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ECONOMIC EFFICIENCY OF SMALL-SCALE IRISH POTATO FARMERS IN NIGERIA AND KENYA UNDER THE POTATO INITIATIVE AFRICA PROJECT

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ABSTRACT

The study assessed the economic efficiency of small-scale Irish potato farmers in Plateau State, Nigeria and Nyandarua County, Kenya. Multi-stage sampling procedure was adopted to select respondents in the study locations in both countries. A total of 295 small-scale Irish potato farmers were interviewed, 188 from Nigeria and 107 from Kenya. In both countries however, farmers interviewed were beneficiaries of the Potato Initiative Africa Project. Data were subjected to stochastic frontier analysis to obtain results of the study. Production efficiency measurement informs investors on the efficiency of input utilization based on a given output. Efficiency is further grouped into technical, allocative and economic efficiencies. Technical efficiency measures the effect of the inputs on a given output and other factors that might affect efficiency. Allocative efficiency measures the cost effect on the total monetary value of the output and finally, economic efficiency gives the overall efficiency of a given farmer. The study infer that farmers in both countries have some level of inefficiencies which was seen to be added by some of their demographic variables. Inefficiencies was seen to also exist among farmers in both countries with respect to production inputs usage. In Kenya, use of agrochemicals was seen to have significantly and positively affected Irish potato output. The study recommends that Farmers in Nigeria are encouraged to copy from farmers in Kenya and adopt an integrated disease management system.

KEYWORDS: Nigeria, Kenya, Allocative, Technical, Economic, Efficiency

INTRODUCTION

Irish potato has been an important commodity to farmers, traders, and consumers as it adds to the household economy and food security in areas where it is heavily cultivated for the single reason that the crop is cultivated for income generation and not to be consumed. The crop originates from the Andes Mountain of South America and was brought to Africa in the 19th century International Potato

Centre (IPC, 2015).

Africa is among the continent with the lowest contribution to the global production of potato tubers, with Oceania being the lowest. Currently, potato production is largely a smallholder activity (FAOSTAT, 2021). Average cultivated land sizes are less than two hectares in both Kenya and Nigeria, and farmers mostly perform farm operations manually with traditional farm tools and pro¬duction techniques. Smallholder farmers are usually constraints with poor quality inputs (seeds, fertilizers and agrochemicals), inadequate information, and access to credit institutions, storage facilities and other production and/or processing equipment (Muthoni and Nyamongo, 2009 and PIA, 2016)). This situation has resulted in low yields, high postharvest losses, and poor quality of produce in both countries (GIZ, 2016).

Muthoni et al., (2020), reported that the unavailability of quality planting materials is a major constraint to a reasonable number of farmers and hence compels most farmers to use planting materials from informal sources such as previous harvests, local markets and neighbours which have continued to decrease the output realized from production. Elmar (2012) linked the low Irish potato yields to low-quality seeds, low-yielding varieties, high incidences of diseases, inadequate soil fertility management, and inadequate seed and ware potato storage facilities. The use of traditional technology and poor management are responsible for low output and income among small-scale potato farmers. The problem continues to worsen due to the use of poor-quality seeds, inadequate storage facilities and the use of traditional production equipment and methods which hinder the efficiency of Irish potato farmers. These further weaken business relations between local producers and processors, limit the availability of healthy and suitable varieties of seeds and lack viable financial solutions along the value chain (Ojo, 2005). The study will therefore determine the economic efficiency of Irish Potato farmers in Nigeria and Kenya.

METHODOLOGY

Description of the Study Area

Plateau State is located in the North Central geopolitical zone of Nigeria. It lies between latitude 9.24220N – 10.11530N and longitudes 8.69570 East – 9.52100 East (Majekodunmi, 2013). The state has a land area of 30,913 km2 with an estimated population of 4,373,708 as of 2020 based on an annual growth rate of 2.6% (World bank, 2019). The state is about 1230m above sea level, with about 1400mm of annual rainfall which spans from April to October (NRCRI, 2015). The climate is characterised by two distinct seasons, the rainy season, and the dry season, which falls between November and March. High temperatures are recorded in March–May while the lowest temperatures popularly called the Harmattan months are between December and January. These seasons are suitable for potato production because they meet the required 15 0 C for tuber formation. Other crops produced

in these areas include tomato, cabbage, carrots, lettuce, cucumber, green beans and onions. Cereal crops such as maize, sorghum and millet are also grown in the area. Potato-producing seasons are April – July (rainy season) and September – January (dry season). Over 80% of potatoes are produced as a sole crop during the dry season and in mixtures during the rainy season. The climate of the State is ideal for Irish potato production as well as vegetables, fruits and other exotic crops.

Nyandarua County is situated in the centre of Kenya. The county lies between latitude 00 33′ 0″ S and Longitude 360 37′ 0″ It has an average elevation of 2,238m. The mean annual rainfall is 1500mm distributed between March and November and a drier period from December to February (Muthoni et al., 2013). The annual temperature of the county ranges between 21-26 0 C, the lowest is usually recorded in June while the highest is in February and March. The county has a land area of 3,304 km2 and an estimated population of 667,650 in 2020 based on 2.3% annual growth (World Bank, 2019). The farming system is majorly rain-fed. The conditions of both countries made it feasible for the potato to thrive well.

Sampling Procedure and Sample Size

For the study, farmers under the Potato Initiative Africa Project were sampled in both countries. Plateau State and Nyandarua County were selected purposively being the PIA project sites and also the major producer of Irish potatoes in both countries (Muhammad, Gindi, Gona, and Kaka, 2016). Mangu and Pankshin LGA were purposively selected because they are the two locations in which the project took place in Nigeria while Oljoro Orok and Kipipiri sub-counties were also selected purposively in Kenya. Finally, 188 Irish potato farmers were interviewed from Pankshin (104) and Mangu (84) while 107 farmers were interviewed in Kenya being the total project farmers in both locations. A total of 295 PIA farmers were interviewed, 188 from Nigeria and 107 from Kenya. Data were obtained from primary and secondary sources; the primary data was sourced through the use of structured questionnaire in digital format (CAPI) while secondary sources were through data from the Plateau Agricultural Development Programme (PADP), National Agricultural Extension and Research Liaison Services (NAERLS) and National Potato Council of Kenya (NPCK). Trained enumerators from both Countries were utilized for data collection while the researcher supervised the conduct of the exercise in Nigeria and NPCK supervised the exercise in Kenya. Using resident enumerators was so helpful as enumerators were able to use their local language for data sourcing in both countries.

Analytical Techniques and Specification of Models

Stochastic Frontier Analysis (SFA)

The stochastic frontier model would be used to achieve results for objective “ii” of the study using Frontier version 4.1. The model is explicitly shown as follows;

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$$lnYi = \beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + (Vi - Ui) \quad [1]$$

Where;
Yi = Yield of Irish Potato of the ith farmer (kg/ha)
X_1 = Quantity of potato seeds used (kg/ha)
X_2 = Quantity of fertilizer used (kg/ha)
X_3 = Total Man days used (man-days/ha)
X_4 = Total quantity of agrochemicals used (litres/ha)
$\beta_0 - \beta_4$ = Parameters to be estimated
Vi = Random error term assumed to be independent of Ui
Ui = non-negative error term also referred to as the technical inefficiency effects.
ln = Natural logarithm (to base e)

3.5.2.1 Technical Inefficiency Model

To further enhance the results of the study, it will go a long way in identifying the socioeconomic determinants of technical inefficiency. For this study, the model used is specified explicitly as follows;

$$\boldsymbol{Ui = \gamma_0 + \gamma_1 w_1 + \gamma_2 w_2 + \gamma_3 w_3 + \gamma_4 w_4 + \gamma_5 w_5 + \gamma_6 w_6 + \gamma_7 w_7 + \gamma_8 w_8 + e_i} \quad [2]$$

Where;
U_i = Technical inefficiency of the ith farmer
W_1 = Age of the potato farmer (years)
W_2 = Household size (number)
W_3 = Farm Size (Hectares)
W_4 = Education Years (Years)
W_5 = Amount of Credit
W_6 = Years of experience in potato production (years)
W_7= Association membership (Yes/No)
W_8= Non-farm income (NGN)
e_i = Error term
$\gamma_0 - \gamma_5$= Parameters to be estimated

Specification of the Stochastic Frontier Cost Model

This would be used to measure the cost efficiency (allocative efficiency) of Irish potato producers in the study sites, this will be employed to achieve part of objective "iii" and it is explicitly given as;

$$lnCi = \alpha + \alpha_1 lnP_1 + \alpha_2 lnP_2 + \alpha_3 lnP_3 + \alpha_4 lnP_4 + (V_i + U_i) \quad [3]$$

Where;

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ln = Natural logarithm
Ci = Income from Irish potato production (NGN/ha)
P_1 = Cost of potato seeds (NGN/ha)
P_2 = Cost of fertilizer used (NGN/ha)
P_3 = Cost of labour used (NGN/ha)
P_4 = Cost of agrochemicals used (NGN/ha)
α_1 - α_4 = Parameters to be estimated
Vi = Random error independent of Ui
Ui = Non-negative error

RESULTS AND DISCUSSIONS

Maximum Likelihood Estimate for Frontier Production Function in Nigeria

Results of the maximum likelihood estimate of the frontier production function as shown in Table 1 for Nigeria indicates that the elasticities for fertilizer and labour were statistically significant at 1%. Fertilizer has positive elasticity (0.124) and hence improves the production efficiency of the beneficiary group of farmers. The positive elasticity for fertilizer infers that a unit increase in the quantity of fertilizer used will result in a 0.124kg increase in Irish Potato output per hectare and this is reported to be an essential variable in determining the efficiency of this group of farmers although the optimum production level is not reached yet. Labour elasticity is -0.209 and statistically significant at 1% implying labour has reached stage III of production and a unit increase in labour results in a decrease of 0.209kg of Irish potato per hectare. This implies that labour is over-utilized, its use must be decreased to target the optimality stage (i.e stage II). Other production variables that is, seeds and agrochemicals were seen to increase Irish potato output per hectare by 0.056kg and 0.029kg respectively, these were however statistically insignificant implying they are yet to attain optimality threshold and therefore the quantities used for these inputs can be added to gain increased output until stage II of the production frontier is attained.

On variables for the inefficiency model of the farmers in Nigeria, household size, farm size, years in education, years of experience and non-farm income were found to be statistically significant at 1% indicating their role in decreasing/increasing inefficiency. However, only years in education (0.002) and years of experience (0.049) were found to decrease the inefficiency of Irish potato farmers implying those variables reduce farmers' inefficiency. The amount of credit accessed though not significant was found to reduce the inefficiency level of Irish potato farmers. Age of Irish potato farmers and association membership (years) were found to increase farmer's inefficiency. The former (age) usually tends to decrease farmers efficiency because productivity also translate to efficiency and it tends to decrease with increase in age while the latter (association membership) especially in developing countries is only seen as a means of obtaining free goods (in form of inputs or cash) from

certain group of individuals hence makes the variable that ought to bring farmers together and improve on their system of production and in turn improves their efficiency, a variable that increases their inefficiency because the expected benefit to be derived from coming into groups has in most cases been overtaken by subjectiveness.

The study, however, contradicts the results of Dominic and Ogheneruemu (2021) which reported household size to have a negative relationship with inefficiency hence decreasing the level of inefficiency of Irish potato farmers.

Generally, the gamma values of the beneficiary and non-beneficiary groups are 76.3% and 98.0% respectively and both are significant at 1%. This implies the fitness of the model used and also indicates that the variability in the output of Irish potato farmers is attributed to inefficiency variables. Moreov4er, the presence of technical inefficiency was tested by the Likelihood Ratio (LR) test which was 194.96 and 205.99 for the beneficiary and non-beneficiary groups and at the same time greater than the critical chi-square value of 17.28 implies that technical inefficiency exists and the null hypothesis of no technical inefficiency is rejected.

Maximum Likelihood Estimate for Frontier Production Function in Kenya

Also in table 1, the results of the technical efficiency of Irish potato farmers in Kenya indicated that seeds and agrochemicals use were positive and statistically significant at 1%. This implies that the use of an additional unit of seeds and agrochemicals results in a proportionate increase in Irish potato output per hectare by 0.188kg and 192.797kg respectively and also the significance emphasised the importance of those variables in attaining the production efficiency of Irish potato farmers. Variable on fertilizer use indicated a positive relationship with efficiency, earning a unit increase in quantity of fertilizer used results to a proportionate increase in output per hectare by 0.037kg. The elasticity of labour-use (-0.059) decreases Irish potato output and is not significant, indicating the under-use of the variable, there is, therefore, a need for increasing the quantity used of the variable.

Results of inefficiency model of the MLE for farmers in Kenya indicated years in education and years of experience to decrease inefficiency by -0.023 and -0.022 respectively and are all statistically significant at 1%. Farm size and non-farm income are also statistically significant but increase beneficiary farmers' inefficiency. Age, household size, amount of credit and association membership are statistically insignificant and increases beneficiary group inefficiency by 0.001, 0.004, 0.000 and 0.002 units respectively.

Gamma values for the farmers in Kenya is 0.954 statistically significant at 1%. Output from tests of inefficiency using the LR test reported 315.70 as LR values for the farmers. The value (LR test) is

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much larger than the equivalent chi-square values of 17.28 hence indicating the existence of inefficiency thus the rejection of the null hypothesis that states there is no technical inefficiency.

This study partially contradicts the findings of Uche et al. (2021) who reported fertilizer to have an inverse relationship with Irish Potato Output. Furthermore, the study also contradicts Barasa et al. (2019) and Nyagaka et al. (2010) that reported all production variables to have a positive relationship with Irish potato output. Nevertheless, the study agrees with the findings of Dominic and Ogheneruemu (2021) that reported labour has an inverse relationship with Irish potato output hence decreasing the production efficiency of Irish potato farmers.

Table 1: Maximum Likelihood Estimates for Frontier Production Function Nigeria and Kenya

Variables	Nigeria			Kenya		
	Coef	SE	t	coef	SE	t
beta 0	7.229	0.902	8.015	9.939	0.587	16.938
Seeds (kg/ha)	0.056	0.057	0.975	0.188***	0.033	5.761
Fertilizer (kg/ha)	0.124***	0.040	3.052	0.037	0.039	0.945
Agrochemicals (L/ha)	0.029	0.100	0.295	192.797***	0.325	592.663
Labour (man-days/ha)	-0.209***	0.018	-11.678	-0.059	0.105	-0.565
Delta 0	-0.370	0.159	-2.323	0.800	0.127	6.312
Age (Number)	0.001	0.002	0.819	0.001	0.001	1.363
Household Size (Number)	0.017***	0.006	2.894	0.004	0.005	0.913
Farm Size (Ha)	0.456***	0.031	14.630	0.023***	0.008	2.742
Education (Years)	-0.002***	0.000	-5.382	-0.023***	0.003	-7.526
Amount of Credit (N)	-0.002	0.056	-0.041	0.000	0.000	0.675
Experience (Years)	-0.049***	0.003	-14.440	-0.022***	0.001	-15.108
Association Membership (Years)	0.004	0.004	0.897	0.002	0.003	0.831
Non-Farm Income (N)	0.013***	0.003	4.257	0.967***	0.100	9.666
sigma-squared	0.108***	0.009	11.951	0.018***	0.002	7.389
Gamma	0.763***	0.076	10.080	0.954***	0.051	18.541
log-likelihood function		-57.279			-64.545	
LR test		194.561			315.702	

Source: Survey Data (2022) ***; **; * =p<0.01; p<0.05; p<0.10, respectively

4.3.3 Maximum Likelihood Estimate of Frontier Cost Function in Nigeria

Table 2 indicated that seeds and agrochemicals are significant. Seed is positively related to Irish potato revenue with a coefficient of 0.846 implying a unit increase in the cost of seeds used will result in a proportionate increase in revenue by N0.846 and is statistically significant at 1%. For agrochemicals,

a negative relationship was observed implying a unit increase in cost spent for agrochemicals will lead to a proportionate decrease in revenue by N0.530 and also statistically significant at 1%. The cost of fertilizer although not significant was also found to increase the revenue of beneficiary Irish Potato farmers.

Generally, the gamma coefficients of Irish potato farmers in Nigeria indicated that 94.6% of the variation existing from revenue generated from the cultivation of 1ha of Irish potato field is well explained respectively. The sigma squared values were also statistically significant at 1% indicating the goodness of the model used for cost efficiency.

Allocative efficiency of the farmers in Kenya showed that only the coefficient of agrochemicals is significant and has a positive relationship with revenue. This implies that a unit increase in the cost expended on the use of agrochemicals will result in a proportionate increase in revenue by N0.051. Other variables indicated a positive relationship thus increasing revenue with a unit increase in cost expended on those variables except seed which has a negative relationship and hence decreases revenue.

The statistical parameters for Irish potato farmers in Kenya indicated a statistical significance of 1% each implying the fitness of the model used. The gamma indicator implies 89.0% of variation in revenue of farmers has been explained by the model.

In general, the study counters the findings of Aristide and Alfred (2015) that reported labour, fertilizer and seed to have a positive relationship with the revenue of farmers in Musanze District, Northern Rwanda. It however partly agrees with the findings of Begum et al. (2010) that indicated human labour and seed prices inversely affect the revenue of Irish potato farmers in Bangladesh.

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Table 2: Maximum Likelihood Estimate of Frontier Cost Function

Variables	Nigeria			Kenya		
	Coef	SE	t	Coef	SE	t
beta 0	8.835	3.391	2.606	0.842	0.996	0.845
Seeds	0.843***	0.061	13.847	-0.059	0.063	-0.945
NPK	0.137	0.099	1.383	0.046	0.074	0.625
Agrochemicals	-0.530***	0.146	-3.625	0.051***	0.008	6.639
Labour	-0.109	0.258	-0.422	0.358	0.335	1.069
sigma-squared	1.023***	0.188	5.448	0.636***	0.111	5.753
Gamma	0.946***	0.049	19.471	0.890***	0.002	388.328
log-likelihood		-170.522			-78.108	
LR Test		9.216			38.592	

Source: Survey Data (2022) ***; **; * =p<0.01; p<0.05; p<0.10, respectively

Distribution of Respondents according to Economic Efficiency

Frequency distribution of respondents according to economic efficiency as shown in table 3 reported that in Nigeria, a significant proportion (37.8%) of the beneficiary group operates at an economic efficiency threshold of 0.01-0.20, followed by 22.9% to 0.81-1.00 economic efficiency level. The least (10.6%) operate at a level of 0.61-0.80. A mean economic efficiency of 0.70 was observed for the Irish potato farmers in Nigeria. This further implies that on average Irish potato farmers were able to attain about 70% of potential output due to economic efficiency.

In Kenya, 36.7% of the Irish potato farmers belong to the economic efficiency level of 0.81-1.00. This was followed by the economic efficiency threshold of 0.21-0.40 with 28.0% and the least (8%) lies with the range 0.01-0.20. The result showed mean economic efficiencies of 0.90 implying that the majority of farmers in Kenya operate close to their production frontier. Furthermore, the mean values also mean that 90% of potential output was attained due to economic efficiency by Irish potato farmers in Kenya.

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Table 3: Distribution of Farmers according to Economic Efficiency

Economic Efficiency Category	Nigeria		Kenya	
	Freq	%	Freq	%
0.01-0.20	71	37.8	9	8.4
0.21-0.40	31	16.5	30	28.0
0.41-0.60	23	12.2	18	16.8
0.61-0.80	20	10.6	11	10.3
0.81-1.00	43	22.9	39	36.5
Total	188	100.0	107	100.0
Max	9.83		5.14	
Min	0.04		0.14	
Average	0.70		0.90	

Source: Survey Data (2022)

CONCLUSION AND RECOMMENDATIONS

The study concluded that farmers in both countries have some level of inefficiencies which was seen to be added by some of their demographic variables. Inefficiencies was seen to exist among farmers in both countries with respect to production inputs usage. In Kenya, use of agrochemicals was seen to have significantly and positively affected Irish potato output. The study therefore gave the following recommendations;

i. Farmers in Nigeria are encouraged to copy from farmers in Kenya and adopt an integrated/unified disease management system of conducting spraying activity collectively and at the same time. This has proven to be an effective measure in eliminating the deadly blight of potatoes in Kenya aside the preventive approach of pest/disease control. Extension organizations can help on this by coming up with seasonal calendars for different crops

ii. Research institutes with the mandate on root and tuber crops should be empowered and funded to conduct researches intended in improving local Irish potato varieties as obtained with the Shangi variety of Irish potato in Kenya

iii. Farmers in both countries need to be trained on group formation and dynamics and how to leverage on farmers group to solve their production challenges especially blight infestation and high input costs

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