegetable production	Organic vegetable production	t-value
<b>Costs (₦)</b>			
Cost of labour	13,642.86 <sup>a</sup>	51,913.79 <sup>a</sup>	-3.687
Cost of organic manure	-	3,984.48	-
Cost of inorganic fertilisers	7404.76	-	-
Cost of pesticides	3,785.71	-	-
Cost of seeds	3,952.38 <sup>a</sup>	2,072.41 <sup>a</sup>	-4.156
Cost of transportation	3,280.95 <sup>a</sup>	2,537.93 <sup>a</sup>	-3.442
Cost of implements	5,661.90 <sup>a</sup>	4,115.52 <sup>a</sup>	-3.782
<b>Total variable cost (TVC)</b>	<b>37,728.57<sup>a</sup></b>	<b>64,624.13<sup>a</sup></b>	<b>-4.640</b>
<b>Total fixed cost (TFC)</b>	<b>43,809.52<sup>a</sup></b>	<b>36,077.59</b>	<b>0.267</b>
<b>Total cost (TC)</b>	<b>81,538.09</b>	<b>100,701.72</b>	
<b>Total revenue (TR)</b>	<b>358,983.33<sup>a</sup></b>	<b>291,207.76<sup>a</sup></b>	4.537
Net revenue	277,445.24 <sup>a</sup>	190,506.04 <sup>a</sup>	5.245
Gross margin	321,254.76 <sup>a</sup>	226,583.63 <sup>a</sup>	3.435
Return on investment	4.403	2.892	
Source: Field survey, 2018.			

Table 3 also reveals that, as for the inorganic farming system, farm size, labour, and the quantity of seeds are significant at the 1% level. All their coefficients are positive, implying that the 1% increase in these inputs (farm size, labour and the quantity of seeds) will lead to 1.028%, 0.096% and 0.001% increases in the quantity of vegetable production by the farmers, thus increasing the efficiency level, respectively. Also, for the organic farming system, farm size and the quantity of seeds are significant at the 1% level, and labour and the quantity of organic manure are significant at 5% and 1% levels. The coefficient of these significant variables (farm size, labour, the quantity of organic manure and the quantity of seeds) are positive, implying that the more these inputs are put into use in vegetable production, the higher the level of vegetables, thus increasing the technical efficiency and causing a decrease in the technical inefficiency.

**Table 3.** The maximum likelihood estimate of the stochastic frontier production function

Variables	MLE inorganic	MLE organic
<b>Efficiency function</b>		
Farm size (ha)	1.0282*** (26.36)	0.8190*** (9.10)
Labour (mandays)	0.0955*** (3.37)	0.0830** (2.11)
Quantity of fertilisers (kg)	0.0115 (0.88)	-
Quantity of organic manure (kg)	-	0.0264* (1.94)
Quantity of seeds (kg)	0.0013*** (3.25)	0.0019*** (8.20)
Quantity of pesticides (litres)	0.0153 (1.08)	-
Constant	7.5137*** (74.32)	7.1869*** (44.59)
<b>Inefficiency function</b>		
Age	1.0527* (1.74)	0.5623 (1.03)
Gender	-0.0228 (-0.02)	-1.1144 (-1.4)
Marital status	0.3903 (0.61)	0.0088 (0.03)
Years of education	-2.1148*** (12.76)	-0.1957*** (-4.99)
Household size	-0.3384 (-1.08)	-0.2505* (-1.70)
Farming experience	-4.0475** (-2.46)	-0.908 (-1.02)
Constant	0.2394 (0.07)	0.0785 (0.06)
<b>Diagnosis statistics</b>		
Sigma-square ( $\sigma^2$ )	0.017 (6.35)	0.0357 (7.32)
Gamma ( $\gamma$ )	0.8189 (19.04)	0.7893 (4.39)
Number of observation	42	58
Wald $\chi^2(3)$	874.7	188.76
Log likelihood	-17.269848	-11.125615
Prob > $\chi^2$	0.000	0.000
Source: Field Data Analysis, 2018. Values in parentheses represent t-statistics. Note: *** implies the 1%, ** implies the 5% and * implies the 10% significance level.		

The elasticities of the mean value of farm output with respect to farm size, labour, fertilisers and pesticides under the inorganic farming system are 1.02, 0.09, 0.01, 0.001 and 0.02, respectively. There is evidence of increasing returns to scale under the inorganic farming system as the elasticity of the production function with respect to the factors of production was greater than 1 ( $1.02+0.09+0.01+0.001+0.02=1.14$ ). Given the specification of the models, the results show that the elasticity of the mean value of farm output was estimated to be an increasing function of farm size, labour, fertilisers and pesticides. The returns-to-scale parameter indicates what happens when all production resources are varied in the long run by the same proportion. However, the elasticities of the mean value of farm output under the organic farming system with respect to farm size, labour, manure and the quantity of seeds are 0.82, 0.08, 0.03 and 0.002, respectively. There is evidence of decreasing returns to scale under the organic farming system as the elasticity of the production function with respect to the factors of

production was less than 1 ( $0.82+0.08+0.03+0.002=0.932$ ). This implies that the farmers are in stage II in the production function curve. At this stage, every addition to the production inputs would lead to a less than proportionate addition to the output. This suggests that this is the most efficient stage for the farmers to operate.

#### *The distribution of the technical efficiency scores under inorganic and organic farming systems*

Table 4 presents the frequency distribution of the technical efficiency of the sampled vegetable farmers under the inorganic and organic farming systems. The technical efficiency distribution clearly shows that the technical efficiency skewed heavily in the 0.90 and 1.00 range, representing 71.4% of the sampled vegetable farmers under the inorganic farming system. The predicted technical efficiency differs among the sampled vegetable farmers under the inorganic farming system, with minimum and maximum values of 0.5274 and 0.9611, respectively and a mean technical efficiency value of 0.8957. The wide variation in technical efficiency estimates is an indication that most of the farmers use their resources inefficiently in the production process, and there are opportunities for improving their current level of technical efficiency.

**Table 4.** The distribution of the technical efficiency scores

Technical efficiency scores	Inorganic		Organic	
	Frequency	Percentage (%)	Frequency	Percentage (%)
<0.5	-	-	5	8.6
0.50–0.69	2	4.8	14	24.1
0.70–0.89	10	23.8	29	50
0.90–1.00	30	71.4	10	17.2
Mean	0.8957 <sup>a</sup>		0.7564 <sup>a</sup>	
Minimum	0.5274		0.336	
Maximum	0.9611		0.9507	
N	42		58	

Source: Field Data Analysis, 2018, <sup>a</sup> means that there is a significant difference in means.

The distribution of the technical efficiency clearly shows that the technical efficiency skewed heavily in the 0.70 and 0.89 range, representing 50% of the sampled vegetable farmers under the organic farming system. The predicted technical efficiency differed among the sampled vegetable farmers under the organic farming system, with minimum and maximum values of 0.3360 and 0.9507, respectively and a mean technical efficiency value of 0.7564. The wide variation in technical efficiency estimates is an indication that most of the farmers use their resources inefficiently in the production process, and there are opportunities for improving their current level of technical efficiency.

It is worthy of note that there was a significant difference in the technical efficiency of farmers under the farming systems with production under the inorganic farming system significantly higher than under the organic farming system ( $P<0.01$ ).

### *The determinants of technical inefficiency under inorganic and organic farming systems*

Table 3 reveals the analysis of the inefficiency model. The signs and significance of the estimated coefficients in the inefficiency model have important implications for the farmers' technical efficiency. A negative sign means that the variable increases efficiency, whereas a positive coefficient means a decrease in the efficiency level. The age of the farmer, years of education and farming experience significantly influenced the technical inefficiency under the inorganic farming system. The age of farmers had a significant positive relationship with the technical inefficiency at 10%. This implies that as the vegetable farmer gets older, the level of technical inefficiency will increase. This is in accordance with the findings of Bidgoli et al. (2019) that the older the farmer, the less technically efficient the farm. Years of education of the farmer had a significant negative relationship with the technical inefficiency at 1%. The negative effect of years of education indicates that technical efficiency rises with an increase in years of education since education is an important factor in recognising and seizing investment opportunities. Highly educated farmers are more likely to adopt innovations than the illiterate ones (Osinowo and Tolorunju, 2019). The coefficient of farming experience had a significant negative relationship with the technical inefficiency at 5%. This follows the a priori expectation that technical efficiency should increase with an increase in years of experience, since experience is expected to be positively correlated with the adoption of improved production technology and techniques (Ojo and Afolabi, 2000).

Furthermore, the study presents the factors that influence technical inefficiency under the organic farming system. The years of education of the farmer and household size significantly influence technical inefficiency under this farming system. The coefficient of the years of education of the farmer had a negative and significant relationship with the technical inefficiency at the 1% level of significance. This implies that as the years of education of the vegetable farmer increase, the level of technical inefficiency decreases. As established under the inorganic farming system, the more knowledgeable the farmers are, the higher their likelihood to adopt innovations. Also, the coefficient of the household size of farmers had a negative and significant relationship with the technical inefficiency at the 10% level of significance. This implies that as the number of household members increases, the level of technical inefficiency will decrease. This could be due to the fact that large household members could be used as a source of family labour which would invariably increase the technical efficiency of production. This disagrees with the results of Obayelu et al. (2016) that household size increases the technical efficiency of the farmers.

## CONCLUSION

This study estimated the profitability and the technical efficiency of vegetable production under inorganic and organic farming systems in Owerri municipal, Imo State, Nigeria. The findings of this study concluded that both organic and inorganic vegetable productions in Owerri municipal are profitable; however, the inorganic farming system had significantly higher returns than the organic farming system. The results have revealed that there is a wide variation in technical efficiency estimates for both systems, which indicates that most of the farmers use their resources inefficiently in the production process. There are still opportunities for improving their current level of technical efficiency. The mean technical efficiencies were 0.8957 (89.57%) and 0.7564 (75.64%) under inorganic and organic farming systems, respectively. The direct factors that increased vegetable production were farm size, labour, the quantity of manure and the quantity of seeds used under both systems. Furthermore, the age of the farmer, years of education and farming experience were the variables that significantly influenced technical inefficiency under the inorganic farming system. In contrast, the years of education of the farmer and household size significantly influenced technical inefficiency under the organic farming system.

Although the vegetable producers under the two considered farming systems are found to be technically efficient, there is a need to increase the use of variables for the efficient production of vegetables in the study area. The findings from this study have policy implication found useful for improving vegetable production in the study area. It has been established that as the vegetable farmer gets older, the

level of technical inefficiency increases; therefore, policies that would attract young people to the vegetable farming business are advocated. This would lead to an increase in the production level, given that young people are more receptive to agricultural innovation than older farmers. Education is one of the policy variables which can be used to improve the current level of the agricultural technical efficiency of vegetable farmers in Nigeria. The study, therefore, suggests the formulation and implementation of agricultural policy in the country that would attract educated people to farming and also encourage illiterate farmers to undergo education or training, which would lead to an increase in the level of productivity in vegetable production. The findings of this study have confirmed that the inorganic farming system is found to be more profitable than the organic farming system; hence, farmers are encouraged to focus more on practising organic farming than inorganic farming.

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## Usporedna analiza profitabilnosti i tehničke efikasnosti dva sistema proizvodnje povrća u Nigeriji

### Sažetak:

Povećanje poljoprivredne produktivnosti poboljšane raznovrsnim sistemima proizvodnje presudno je za održivu prehrambenu sigurnost i ekonomski razvoj. Cilj ove studije je da uporedi profitabilnost i tehničku efikasnost proizvodnje povrća i faktore koji utiču na tehničku efikasnost proizvodnje povrća između konvencionalnog i organskog sistema proizvodnje u Državi Imo, Nigerija. Primarni podaci prikupljeni su pomoću strukturiranih upitnika koji su obuhvatili 100 proizvođača povrća korišćenjem postupka višefaznog uzorkovanja. Budžetska analiza i model stohastičke granice proizvodnje korišćeni su za procenu profitabilnosti i tehničkih efikasnosti proizvodnje. Prosečni proizvođač ostvario je 277.445,24 ₦ odnosno 190.506,04 ₦ po hektaru kao profit od konvencionalne i organske proizvodnje povrća i potencijalno može zaraditi 4,40 ₦ odnosno 2,89 ₦ na svaku uloženu nairu. Međutim, sistem konvencionalne proizvodnje ostvario je znatno veće povraćaje nego sistem organske proizvodnje. Srednja tehnička efikasnost za organske i konvencionalne proizvođače povrća bila je 89,57%, odnosno 75,64%. Veličina gazdinstva, radna snaga i količina semena bili su presudni faktori koji su uticali na tehničku efikasnost oba sistema proizvodnje. Takođe, starost, godine obrazovanja i poljoprivredno iskustvo bile su značajne promenljive koje su uticale na tehničku neefikasnost konvencionalnih proizvođača, dok su godine obrazovanja i veličina domaćinstva značajno uticale na tehničku neefikasnost organskih proizvođača. Ova studija se zalaže za subvencionisane inpute za organske proizvođače kako bi nadoknadili niže prinose i politike koje bi privukle mlade ljude da se bave povrtarstvom radi povećanja nivoa proizvodnje.

**Ključne reči:** usporedna analiza; profitabilnost; stohastička granica; povrće