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Determinants of Cost Efficiency among Smallholder Maize Producers in Kano and Kaduna States, Nigeria.

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ABSTRACT

This study focused on the determinants of cost efficiency among smallholder maize growers in Kano and Kaduna States of Nigeria. The study utilized a simple random sampling approach to select 200 small-scale maize growers. Primary data from cross-sectional sources were utilized based on a well-organized questionnaire. The questionnaires were administered to the respondents with the use of well-trained enumerators and agricultural extension agents in the year 2024. The data were evaluated using descriptive statistics and a stochastic cost efficiency frontier model. The outcome shows that the mean age of maize growers was evaluated at 48, 95% Confidence Interval CI [45.6, 50.4] years. The mean maize farm size was 1.42, 95% CI [1.349, 1.49] hectares per grower, which indicates that most growers cultivated small-scale farmland. The cost of seeds, the cost of fertilizer, the cost of labour, and depreciation costs were significantly different from zero in influencing cost efficiency among maize growers at $p < 0.01$. The cost of agrochemicals and maize output is significantly different from zero in influencing cost efficiency among maize growers at $p < 0.05$. The socio-economic stimuli significantly affecting cost inefficiency among maize growers include age, farming experience, household size, and level of education. The calculated scale effect was 10.27, 95% CI [10.78, 9.7365]; the calculated scale effect is greater than one, which signifies that there are positive economies of scale. This signifies that a unit increase in the total production costs increased the total maize output by 10.27 times during the course of maize farming. The study recommends that the maize growers should form themselves into cooperative groups. This will enable them to access credit, improved maize seeds, fertilizers, agrochemicals, and other farm inputs, information, and share ideas about maize farming.

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Nijerya'nın Kano ve Kaduna Eyaletlerindeki Küçük Toprak Sahibi Mısır Üreticileri Arasında Maliyet Verimliliğinin Belirleyicileri.

ÖZET

Bu çalışma, Nijerya'nın Kano ve Kaduna eyaletlerindeki küçük çiftçi mısır yetiştiricileri arasında maliyet verimliliğinin belirleyicilerine odaklanmıştır. Çalışmada, 200 küçük ölçekli mısır yetiştiricisini seçmek için basit rastgele örnekleme yaklaşımı kullanılmıştır. İyi organize edilmiş bir ankete dayalı olarak kesitsel kaynakların birincil verileri kullanılmıştır. Anketler, 2024 yılında iyi eğitimli sayım görevlileri ve

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tarımsal yayım temsilcileri kullanılarak katılımcılara uygulanmıştır. Veriler, tanımlayıcı istatistikler ve stokastik maliyet verimliliği sınır modeli kullanılarak değerlendirilmiştir. Sonuçlar, mısır yetiştiricilerinin ortalama yaşının 48, %95 Güven Aralığı CI [45,6, 50,4] yıl olarak değerlendirildiğini göstermektedir. Ortalama mısır çiftliği büyüklüğü yetiştirici başına 1,42, %95 CI [1,349, 1,49] hektardır; bu, çoğu yetiştiricinin küçük ölçekli çiftlik arazisi işlediğini göstermektedir. Tohum maliyeti, gübre maliyeti, işçilik maliyeti ve amortisman maliyetleri mısır yetiştiricileri arasında maliyet verimliliğini etkilemede sıfırdan anlamlı derecede farklıydı $p < 0,01$. Tarımsal kimyasalların maliyeti ve mısır çıktısı mısır yetiştiricileri arasında maliyet verimliliğini etkilemede sıfırdan anlamlı derecede farklıydı $p < 0,05$.Mısır yetiştiricileri arasında maliyet yetersizliğini önemli ölçüde etkileyen sosyoekonomik uyaranlar arasında yaş, çiftçilik deneyimi, hanehalkı büyüklüğü ve eğitim düzeyi yer almaktadır. Hesaplanan ölçek etkisi 10,27, %95 GA idi [10,78, 9,7365], hesaplanan ölçek etkisi birden büyüktür, bu pozitif ölçek ekonomileri olduğunu gösterir. Bu, toplam üretim maliyetlerindeki bir birimlik artışın mısır çiftçiliği süresince toplam mısır çıktısını 10,27 kat artırdığını gösterir. Çalışma, mısır yetiştiricilerinin kooperatif grupları oluşturmalarını önermektedir, bu onların krediye, geliştirilmiş mısır tohumlarına, gübrelere, tarım kimyasallarına ve diğer çiftlik girdilerine, bilgilere erişmelerini ve mısır çiftçiliği hakkında fikir paylaşmalarını sağlayacaktır.

Anahtar Kelimeler
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INTRODUCTION

Maize (*Zea mays L*) is an important staple and the third most significant cereal crop after sorghum and millet in Nigeria (Ogundari et al., 2006). Maize is cultivated for food, feed, and folder for livestock, as a source of income and foreign exchange earnings for Nigeria (Alabi and Safugha, 2022). Maize is used as raw material in different agro-based industries, and is used in the production of starch, fuel, food sweeteners, and medicine (Alabi and Safugha, 2022; Egwuna et al., 2019). Nigeria produced 12.9 million tons of maize in 2022, and 12.7 million tons of maize in 2021, which is approximately a 1.57% increase over the previous year 2021 (FAO, 2024). The world output of maize in 2021 and 2022 was 1207.9 and 1163.5 tons, respectively (FAO, 2024). Due to the low productivity of maize, Nigeria cannot satisfy the large quantity of maize demanded, which is approximately 12-15 million tons; the demand and supply gap is approximately 4 million tons of maize. The low performance of maize can be attributed to its dependence on subsistence agriculture (smallholder farmers) with rudimentary farm systems, low yield per hectare, low capitalization, diseases and pests, price fluctuations, poor storage, and resource utilization (Ojo, 2000). The studies of Awotide et al. (2008) noted that the use of unimproved local seeds, inadequate fertilizers, the use of manual labour input, and lack of farmland limit maize farming in Nigeria. Resources such as fertilizers, pesticides, and herbicides are scarce, and when available, the smallholder farmers cannot afford to procure the quantities they require. Efficiency remains a significant aspect that needs to be considered in agriculture in order to enhance the production and distribution of resources optimally so as to meet the food demand of the populace (Abdul et al., 2017). In agriculture, attention has shifted from production to efficiency in production by giving more attention to the optimum production plan in order to maximize output or minimize the cost of production or maximize profit or a combination of these, as they reflect key objectives of any firm. As noted by Farrell (1957) and Amaza and Maurice (2005), efficiency can be defined as the possibility of firms producing a certain optimal level of product from a given bundle of inputs or a certain level of output at minimum cost. Efficiency forms a significant part of productivity growth, especially in an economy in which resources are scarce and opportunities for new technologies are limited. Efficiency will be able to show that it is possible to raise productivity without increasing the resource base or developing a new technology by enhancing efficiency. The extent of inefficiency will also help in deciding whether to enhance efficiency or to develop new technologies to increase agricultural productivity (Adeyemi et al., 2017). Sakurai et al. (2006) explained that agricultural productivity does not just depend on crop

yield, but it is also determined by the efficiency of the production unit. The performance can be compared with the normative desired level or with that of any other farm. The evaluation of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources or a certain level of output at least cost. According to Farrell (1957), the concept of efficiency can be divided into technical efficiency, price or allocative efficiency, and economic (cost) efficiency. Technical efficiency can be defined as the ability of a firm to produce the maximum output for a given amount of inputs, with the availability of a given level of production technology. Allocative efficiency refers to a firm that utilizes the optimal amount of inputs to produce the optimal mix of output given the production technology and prices it faces. Economic efficiency refers to the product of technical and allocative efficiencies, which is achieved when both allocative and technical efficiencies have been attained. Cost efficiency refers to a firm that produces a predetermined quantity of output at minimum cost for a given level of technology. Cost efficiency is the capacity of a farm to produce at a given level of output using cost-minimizing input prices. The evaluation assumes that the farm intends to optimize a cost-minimization objective function subject to resource constraints. Similarly, cost efficiency arises when the value of the marginal revenue product is not equal to that of the marginal cost of that input (Maurice et al., 2015).

THEORETICAL FRAMEWORK

Farell (1957) distinguishes between technical and allocative efficiency or price efficiency as a measure of production Efficiency through the use of a frontier production and cost function, respectively. The methodology has been applied widely, while it undergoes many improvements and refinements. Ogundari et al. (2006) noted that the improvement in the development of the stochastic frontier model assists one to evaluate the firm level of efficiency using the maximum likelihood estimate. The stochastic frontier model has a composed error structure with two-sided symmetries and one-sided parts. The one-sided part shows the inefficiency, while the two-sided components show the random effects outside the control of production units, in addition to measurement errors and other statistical noise typical of empirical relationships.

According to Nguyen et al. (2008), the duality theory assumes producers to be optimizers or cost minimizers. It is supported by sound theory and empirical advantage, which includes an econometric model of objective functions that are prices rather than quantities, non–imposing of linear homogeneity among outputs and inputs, alleviation of the problem of multicollinearity, and simple derivation of measures of economic interest such as price elasticity. Given a perfectly competitive market, the unrestricted profit function contains the same economic information as the cost function. There are some problems which are associated with the selection between cost and profit evaluation; this selection depends on the data availability, quality of data, ease of estimation, or other empirical considerations (Xayavong et al., 2011). Chambers (1988) noted that the cost function represents the dual approach in that technology is seen as a constant towards the optimizing behavior of firms. The cost function can be used to simultaneously predict both the technical and allocative efficiency of a firm (Coelli, 1995), and also to generate all the economically relevant information about the firm level technology as it is generally positive, concave, non-decreasing, homogeneous of degree one to one input prices, and non-decreasing

EMPIRICAL REVIEW

The previous studies of Ogundari et al. (2006) examined economies of scale and cost efficiency in small-scale maize production: empirical evidence from Nigeria. The study employed the use of descriptive statistics and a stochastic cost efficiency frontier model for data analysis. The variables included in the cost efficiency model include the cost of labour, the cost of fertilizer, the cost of seed, annual depreciation cost, and maize output. The mean cost efficiency of the farm was estimated at 1.161, this implies that an average maize farms has costs that are about 16% above the minimum defined by the frontier, this means that approximately 16% of their costs are wasted relative to the farm with the best practices using the same technology and producing the same output of maize.

The previous studies of Paudel and Matsuoka (2009) estimated the cost efficiency of maize production in Nepal: a case study of the Chitwan district. The data were analyzed using descriptive statistics and a stochastic cost efficiency frontier model. The variables included in the cost efficiency model include the cost of tractor, cost of animal power, cost of labour, cost of fertilizer, cost of pesticides, cost of manure, cost of seed, and maize output. The mean cost efficiency of an average maize farm was estimated at 1.634, which means that an average maize farm incurred costs that are approximately 63% above the minimum cost defined by the frontier. This means that approximately 63% of the costs of maize farms are wasted in comparison to the best practice farms using the same technology, and producing the same output.

The previous study of Ogundari and Ojo (2007) evaluated the production efficiency of cassava farms in Osun State, Nigeria. The study employed the use of stochastic frontier production and cost efficiency frontier model for data analysis. The outcome shows that the cassava farms exhibited decreasing positive return to scale, which means

that cassava farmers were efficient in allocating their resources. The mean technical, economic, and allocative efficiencies were estimated as 0.903, 0.807, and 0.89, respectively.

The current work of Zaikuwi et al. (2014) evaluated the determinants of cost efficiency in cowpea production in Adamawa State, Nigeria. The study utilized the use of descriptive statistics and the cost efficiency frontier model for data analysis. The outcome shows that the mean allocative efficiency was evaluated at 0.66, which means that the producers operate at 34% below the frontier. The inefficiency models revealed that farming experience, family size, extension contact, and gender significantly reduce cost inefficiency among the producers.

Research Questions

This study proffers answers to the under-listed research questions:

(i)What are the farm-specific and farmers' features among smallholder maize growers?

(ii)What are the stimuli affecting cost efficiency among smallholder maize growers?

(iii)What are the institutional and socio-economic stimuli affecting cost inefficiency among smallholder maize growers?

(iv) What are the cost efficiency scores among smallholder maize growers?

Objectives of the Study

The major goal of the study focused on the determinants of cost efficiency among smallholder maize producers in Kano and Kaduna States, Nigeria. Specifically, the objectives were:

(i) determine the farm-specific and farmers' features,

(ii) evaluate the stimulus affecting the cost efficiency,

(iii) evaluate the socio-economic stimulus affecting cost inefficiency, and

(iv) determine the cost efficiency scores among smallholder maize growers.

Hypotheses of the Study

The study was guided by the under-listed null-hypotheses:

(i) The estimates of the input costs' elasticities are not positive.

(ii)There is no significant relationship between socio-economic stimulus and cost inefficiencies.

(iii)The cost efficiency scores are not significantly different from zero.

MATERIALS and METHODS

This work was conducted in North West, Nigeria. The maize farming is predominantly practiced in Kano and Kaduna States, Nigeria. A simple random sampling approach was utilized to select 200 maize growers within the two states. The approach was employed because it avoids an element of bias in selecting the maize growers. Secondly, the sampling approach affords the opportunity for every grower to have an equal chance of being selected. The limitations of the simple random sampling approach were under-representation of certain sub-groups, difficulty accessing lists of the full population, time-consuming, the process may cost an individual a substantial amount of capital, sample selection bias can occur, cumbersome, and challenging when the population is heterogeneous and widely spread. The sample frame of maize growers approximately 400 respondents. The total sample number consists of 100 maize growers, selected from each of the two states, respectively. Primary data obtained from cross-sectional sources were utilized based on a well-organized questionnaire that was subjected to reliability and validity tests. Enumerators were recruited and trained on the content of the research instrument (questionnaire) and the interviewing processes. Some agricultural extension agents who were familiar with the geographical terrains and socio-economic characteristics of the people were recruited, trained, and mobilized as enumerators. The questionnaires were administered and retrieved for analysis in the year 2024. The data obtained were evaluated utilizing descriptive statistics and stochastic cost efficiency frontier model.

The Stochastic Cost Efficiency Frontier Model

According to Okello et al. (2019), the stochastic frontier approach (SFA) was preferred over the non–non-parametric data envelopment analysis (DEA) since it uses the method of maximum likelihood estimates that gives more robust outcomes as opposed to DEA, which relies heavily on programming. Erkoc (2012) noted that the stochastic frontier approach is superior to DEA where there is high–quality data, while DEA was found to be better than SFA where there is poor–quality data, such as panel data studies where the researcher has no control over the quality of the

data. The analytical framework for the stochastic cost function used for the evaluation, according to Okello et al. (2019), is specified in equation (1):

$$C_{ij} = F\ (W_i, Y_i, \gamma) exp\ \pi_i\ ,\ i = 1, 2.....n\ farms \quad (1)$$

Where C_i is the cost of maize production for the ith farm, W_i is a vector of inputs associated with farm i producing output Y_i of maize, and π_i is the composite error term, which can be decomposed into $\delta_i + \mu_i$, where μ_i is the inefficiency parameter and δ_i is the stochastic term associated with random variations in production, while γ is a vector of parameters associated with the production function. F (.) is the functional relationship between cost, prices, and output.

The stochastic cost efficiency frontier model as used by Egbodion and Amadu (2015) and Ogundari et al. (2006) is expressed as:

$$Ln\ Z_i = \beta_0 + \sum_{j=1}^{5} \beta_i\ LnP_i + \beta_k LnP_k + v_i - u_i \quad (2)$$

$$LnZ_i = \beta_0 + \beta_1 LnP_1 + \beta_2 LnP_2 + \beta_3 LnP_3 + \beta_4 LnP_4 + \beta_5 LnP_5 + \beta_5 LnP_5 + Vi - Ui \quad (3)$$

Where,
Z_i = Total Cost (Naira)
β_0 = Constant Term
P_1 = Cost of Seed (₦)
P_2 = Cost of Fertilizer (₦)
P_3 = Cost of Labour (₦)
P_4 = Cost of Agrochemicals (₦)
P_5 = Annual Depreciation Cost of Farm Tools (₦)
P_6 = Maize Output (Kg)
β_1-β_6 = Regression Coefficients
V_i = Random Errors
U_i= Error Term as a result of CIE (Cost Inefficiency)

The Cost Inefficiency Model is specified as follows:

$$U_i = \propto_0 + \propto_1 Z_1 + \propto_2 Z_2 + \propto_3 Z_3 + \propto_4 Z_4 + \propto_5 Z_5 \quad (4)$$

Where,
U_i = Cost Inefficiency
$\propto_0$ = Constant Term
$\propto_1 - \propto_6$ = Parameters to be Estimated
Z_1 = Age of Maize Growers (Years)
Z_2 = Maize Farming Experience (Years)
Z_3 = Household Size (Number)
Z_4= Level of Education (Years)
Z_5 = Contact with Extension Officers (Number of Contacts per Month)

RESULTS and DISCUSSION

The Summary Data of Continuous Variables of Farm-Specific and Farmers' Features of Maize Growers

The summary data of continuous variables of farm-specific and farmers' features of maize growers were presented in Table 1. They include the standard deviation and the sample mean of the variables. The continuous farmer features under consideration include age, education level, farming experience, and household size. The continuous farm-specific features under consideration include farm size and output of maize. The outcomes show that the mean maize farm size was 1.42, 95% CI [1.349, 1.49] hectares per grower, which indicates that most growers cultivated small-scale farmland. This outcome agrees with the study of Paudel and Matsuoka (2009), who obtained the mean maize size of 0.65 hectares per farmer among maize producers in Nepal. The mean age of maize growers was evaluated at 48, 95% CI [45.6, 50.4] years, with a standard deviation of 13.38, meaning that the maize growers were relatively young. The educational level of the growers shows that the mean value of the years of schooling was 12, 95% CI [11.4, 12.6] years, with the standard deviation of 8.64. This implies that the level of education of the growers was high. The average years of farming experience were 14, 95% CI [13.3, 14.7] years (*SD* =11.27). This study agrees with the outcome of Ogundari et al. (2006), who obtained an average farming experience of approximately 13.60 years among maize growers in Ondo State, Nigeria. Averagely, the maize growers had a household size of 9, 95% CI [8.55, 9.45] persons per household. The output of maize was recorded at 2236.3 kg ha^{-1}.

Table 1. The Summary Data of Continuous Variables of Farm-Specific and Farmers Features among Maize Growers

Variables	Unit of Measurement	$\bar{X}_i$	SD
Farm Size	Hectare	1.42	0.74
Age of farmers	Years	48	13.38
Education Level	Years	12	8.64
Maize Farming Experience	Years	14	11.27
Household Size	Number	9	5.72
Output of Maize	Kg per Ha	2236.3	173.41

Source: Field Survey (2024)

The Stimuli Influencing Cost Efficiency among Maize Growers

The results of the maximum-likelihood (ML) estimates of the parameters of the stochastic cost frontier models were presented in Table 2. The outcomes revealed that all explanatory variables conform to a priori expectation, as all the evaluated coefficients of the cost of seeds, cost of fertilizer, cost of labour, cost of agrochemicals, depreciation cost, and maize output gave the positive coefficients, this means the conformity with the assumption that the cost function monotonically increases with the input prices. This outcome agrees with reports of Paudel and Matsuoka (2009). The cost of seeds, the cost of fertilizer, the cost of labour, and depreciation costs were significantly different from zero in influencing cost efficiency among maize growers at $p < 0.01$. The cost of agrochemicals and maize output is significantly different from zero in influencing cost efficiency among maize growers at $p < 0.05$. This means that these variables were the important determinants of maize production in the area. The coefficient of the cost function is referred to as the cost elasticity of production. The cost elasticities with respect to all the input variables used in the production evaluation are positive, which means that an increase in the cost of seeds, cost of fertilizer, cost of labour, cost of agrochemicals, annual depreciation cost, and maize output in kg will increase total production cost. This indicates that a unit increase in the costs of seeds and fertilizers, while keeping all other stimuli constant, will increase the total production cost by approximately $\beta = 0.1333$, $SE = 0.011$, $p = 0.000$, and $\beta = 0.39010$, $SE = 0.048$, $p = 0.000$, respectively. Similarly, a unit increase in the cost of labour and agrochemicals while keeping all other stimuli constant will increase the total cost of production by $\beta = 0.4505$, $SE = 0.092$, $p=0.000$, and $\beta = 0.1212$, $SE = 0.062$, $p = 0.070$, respectively. Additionally, a unit increase in depreciation cost and maize output while keeping all other stimuli constant will increase the total production cost b $\beta = 0.2695$, $SE = 0.0690$, $p = 0.001$, and $\beta = 0.0974$, $SE = 0.0475$, $p = 0.020$, respectively. The cost efficiency evaluation of maize growers revealed that there was the presence of a cost inefficiency effect in maize farming as evidenced by the significance of gamma value of 0.6761 at $p < .01$. This means that approximately 67.61% of the variations in the total cost of production among sampled maize growers was due to the differences in their cost efficiencies. The model is assumed to be the representation of the data, considering the highly significant value of the Log Likelihood function assumed with the maximum likelihood approach. The value of the sigma square was 0.1032, which indicates the correctness of the fit of the model as assumed for the composite error term.

The Socio-Economic Stimulus Affecting Cost Inefficiency among Maize Growers

The socio-economic stimuli affecting cost inefficiency among maize growers are depicted in Table 2. The explanatory stimuli in the model show that the signs and significance of the evaluated coefficients in the inefficiency component have important implications on the cost efficiency of the maize farming in the study area. The negative coefficients for age ($\beta = -0.022$, $SE = 0.0102$, $p=0.030$,)and farming experience ($\beta = -0.1073$, $SE = 0.01301$, $p=0.000$) means that the aged maize growers and the most experienced growers in the maize farming are more cost efficient than the younger growers, this means that as the age and farming experience of growers increase, the cost inefficiency of the growers decreases. The negative and significant coefficient for household size ($\beta = -0.0729$, $SE = 0.0052$, $p=0.000$) with the working age members signifies that the cost efficiency increases with the increase in household size. This is because the growers with larger family size rely on family labour and therefore reduce the cost inefficiency for maize farming. Similarly, the negative and significant coefficient for the level of education($\beta = -0.4044$, $SE = 0.0345$, $p=0.000$) implies that the higher is the number of years spent in school education, the lower is the cost inefficiency of the maize grower. This signifies that the farmers with more years of education are more economically efficient. The prior expectation is that cost efficiency should increase with the increase in the years of schooling since the level of education is expected to be positively related to the adoption of the improved technologies and production techniques (Ojo and Ajibefun, 2000). In addition, Paudel and Matsuoka (2009) noted that an increase in the years spent in school education may enhance skill, knowledge, and attitude to adopt more efficient technology and to allocate the inputs of production of the maize farms more efficiently.

Table 2. Maximum Likelihood Estimates of the Stochastic Cost Frontier of Maize Growers

Variable	Beta Coefficient	Standard Error	Z-Score	*p* value
Cost of Seed	0.1333***	0.0115	11.5	0.000
Cost of Fertilizer	0.3910***	0.0481	8.12	0.000
Cost of Labour	0.4505***	0.0927	4.90	0.000
Cost of Agrochemicals	0.1212*	0.0627	1.93	0.070
Depreciation Cost	0.2695***	0.0690	3.91	0.001
Maize Output	0.0974**	0.0475	2.05	0.020
Constant	5.587***	0.3963	14.10	0.001
Cost Inefficiency Component				
Age	-0.0229**	0.0102	-2.23	0.030
Farming Experience	-0.1073***	0.0052	-8.24	0.000
Household Size	-0.0729***	0.0130	-13.96	0.001
Education Level	-0.4044***	0.0345	-11.7	0.000
Diagnostic Statistics				
Log Likelihood	-41.9309			
Sigma Square	0.1032			
Gamma	0.6761			

Source: Field Survey (2024)

The Cost Efficiency Scores among Maize Growers

The cost efficiency scores among the maize growers were presented in Table 3. The predicted cost efficiencies ranged from 1.1 to 6.9. The mean cost efficiency of the maize farms was evaluated at 2.8942, 95% CI [3.039, 2.7495] this means that the average maize farm incurred costs that are about 89% above the minimum cost defined by the frontier. This signifies that over 189% of the maize farms' costs are wasted in comparison to the best practices farms facing the same technology, and producing the same output. The average cost efficiency score greater than 2 means a significant level of inefficiency among the growers, this implies that, on average, the growers are spending more than double what they should to produce the same level of output, this implies a major problem with resource allocation and cost management. In cost efficiency scoring systems, a score above one is considered inefficient; also, a cost efficiency score above 2 implies a very concerning level of inefficiency. The minimum and maximum cost efficiency scores obtained by the maize growers were 1.000 and 6.135, respectively. The higher value of the cost efficiency represents the more inefficient farms during the course of maize farming. The frequencies of the cost efficiency scores range between 1.1 and 1.9, representing 48.50% of the sampled maize farms, this implies that half of the maize growers are fairly efficient in producing at the given level of output, utilizing the cost-minimizing input ratios. This signifies that the maize farms need to minimize the waste of resources associated with the maize farming process. This study is in line with the outcomes of Ogundari et al. (2006), who stated that the frequencies of occurrence of the predicted cost efficiency between 1.0 and 1.1, representing 83% of the sampled maize farmers in Ondo State, Nigeria.

Table 3. Summary Figures of the Distribution of Cost Efficiency Scores among Maize Growers

Cost Efficiency Scores	Frequency	Percentage
1.1 – 1.9	97	48.50
2.0 – 2.9	35	17.50
3.0 – 3.9	12	06.00
4.0 – 4.9	14	07.00
5.0 – 5.9	27	13.50
6.0 – 6.9	15	07.50
Total	200	100.00
Minimum	1.0000	
Maximum	6.135	
Mean Cost Efficiency	2.8942	

Source: Field Survey (2024)

The Scale Effects (SE)

The scale effect among the maize farms was calculated as the inverse coefficient of cost elasticities with respect to the maize output recorded in Kg. The calculated scale effect was 10.27, 95% CI [10.78, 9.7365], this was computed

as ($\frac{1}{0.0974}$), the calculated scale effect is greater than one; this signifies that there are positive economies of scale. This signifies that a unit increase in the total production costs increased the total maize output by 10.27 times during the course of maize farming. The positive economies of scale also signify that an average maize grower experiences a decrease in the total production cost in the course of farming, irrespective of the area of maize farming. This means that the maize growers, despite being smallholder farmers, expand their production capacities in order to reduce their costs to the lowest minimum in the course of farming, irrespective of their size of their operation. The study revealed that the maize growers are experiencing an increasing return to scale, which is stage I of the production surface. The study of Reddy et al. (2004) noted that stage I of production can be regarded as a sub-optimal stage; in this stage, the fixed resources are abundant relative to the variable resources.

The Results of the Hypotheses Test

Tables 2 and 3 presented the results of null–hypotheses of interest. Table 2 shows that the first null–hypothesis was rejected as all the coefficients of input costs and maize output were positive. Likewise, the result of the second null–hypothesis was strongly rejected, indicating that there is a significant relationship between socio–economic factors such as farming experience, household size, and education level and cost inefficiencies of maize production. Table 3 shows that the third null–hypothesis was also rejected, which means that the cost efficiency scores were different from zero. This study is similar to the work of Ogundari et al.(2008), who reported that the input elasticities of land, planting materials, labour, fertilizer, and herbicides were all positive in influencing rice output in Nigeria.

CONCLUSION

This study focused on the determinants of cost efficiency among smallholder maize producers in Kano and Kaduna States, Nigeria. A simple random sampling approach was used to select 200 maize growers in the area. Primary data from cross-sectional sources were utilized based on a well-organized questionnaire. Data were evaluated using descriptive statistics and a stochastic cost efficiency frontier model. The following conclusions were based on the research hypotheses:

$H0_1$: *The estimates of the input costs' elasticities are not positive.*

The signs and significance of the coefficients in the cost efficiency component are important in making the decision of accepting or rejecting the null hypothesis. The coefficient provides a measure of the input cost elasticities. From the findings, the input cost elasticities were positive, and significantly different from zero, they were estimated as follows; seed (β = 0.1333, SE= 0.0115, p= 0.000), fertilizer (β = 0.3910. SE= 0.0481, p= 0.000), labour (β = 0.4505, SE= 0.0927, p= 0.000), agrochemicals (β = 0.1212, SE= 0.0627, p= 0.070), depreciation (β = 0.2695, SE= 0.0690, p = 0.001) and maize output (β = 0.0974, SE = 0.0475, p = 0.020). This means the null-hypothesis, which states that the coefficient of input cost elasticities is not positive, was rejected, while the alternative hypothesis(Ha_1) was accepted. This study agrees with Abdul et al. (2017) who documented that the input cost elasticities were positive among maize farmers in Adamawa State, Nigeria, and they were estimated as follows; land (0.7283), seed (0.1586), fertilizer (0.0323), family labour (0.0763), hired labour (0.0113), and agrochemicals (0.1410).

$H0_2$*: There is no significant relationship between socio-economic stimulus and cost inefficiency.*

The signs and significance of the socio-economic factors in the cost inefficiency component are important in making a decision to accept or reject the null hypothesis. The negative signs of the coefficient of socio-economic stimuli indicate a decrease in cost inefficiency or an increase in cost efficiency, while the positive signs of the coefficient of socio-economic stimuli indicate an increase in cost inefficiency or a decrease in cost efficiency. The study displayed that the significant socio-economic stimuli influencing cost inefficiency (cost efficiency) include age, farming experience, household size, and level of education. Therefore, the null hypothesis, which states that there is no significant relationship between socio-economic factors and cost inefficiency was rejected, while the alternative hypothesis (Ha_2) was accepted. This work agrees with studies of Tashikalma et al. (2014) who noted that greater family size of average working age increases efficiency this is due as most producers are financially constrained.

$H0_3$*: The cost efficiency scores are not significantly different from zero.*

The size or magnitude of the cost efficiency scores is important in making a decision to accept or reject the null hypothesis. The cost efficiency scores were greater than zero; this study further revealed that the calculated mean cost efficiency score of 2.8942, 95% CI [3.039, 2.7495]. The minimum and maximum cost efficiency scores were 1.000 and 6.135, respectively. The null hypothesis, which states that the cost efficiency scores are not significantly different from zero, is rejected, while the alternative hypothesis(Ha_3) was accepted. This study is in line with the works of Ogundari et al. (2006), who obtained the cost efficiency scores of between 1.00 and 3.10 among maize growers in Nigeria. Based on the outcomes of this work, the following suggestions were made:

(i) The maize growers should form themselves into cooperative groups, this will enable them to access credit, access to formal sources of credit will enable them to acquire improved maize seeds, fertilizers, agrochemicals, and other farm inputs, access information, and share ideas about maize farming. Farmers should be encouraged to form themselves into cooperative groups so that they can pool their resources together, get adequate funds to finance maize farming activities.

(ii) Credit should be provided by public and private organizations at a single interest rate to increase output, credit should be provided at an appropriate time, which will enable the maize growers to procure farm inputs at appropriate time and increase cost efficiency.

(iii) Extension services should be improved and developed to disseminate research findings to maize growers. The extension service-farmers' linkage is important for capacity building, seminars, and workshops for farmers on innovations and new improved technologies that will increase cost efficiency. Effective extension programmes should be developed that will educate the maize growers on efficient allocation of production resources and reduce the negative consequences of inefficient use of resources, educate the maize growers on fundamental farm management skills, which will enables them to plan, appraise and evaluate their farm business activities.The maize growers need to acquire basic education since education positively influences efficiency.Policies designed to educate maize growers through proper agricultural extension services could have a great effect on increasing the level of efficiency, optimizing the farm resources, and increase the output of maize farmers.

(iv) Policies and programmes that will focus on encouraging more young people to agriculture should be formulated, enacted and implemented. Also, government should direct its agricultural programmes to exopand the maize growing areas through the provision of adequate facilities. Any expansion in their current level of production would bring down the cost of production per unit.

The significance of the schooling years of maize growers implies that the provision of education facilities as well as the inclusion of the younger generation, which is more educated, will significantly improve the cost efficiency of maize farming.

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