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TECHNICAL EFFICIENCY OF IRISH POTATO PRODUCTION: A CASE STUDY FROM NIGERIA

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ABSTRACT

Research background: Irish-potato (*Solanum tuberosum L.)* is one of the main root crops in Nigeria with the potential to improve food security, income and human nutrition. However, farmers are losing outputs due to inefficiency in resource use, whereas, past studies on Irish potato in Nigeria have not focussed on efficiency of the enterprise.
Purpose of the article: This study is aimed at measuring technical efficiency to provide a way of quantifying and comparing the performance of each farmer, and identification of factors responsible for variation in technical efficiency. Hence, technical efficiency, and its determinants and returns to scale of Irish-potato farmers were analysed
Methods: Primary data was collected from 260 Irish potato farmers using a structured questionnaire through a multi-stage sampling method. Descriptive statistics (frequency, mean, standard deviation and percentages) and a two-stage estimation procedure to fit the stochastic frontier production function for Irish potato farmers were used.
Findings & value added: Results indicated that the farmers have a mean age of 48 years which indicates an agile workforce. Over 80% of the farmers possessed some form of formal education, predominantly at the secondary level. The efficiency estimates indicated a disparity in technical efficiency among farmers with a mean technical efficiency of 89±4%. The farmers were producing at decreasing returns to scale. At the same time, socio-economic factors of gender, extension contact, membership in cooperative society and farming experience were positive determinants of farmers' technical efficiency, while household size was negative. Thus, being a male farmer, farming experience, encouraging contact between farmers and extension workers as well as membership in cooperative societies, while reducing household size can improve technical efficiency in Irish potato production.

Key words: Irish potato; farmers; technical efficiency; returns to scale, SFA
JEL Codes: C21; D22; D61; Q12

INTRODUCTION

Irish potato (*Solanum tuberosum* L.) is the greatest contributor of food energy in the developing regions of the world, providing 75 percent in food energy per unit area of the countries while both wheat and rice are capturing 58 percent of the total share in food energy (**FAO, 2017; Sher *et al*., 2016**). Global output is estimated at 388 million metric tonnes and the yield per hectare stands at 20,110.8kg/ha (**FAOSTAT, 2019a**). Developing countries produce over half of the world's output with China having the highest production in the world (99,205,600 metric tonnes in 2017), and almost one-third of the world's output is harvested in China and India (**FAOSTAT, 2019a**). Global domestic consumption rate of fresh and processed Irish potato stands at 34.64 kg/capita (**FAOSTAT, 2016**). In Africa, Irish potato production is estimated at 25 million metric tonnes with a yield of 13,215.4kg/ha (**FAOSTAT, 2019a**), and a consumption rate (fresh and processed) of 18.76 kg/capita/year in 2011 (**FAOSTAT, 2016**). In sub-Saharan Africa, Irish potato has had an average growth in demand of 3.1% and rank as the number one staple, particularly in East Africa (**Wassihun *et al*, 2019**). Nigeria is the seventh largest producer in Africa, with an output of 1,284,370 metric tonnes and a yield of 37,201 hg/ha (3,720.1 kg/ha) in 2017 (**FAOSTAT, 2019a**). Domestic consumption of both fresh and processed Irish potato stands at 4.63kg/capita (**FAOSTAT, 2016**). Potato is critical to food security and sustenance of livelihoods of subsistent farmers, especially in the highlands areas where its growth can be economically sustained (**Amadi, *et al*; 2021**). The crop is mainly cultivated in commercial quantities in Plateau, Kaduna and Taraba states (**Dimlong, 2012**).

Irish potato is an underexploited food crop in Nigeria, despite its wide cultivation in commercial quantities (**Muhammad *et al*., 2016**) and potential to improve food security, income and human nutrition (**Schulte-Geldermann 2013**). Several efforts have been devoted to the development and transfer of new technologies to improve Irish potato production in Nigeria; including Irish potato seed multiplication, training of farmers, Irish potato research, breeding and selection of new improved varieties (**Zemba *et al*., 2013**). However, annual Irish potato production in Nigeria has not improved appreciably (**Jwanya *et al*., 2014; FAOSTAT, 2019b**). This indicates that technological advances generated through research and investments have not widely translated into improved efficiency.

Previous research on Irish potato focused on agronomic practices, marketing efficiency, growth and crop productivity (**Okonkwo *et al*., 2009; Wuyep et al., 2013; Zemba *et al*., 2013; Sanusi *et al*., 2017**). Growth in output is not determined by introducing new technology alone, but by the efficiency with which technologies and inputs are used (**Jwanya *et al*., 2014**). Most resources used in agricultural production are not used at optimal levels and are constantly degraded (**Panwall, 2018**). These differences in technical efficiency level among farmers arise due to inefficiencies linked to farmers' and farms' specific characteristics (**Wubshet, 2018**). Irish potato farmers are losing yield due to inefficiency in resource use, and attaining high technical efficiency remains a problem among Irish potato farmers (**Kiptoo *et al*., 2016**). Hence, there is a knowledge gap on technical efficiency in Irish potato production and factors determining technical efficiency in Nigeria (**Sanusi & Babatunde, 2017**). This study was undertaken to investigate the technical efficiency of Irish potato farmers, the response of output to inputs used and determinants of technical efficiency of Irish potato farmers in Plateau state, Nigeria.

THEORETICAL AND CONCEPTUAL UNDERPINNING

The study draws on the theory of production in which a farm is viewed as a cost minimising and profit maximising entity. The farm is a producing unit having the ultimate objective of profit maximization, output maximization, cost minimization, utility maximization or a combination of the four (**Oluwatayo *et al*., 2008**). Hence, employing a production function, which is a model used to specify the relationship between independent and dependent variables, the specification of the economic production function model can be represented as:

$Y = f(X_1, X_2, \ldots, X_n)$

Where: Y represents a firm's output and a number of inputs represented by the X_1 to X_n purchased at given prices, $N = N_1, N_2, \ldots, N_n$.

Measuring production efficiency requires an understanding of farm and farmer production characteristics that influence input usage and the consequent output. Hence, the production function; $Y = f(L, K)$ is used to express the relationship.

Where *f* shows the maximum output that can be produced using combinations of inputs. *Y* is output, *L* and *K* are inputs used.

The farmer maximizes profit by either increasing the quantity of *Y* or by reducing the cost of producing *Y*. Hence, efficiency can be measured using either one of two approaches: input-oriented or output-oriented approaches (**Farrell, 1957**). The input-oriented approach addresses the question of how much can a production unit be proportionally reduced such that the quantities of input used to produce a given amount of output is reduced without any change in the output (**Coelli *et al*., 1998**). According to **Farrell (1957)**, input-oriented measure of farm efficiency can be illustrated using two firms which employ two inputs of production, capital (*K*) and labour (*L*), to produce a single output (*Y*), and face a production function, $Y = f(L, K)$, under the assumption of constant returns to scale. The firm seeks the level of technology that attains the least combination of inputs required to produce a unit of output. This is usually shown on an isoquant. Thus, all input combinations along the isoquant are considered technically efficient. There are technically efficient and inefficient point along the isoquant. Hence, a firm operating at a technically inefficient point will be technically inefficient since it uses inputs that could have been saved without decreasing the amount of output. Thus, all inputs need to be reduced by a percentage to achieve technically efficient production. This describes the technical efficiency (TE) of the producer. Output oriented approach of efficiency measurement, on the other hand, addresses the question of by how much can the output be increased such that the given level of input used remains unchanged, that is, without increasing the number of inputs used (**Coelli *et al*., 1998**). This approach uses production possibility curves which show the possible combination of two outputs that can be produced from a given input and level of technology. The production possibility curve represents the upper bound of production possibilities, hence, producers cannot be located above but can be located either on the curve, indicating efficient firms, or even below it, indicating inefficient firms. Hence, technical efficiency under the output-oriented approach measures the proportion by which outputs could be increased without requiring extra input. For both input and output-oriented approaches, technical efficiency lies between 0 and 1.

In sum, technical efficiency measures how well the individual transforms inputs into a set of outputs **(Wubshet, 2018; Tolno, 2016**) and can be influenced by both external and internal factors (farm inputs) associated with the production environment (**Bokusheva *et al*., 2006; Hasanthika *et al*., 2013)**. In this study, the dependent variable is the value of agricultural output harvested on the given farm. The independent variables considered to assess the technical efficiency of Irish potato farmers include various inputs such as area planted with Irish Potato, labour, fertilizers and other agrochemicals used in Irish Potato farming. The technical inputs and the management practices jointly determine the quantity and quality of output produced. Hence, the technical efficiency level of farmers is influenced by socio-economic, institutional and managerial factors which interact to affect the technical efficiency of Irish potato farming in line with **Wubshet (2018)**, **Kuwornu, *et al*. (2012)** and**, Abdulquadri & Mohammed (2012)**.

DATA AND METHODS

Study area

This study was carried out in Plateau State, North-Central Nigeria. Primary data was collected using a structured questionnaire through a multi-stage sampling method. In the first stage, two local government areas (LGAs), Bokkos and Mangu, were randomly selected out of the five major Irish potato-producing LGAs. The second stage involved a simple random sampling of three districts each from the list of eight districts in each of the two LGAs. From the six districts, three villages each were randomly selected to make a total of 18 villages. The last stage involved a random selection of Irish potato farmers from the 18 villages in proportion to their size since an updated list of Irish potato farmers in the study area was not available. A total of 260 Irish potato farmers were randomly selected, but only 252 gave complete information which was used for data analyses. Analytical tools employed include Descriptive statistics and Stochastic frontier production function using the STATA package.

Theoretical Framework and Estimation Procedure

The stochastic frontier production function (SFPF) utilises the maximum likelihood technique due to its composite error term. Also, the technical efficiency of an individual farm is defined in terms of the ratio of observed output (Y_i) to the corresponding frontier output (Y_i^*) conditional on the level of inputs used by the firm and given the available technology (Eq. 1).

$$TE_i = \frac{y_i}{y_i^*} \quad \text{i.e.} \quad TE_i = \frac{f(x_i\beta_i)\,exp(v_i - u_i)}{f(x_i\beta_i)exp v_i}\ ;$$

$$TE_i = \exp(-u_i) \tag{1}$$

Where:

TE_i technical efficiency of farmer i; Y_i observed output from farm i; Y_i^* and frontier output for farm i.

The technical efficiency values are assumed to range between zero and one; that is as fixed given values ($0 \leq TE_i \leq 1$). Thus, the technical inefficiency is equal to $1 - TE$

Model Specification

A two-stage estimation procedure was used to run the stochastic frontier production function.

Stage one: The model used for this study followed that of **Maina *et al.* (2018)** and **Dube *et al*. (2018)** with a slight modification in explanatory variables. The production function is as shown Eq. 2.

$$Y = f(x) \tag{2}$$

The farmers' technical efficiency is given by the equation of the Stochastic frontier production function as in Equation 3.

$$lnY = \beta_0 + \beta_1 l_n X_1 + \beta_2 l_n X_2 + \beta_3 l_n X_3 + \beta_4 l_n X_4 + v_i - u_i \tag{3}$$

Where:

Y Output of Irish potato (kilogram),

X_1 Farm size (hectare),

X_2 Quantity of Irish potato seed planted (kilogram),

X_3 Agrochemicals (litre),

X_4 Total labour used (man-days)

v_i Stochastic error term

u_i The inefficiency component of the error term

ln Natural Logarithms

β Coefficients to be estimated

Variance parameters: sigma-square (σ2) gamma (γ) and lambda (λ)

Also, the following relationships $\sigma^2 = \sigma_v^2 + \sigma_u^2$;

$\gamma = \frac{\sigma_v^2}{\sigma^2}$; $\lambda = \frac{\sigma_v^2}{\sigma_u^2}$

Where: σ^2, σ_u^2 , σ_v^2 are the overall variance of the model, the variance of the random error, and variance of the technical inefficiencies respectively. The variances of the random errors, σ_v^2 and that of the technical inefficiency effects σ_u^2, and the overall variance of the model sigma-squared (σ^2) are related thus: $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and the ratio $\gamma = \sigma_u^2 / \sigma_v^2$ measures the frontier which can be attributed to technical efficiency (**Battese & Corra, 1977**) and used by **Balogun & Akinyemi (2017); Maina *et al.* (2018)**.

The Gamma (γ) shows the explained proportion of the variation between the actual and frontier outputs, which can be attributed to underlying technical inefficiency (**Battese & Corra, 1977**). Technical inefficiency of farms is measured by one minus gamma. Lambda (λ) is expected to be >1. This condition indicates a good fit for the model and the correctness of the specified distribution assumptions (**Tadesse & Krishnamoorthy, 1997**).

Stage Two: Determinants of Technical Efficiency (TE)

Determinants of the farmers' technical efficiency were also examined. To identify the determinants of technical efficiency**,** the second stage of the estimation procedure was used (**Rahji, 2005**). Technical efficiencies were empirically identified and regressed against the farm and farmer characteristics. Based on empirical evidence, these determinants include farmer age, farm experience, marital status, level of education, gender, household size and contact with extension agents (**Rahji, 2005; Balogun & Akinyemi, 2017**).

Technical efficiency values are assumed to range between 0 and 1 as fixed given values. However, these values cannot be assumed to be normally distributed (**Ekanayake, 1987; Squires & Tobor, 1991)**. At this stage, it violates the assumption of ordinary least square which states that the dependent variable should be normally distributed with a mean of 0 and a constant variance suggested that the technical efficiency index estimated must be transformed into the natural logarithm of the ratio of the technical efficiency to technical inefficiency as transformed technical efficiency (TTE) (**Ekanayake, 1987**). This transformation makes it possible for the technical efficiency ratio to assume any value. The dependent variable for the estimating equation is as reported by **Rahji (2005)**. The dependent variable for the estimating equation thus becomes (Eq. 4).

$$TTE = ln(TE/1 - TE) \tag{4}$$

Where;

TTE= Transformed Technical Efficiency

TE= Technical Efficiency

The independent variables hypothesised to determine technical efficiency is explicitly stated as Equation 5.

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 + e_i \quad (5)$$

Where:
U_i Transformed technical efficiency variable;
Z_1 Sex (Male=1, Female= 0);
Z_2 Access to credit (Yes=1, No= 0);
Z_3 Contact with extension agent (Yes=1, No= 0);
Z_4 Membership of cooperative society (member=1, Non-member=0);
Z_5 Farming Experience (years);
Z_6 Household size of farmers (number of persons in the household);
e_i Error term.
While $\alpha_0, \alpha_1, \ldots, \alpha_6$ are parameters to be estimated.
The β's and α's are scalar parameters that were estimated, which reflect the elasticity of the agricultural inputs on output.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Irish Potato Farmers

The description of the socioeconomic characteristics of Irish potato farmers in the study area is presented in Table 1. Males dominate Irish potato farming, and over 70% of the farmers were married with a large household size of 11 persons (Table 1). The mean age of 48 years indicates an agile workforce. This follows closely with **Wassihun *et al.*, (2019)** who also found that Irish potato farmers were mostly male and aged 47 years on the average. Over 80% of the farmers possessed some form of formal education, predominantly at the secondary level. Almost two-thirds of the farmers belonged to cooperative societies, while about 70% of farmers had no access to credit. Nearly three-quarters of farmers had contacts with extension agents, indicating they have access to information about innovations which could improve the efficiency of production. This aligns with **Danso-Abeam *et al.* (2020)** who also found majority of farmers to be members of cooperatives and having contact with extension agents. The mean farm size of about 2 hectares also shows that most farmers were small-holders.

Input-Output Relationship of Irish Potato Farmers

The results of the estimated stochastic frontier production function of Irish potato farmers are shown in Table 2. The results indicated that the variance parameter sigma-squared was significant, with a lambda (λ) value >1 indicating the goodness of fit of the model. The variance ratio, $\gamma = \frac{\sigma_v^2}{\sigma^2}$, where γ indicated slightly more than 50% of the variation in output was due to disparities in technical efficiency (Table 2).

The estimated coefficient of farm size was statistically significant 1% level of probability and had a positive relationship with the quantity of Irish potato produced. This indicates that an increase in the farm size by one hectare will lead to about a 38.3% increase in the kilogram of Irish potato produced. This suggests that as Irish potato farmers increase the farmland allocated to Irish potato cultivation, the output is increased. This is in accordance with **Obare *et al.*, 2010; Dube *et al.*, 2018** who also found that increase in area planted influences output. The estimated coefficient for fertiliser was positive and significant at 5% probability level. This indicates that a 1% increase in the quantity of fertiliser applied is expected to increase the output of Irish potato production by 15.7%. The coefficient for agrochemicals was positive and significant at 1% probability level, for Irish potato production, which implied that a 1% increase in the amount of agrochemicals applied would result in a 16.02% increase in Irish potato output. This suggests that to control risks posed by weeds, pests and diseases and increase output, farmers will have to efficiently and appropriately apply agrochemicals which agrees with **Nyagaka *et al.* (2010); Akpaeti & Frank (2021)**. Labour had a negative influence, significant at 10% probability level; and a coefficient indicating a 1% increase in the quantity of labour used decreases Irish potato output by 5%. This may be because the sources of labour (family and "communal" labour) are readily available but usually poorly motivated, thus, leading to production inefficiencies and consequently affecting Irish potato output.

Table 1: Socioeconomic characteristics of Irish Potato farmers.

Characteristic	Frequency	Per cent
Sex		
Female	72	28.57
Male	180	71.43
Age (years)		
Mean	48	
S.D.	11.02	
Marital status		
Single	66	26.19
Married	186	73.81
Household size		
Mean	11	
S.D.	5.2	
Educational status (years)		
No formal education	30	11.90
1-6	76	30.16
7-12	103	40.87
Above 12	43	17.06
Mean	9	
S.D.	4.8	
Farming experience (years)		
Mean	18	
S.D.	8	
Membership in cooperative		
No	99	39.29
Yes	153	60.71
Access to credit		
No	176	69.84
Yes	76	30.16
Contact with extension agent		
No	62	24.60
Yes	190	75.40
Farm size (ha)		
Mean	2.32	
S.D.	0.86	

Source: Author's computation, 2019. Sample Size = 252.

Table 2: Maximum likelihood Estimates Stochastic Frontier Production function.

Variable	Parameter	Coefficient	Std. Err.	z-value	P>|z|
Constant	β_0	3.9052***	0.3414	11.44	0.000
Farm size (X_1)	β_1	0.3833***	0.0645	5.94	0.000
Seed (X_2)	β_2	0.0385 ns	0.0402	0.96	0.338
Fertilizer (X_3)	β_3	0.1569**	0.0747	2.10	0.036
Agrochemicals (X_4)	β_4	0.1602***	0.0187	8.54	0.000
Labour (X_5)	β_5	-0.0501*	0.0275	-1.83	0.068
Variance Parameter					
σ^2		0.0431			
Lambda (λ)		1.0024			
Gamma (γ)		0.5012			
Sample size		252			

Source: Author's computation, 2019.
Note: ns, *, **, *** not significant or significant at 10, 5 or 1% level.

Table 3. Elasticity of production and returns to scale estimates.

Input	Parameter	Elasticity of production
Farm size (X_1)	β_1	0.3833
Seed (X_2)	β_2	0.0385
Fertilizer (X_3)	β_3	0.1569
Agrochemicals (X_4)	β_4	0.1602
Labour (X_5)	β_5	-0.0501
Returns to scale		0.6888

Source: Author's computation, 2019

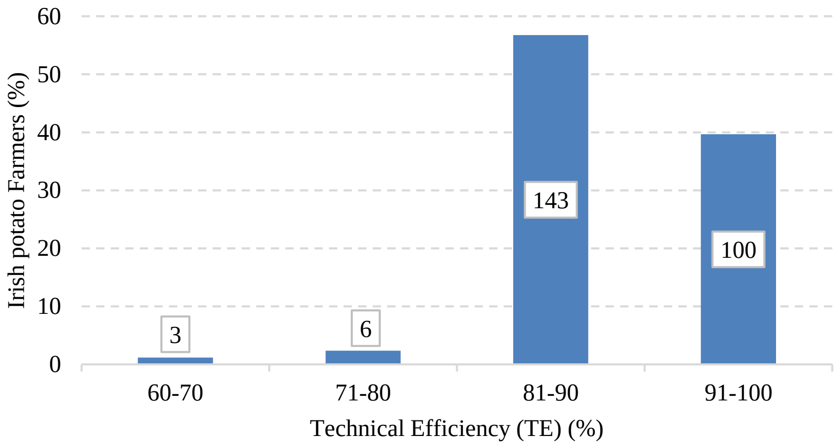

Figure 1. Distribution of Irish Potato Farmers based on their Technical Efficiency

The estimates for elasticity of production and returns to scale of Irish potato farmers are presented in Table 3. Production elasticities for inputs and returns to scale of Irish potato farmers varied. The Returns to Scale was <1 indicating Irish potato farmers were experiencing a decreasing return to scale in production, an indication that inputs used were inelastic: 1% increase in all inputs included on the production function results in <1% increase in output of Irish potato. This indicates farmers are operating in stage II of the production region which is an economic relevance stage of production (the rational Stage) where inputs and output are efficient. At this stage, every farmer attempts to maximise output as well as minimise cost. Farmers should maintain the level of input utilisation at this stage and attempt to maximise output from a given level of inputs. The decreasing returns to scale was consistent with **Nyagaka *et al.* (2010)** and **Watchmann & Watchmann (2020).**

Technical Efficiency of Irish Potato Farmers in the Study Area

The distribution of Irish potato farmers according to technical efficiency levels is depicted in Figure 1. This was derived from the analysis of the stochastic frontier production function. The technical efficiency levels indicate the majority of farmers were operating at technical efficiencies between 81-90%, with fewer at 91-100%; 71-80% and ≤70% technical efficiencies. The least efficient farmer and the most efficient farmer had estimated technical efficiencies values of 65% and 97% respectively, indicating farmers were fairly efficient in production. The distribution is comparable with the results of **Dube *et al*. (2018)** though farther from **Wassihun *et al*., (2019)** who found least efficient farmers to have estimated technical efficiency values of 46% on Irish potato production. The mean technical efficiency score implies that the average farmer was able to obtain 89% of the potential output at the given input level and technology. On average, farmers were relatively efficient, but some output was lost due to technical inefficiency which could be due to farming systems or to inefficiency among the farmers, or both. Although not a single farmer appears as fully technically efficient, the result indicates that on average, the output level can be increased without necessarily employing additional resources. An average farmer in the study area could reduce cost and attain the technical efficiency level of its most efficient counterpart. The least efficient farmer could also reduce cost and attain the technical efficiency level of the most efficient farmer through adopting practices and technology used by the most efficient farmer. The results of this study agree with **Nyagaka *et al.* (2010)** and **Akpaeti & Frank (2021)** on the technical efficiency of smallholder farmers.

Determinants of Technical Efficiency of Irish Potato Farmers

Table 4 reveals the regression estimates for the determinants of technical efficiency of Irish potato farming in the study area. Most of the estimated regression coefficients were positive, and significant, indicating their relative effect in increasing technical efficiency. The coefficient of multiple determinations (R^2) indicated independent variables explained variation in technical efficiency; the remaining amount was attributed to uncaptured variables in the model. The F-Statistics was significant, indicating the joint effect of variables included in the model was able to determine technical efficiency. The coefficient of Sex was positive, and significant at 1%, indicating that being a male farmer improves technical efficiency. The majority of the farmers were male. This suggests that male farmers were more likely to be technically efficient than female farmers. Being male farmer increased technical efficiency by 3.3816 magnitudes compared to being a female farmer. This could be explained by the fact that the male farmers are decision-makers, had access to land, labour supply and other production resources due to cultural prejudice. This result is consistent with **Danso-Abeam *et al*. (2020)** Similarly, the coefficient of extension contact was positive and significantly influenced technical efficiency at 1% level. Farmers who have contacts with extension officers would increase technical efficiency as such farmers gain better knowledge on input use, access modern agricultural technology, obtain information on proper agronomic practices relating to land preparation, planting, weeding, fertiliser application, pests and diseases control, improving farmer technical efficiency (**Dube *et al*., *2018***). Membership in cooperatives had a positive and significant influence on technical efficiency at 1% level. This indicates that farmers who are members of cooperatives are more likely to improve their technical efficiency because they tend to enjoy benefits such as access to relevant information on-farm management practices, introduction of new technologies, and financial assistance (**Nyagaka *et al*., 2009; Akpaeti & Frank, 2021**). The farming experience was positive and significant at 5% level, indicating that a year increase in farming experience would increase technical efficiency indicating by 5.79% (Table 1). Hence, the more years farming, the better the technical efficiency of the farmer. Farmers who have more years of experience would be more likely to have good managerial abilities, improved technical skills, and broader networking with other farmers on best agronomic practices and efficient use of inputs (**Otitolaiye *et al*., (2014**). Household size was negatively and significantly influenced technical efficiency at 1% level. This implies that increased household size would reduce technical efficiency. This may be due to a greater cash constraint leaving the household with little cash to purchase production inputs and new technologies (**Dube *et al*.,** 2018; **Danso-Abeam *et al*., 2020**). Finally, it was noted that none of the Irish potato farmers operated on the production frontier (efficient level), indicating there is room for improvement. Irish potato farmers operate at a rational state of production.

Table 4. Estimated factors influencing technical efficiency of Irish potato farmers.

Variable	Parameter	Coefficient	Std. Err.	t- value	P>|t|
Constant	α_0	4.7353***	0.5828	8.13	0.000
Sex (Male = 1, Female = 0)	α_1	3.3816***	0.5276	6.41	0.000
Access to credit (Yes = 1, No = 0)	α_2	0.5346 ns	0.3888	1.37	0.170
Extension contact (Yes = 1, No = 0)	α_3	0.8941***	0.1121	7.98	0.000
Membership in cooperative (Yes = 1, No = 0)	α_4	1.6831***	0.4434	3.80	0.000
Farming experience (Years)	α_5	0.0579**	0.0273	2.12	0.035
Household size (number)	α_6	-0.1449***	0.0391	-3.70	0.000
R^2 = 0.51					
Adj R^2 = 0.50					
F-Stat = 42.37***					
Sample size = 252					

Source: Author's computation, 2019, ns, **, *** not significant or significant at 5 or 1% levels, respectively.

CONCLUSIONS AND RECOMMENDATIONS

This study set out to measure the technical efficiency of Irish potato farmers in Nigeria's Plateau state and identify the factors that cause variation in the technical efficiency of farmers in the study area. None of the sampled Irish potato farmers operated on the production frontier (efficient level), indicating a gap in efficiency and room for its improvement. The farmers were operating below the production frontier due to technical inefficiency, which is attributed to farming systems or due to the inefficiency among the sampled farmers, or both. The study established that Irish potato farmers operate at the rational state of production. In contrast, socioeconomic factors of gender, extension contact, membership in cooperative society and farming experience were positive determinants of farmers' technical efficiency, while household size was a negative determinant/was negative. Thus, encouraging contact between farmers and extension workers will enhance their level of efficiency in the production of Irish potatoes. Since farming experience also improves the level of efficiency, new entrants into Irish potato farming should consider either hiring experienced Irish potato farmers or understudying them for efficient production. Membership of cooperative societies should also be encouraged among Irish potato farmers to attain an optimal level of efficiency. It is also recommended that birth control measures are recommended for Irish potato farming households to bring about the desired efficiency level in production. Finally, since it was established that being a male farmer increases efficiency of Irish potato production compared to being a female farmer, it is recommended that further research should be done to identify factors that can increase the efficiency of Irish potato production among female farmers.

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