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Economics of Scale and Cost Efficiency in Small Scale Maize Production in Mubi North Local Government in Adamawa State, Nigeria

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Abstract: This study presents economics of scale and cost efficiency of small scale production of maize in Mubi North local government in Adamawa State, Nigeria. A multi stage sampling techniques was used to select 180 farmers in the study area. The results shows that maize farming in the study area is profitable and economics of scale was obtained as 1.252 (E_S>1), hence economics of scale exists. Results of the stochastic frontier cost function showed that variance parameter gamma (γ) and sigma (σ^2) are both significant at 1% level. Parameter of estimate indicated positive relationship and significance at 1% level for fertilizer, herbicides, seeds and hired labour. Mean cost efficiency index was 1.04, slightly above frontier cost indicating that they are efficient in allocating their scarce resources.

Key words: Economics of scale, stochastic frontier cost function, cost efficiency, small scale maize production, Mubi North L.G

INTRODUCTION

Maize and other cereals constitute important sources of carbohydrates, proteins, vitamin B and minerals (Iken *et al*., 2002). Maize is a stable food crop for most sub-saharan Africans of which Nigeria is inclusive with per capital kg year^{-1} of 40 (FAO, 2003). In Nigeria maize is the third most important cereal crop after sorghum and millet (Ojo, 2000), the demand for maize as a result of various domestic uses shows that a domestic demand of 3.5 million metric tons outstrips supply production of 2 million metric tons (Akande, 1994). The ability of the Nigerian agriculture to perform its role in agricultural development according to Ogundari *et al.* (2006) has been on decline in the last three decades. Hence, the Nigerian government adopted different agricultural programmes and policies aimed at raising productivity and efficiency of agricultural sector. These programs and policies placed the small holder farmers in central focus. This was due to the fact that the nation's agriculture has always been dominated by the smallholder farmers who represent a substantial proportion of the total farming population and produce over 90% of the total agricultural output in the country (Ajibefun *et al*., 2002). Low capitalisation, price fluctuation, disease and pest, poor storage facilities and inefficiency of resources utilization are the identified problem in maize production in Nigeria (Ojo, 2000). In view of this production, efficiency of small holder farms has important implication for the development strategies adopted in many developing countries where the primary sector is still dominant. An improvement in the understanding of the level of production efficiency and its relationship with host of farm level methods can greatly aid policy makers in creating efficiency, enhancing policies as well as judging the efficacy of the present and past government reforms in the agricultural sector. The broad objective of the study is to examine the economics of scale and cost efficiency in small scale maize production in Mubi North local government in Adamawa State, Nigeria. The specific objectives are to:

- Determine the cost efficiency of the farmer in the study area
- Determine the profitability and economics of scale of maize farming in the study area

Null hypothesis: There is no significant relationship between maize output and the input used by the farmers.

Theoretical framework: Efficiency is the act of achieving good result with little waste of effort. It is the act of harnessing materials and human resources and

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coordinating these resources to achieve better management goal. Farrell (1957) distinguished between technical and allocative efficiency (price efficiency) as a measure of production efficiency through the use of frontier production and cost function, respectively. He defines technical efficiency as the ability of affirm to produce a given level output with a given with a minimum quantity of input under certain technology and allocative efficiency is the ability of the firm to choose optimal input level for a given factor prices. In Ferrell framework, Economic Efficiency (EE) is an overall performance measure and is equal to the product of Technical Efficioency (TE) and Allocative Efficiency (AE) (i.e., EE = TexAE). Therefore, technical and allocative efficiency are components of economic efficiency (Abdulai and Huffman, 2000). Economic application of the stochastic frontier model for efficiency analysis include (Aigner *et al*., 1977) in which the model was applied to U.S. agricultural data. Batesse and Corra (1977) applied the technique to the pastoral zone of eastern Australia. More recently, Ogundari and Ojo (2005), Ojo (2004), Ajibefun *et al*. (2002), Bravo-Ureta and Pinheiro (1993) and Ali and Byerlee (1991) in which they offer a comprehensive review of the application of stochastic frontier model in measuring of the agricultural producers in the developing countries.

Production is define as the transformation of goods and services into finished products (that is input-output relationship) and this is applied to every production process, maize production inclusive (Oyewo *et al*., 2009). The production technology can be represented in the form of cost function. The cost function represent the dual approach in the technology is seen as a constant towards the optimizing behaviour of a firm (Chambers, 1983). In the context of the cost function any error of optimization is taken to translate into higher cost for the producers. However, the stochastic nature of the production frontier would still imply that the theoretical minimum cost frontier would be stochastic.

MATERIALS AND METHODS

Study area: This study was based on the farm level data and small scale maize farmers in Mubi North local government in Adamawa State, Nigeria, the study area comprises of different villages which are rural in nature. Mubi is located approximately on the intersection of latitude 9°30'N and longitude 11°45' E. It has a land mass of 4.728.27 km^2 and a population of 681, 353 (Adebayo and Tukur, 1999; NPC, 2007). Mubi is located with the savannah belt of the Nigeria's vegetation zones (Adebayo and Tukur, 1999).

Sampling procedures: Maize farmers are the target respondents for the study. About 180 maize farmers were selected from the study area and were used for the study. The sampling technique employed is the multistage stratified random sampling technique.

The first stage involved purposive selection of the rural areas such as Muchalla, Muva, Muvur, Bahuli, Madanya, Mayobani and Betso, respectively. The second stage involved simple random sampling through random selection of 180 maize farmers in the study area.

Source of data: Questionaire and interview schedule were the source used to collect data from the farmers for the study.

Data analysis: The data obtained from the field were subjected to analysis using inferential statistics and correlation analysis which was used to test the hypothesis.

The stochastic frontier production model was used to determine the between the dependent variable (maize output) and the independent variables as well as to determine the technical efficiency in farmers operation in the study area.

Model specification

Stochastic frontier model specification: In this study, Battese and Coelli (1995) model is used by Ogundari *et al.* (2006) to specify a stochastic frontier cost function with behaviour inefficiency component and to estimate all parameters together in one step maximum likelihood estimation. This model implicitly expressed as:

$$L_nC_i = g(P_i, Y_i, \beta) + (V_i - U_i)$$

Where:

- C_i = The total production cost
- g = Suitable functional form such as Cobb Douglas
- P_i = Vector variable input prices (transport, fertilizer, labour, seed and herbicides)
- Y_i = The valve of maize produce in kg
- V_i = The systematic component which represents random disturbance cost due to factors outside the scope of the farmers
- U_i = The one sided disturbance farm used to represent cost efficiency and is independent of V_i
- β = The parameter of the estimate

Moreover, for the study the cost efficiency of an individual farm is define in terms of the ratio of the observed cost (C^b) to the corresponding minimum cost (C^{min}) given the available technology. That is cost efficiency (C_{EE}).

$$\frac{C^b}{C^{min}} = \frac{g(P_i, Y_i, \beta) + (V_i + U_i)}{g(P_i, Y_i, \beta + (V_i)} = \exp(U_i)$$

Where:

C^b = The observed cost represents the actual total production cost

C^{min} = Minimum cost and represents the frontier total production cost or least cost total production level

$$C_{EE} = \exp(U_i)$$

C_{EE} takes the values of 1 or higher with 1 definig cost efficient farm. And following the adoption of Battese and Coelli (1995) framework for the analysis of data, the explicit Cobb Douglas functional form for maize farm in the study area is therefore specified as follow:

$$\ln C_i = \beta_0 + \beta_1 l_n P_1 i + \beta_2 l_n P_2 i + \beta_3 l_n P_3 i + \beta_4 l_n P_4 i + \beta_5 l_n P_5 i + \beta_6 l_n P_6 i + \beta_7 l_n Y_i + (V_i + U_i)$$

Where:

C_i = Total production cost

P_1 = Cost of transportation

P_2 = Cost of fertilizer

P_3 = Cost of herbicides

P_4 = Cost of seeds

P_5 = Cost of labour

P_6 = Depreciation cost

Y_i = Output of maize (kg ha^{-1})

The choice of Cobb Douglas is based on the fact that the methodology requires that the function be self-dual as in the case of cost function in which the analysis is based on the inefficiency model U_i is define by:

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i}$$

Where Z_1-Z_4 represents age, farming experience, farm size and literacy level, respectively. These socio-economic variables are included in the model to indicate their possible influence on the cost efficiency of the farmer. The test for the presence of cost inefficiency using generalized likelihood-ratio statistics is shown by:

$$\lambda = 2 l_n (H_0 \frac{1}{H_A})$$

Where:

H_0 = The value of likelihood function in which parameters restriction specified by the null hypothesis H_0 are imposed

H_A = The value of the likelihood functions for the general frontier model

The variance parameters are :

$$(\sigma^2) = \sigma^2 v = \sigma^2 u$$

$$\gamma = \sigma^2 \frac{u^2}{\sigma} v + \sigma^2 u$$

Economics of scale (E_s) Economics of scale may be defined in term of elasticity of cost with respect to output. Economics of scale prevail exist if E_S>1. Diseconomies of scale exist if E_S<1.

In this case where E_S = 1 no economies of scale or diseconomies of scale exist. However, in multi-product setting, economies of scale (E_s) is defined on those reduction on average cost when all output are increased proportionally holding all other input prices constant. Economics of scale is mathematically equivalent to the inverse of the sum of all the elasticises of total production cost with respect to all output (Ogundari *et al*., 2006).

RESULTS AND DISCUSSION

The summary statistics of the variables for the frontier estimation in Table 1 shown the sample mean and standard deviation for each of the variables. The mean value of N24,859.39 as total cost of producing 1,271.69 kg ha^{-1} of maize was obtained from the data analysis with a standard deviation of N11,051.49.

The large standard deviation conforms to the fact that most of the farmers operate at different scale of operation. Analysis of the cost variables of the farmers showed that labour accounts for about 40% of the total cost due to the fact that there is a reduction in a number of house hold participation in farm operation since most farmers sends their children to the city for proper education. Hence, farmers depend heavily on hired labour to do most of the farming operations. This justifies the cost of expended labour. Cost of fertilizer, herbicides and seed account for 26.83, 19.52 and 4.39% of the total cost, respectively.

Table 1: Summary statistics of the variables in stochastic frontier model

Variable	Mean	Standard deviation	TC (%)
Total production cost (N)	24,59.39	11,051.49	-
Cost of transportation (N)	1,197.49	727.12	4.82
Cost of fertilizer (N)	6,670.95	5,250.93	26.83
Cost of herbicides (N)	4,853.36	2,244.83	19.52
Cost of seed (N)	1,091.89	526.29	4.39
Cost of labour (N)	10,077.35	8,568.90	40.54
Depreciation cost (N)	859.01	640.03	3.46
Maize output (kg ha^{-1})	1,271.69	1,838.81	-
Age of the farmers (years)	48.10	11.06	-
Farming experience (years)	24.31	13.05	-
Farm size (ha)	4.42	2.00	-
Literacy level (rating: 0-5)	2.35	2.04	-

Field survey, 2009

While transportation and depreciation cost account for 4.82 and 3.46% of the total cost, respectively. Variables representing the demographic characteristics of the farmers employed in the analysis of the determinant of cost efficiency include age of the farmers, farming experience and farm size and literacy level. The average age of the farmers was 48.10 meaning that the farmers are in their middle age (i.e., relatively young). The average farming experience was 24.31 years, implying the maize farmers has many years of experience and so should produce high output. Literacy level was rated 2.35 meaning that most of the farmers attended primary school and a bit of secondary education (i.e., relatively educated). Maximum likelihood estimates of the parameters of the stochastic cost frontier model are shown in Table 2.

All the parameter estimate have the expected signs with the cost of transportation, fertilizer, herbicides, seed, labour, annual depreciation and maize output are highly significant at 1% level meaning that these factor are significantly different from zero and thus are important in maize production. The cost elasticises with respect to all input variables used in the production analysis is are positive and imply that an increase in the cost of transportation, cost of fertilizer, cost of herbicides, cost of seed, cost of labour, annual depreciation cost and production (maize output in kg) increases total production cost by 0.03, 1% increase in the cost of fertilizer will increase total cost by 0.07, 1% increase in the cost of herbicide will increase total cost by 0.02, 1% increase in the cost of seed will increase total cost by 0.2, 1% increase in annual depreciation will increase the total cost by 0.10%; 1% increase in maize output will increase the total production cost by 0.23%.

Table 2: Maximum likelihood estimates of parameters of the cobb douglas frontier function for maize farmers in the study area

Variables	Parameters	Estimated coefficient (t-ratio)
General model		
Constant	β_0	1.712*** (15.409)
Cost of transportation (N)	β_1	0.00031*** (3.575)
Cost of fertilizer (N)	β_2	0.072*** (2.707)
Cost of herbicide (N)	β_3	0.024*** (2.402)
Cost of seed (N)	β_4	0.204*** (4.361)
Cost of labour (N)	β_5	0.136*** (5.729)
Depreciation cost (N)	β_6	0.104*** (3.785)
Maize output (kg)	β_7	0.228*** (5.902)
Cost elasticity		0.799
Inefficiency model		
Constant	δ_0	-0.546 (-0.600)
Age of farmers (years)	δ_1	-0.119*** (-3.011)
Farming experience (years)	δ_2	0.194*** (5.948)
Farm size (ha)	δ_3	-0.861*** (-4.307)
Literacy level (rating 0-5)	δ_4	0.517*** (2.914)
Variance parameters		
Sigma-squared	σ^2	0.775*** (3.955)
Gamma	γ	0.910*** (27.549)
Log likelihood function	uf	136.593

Field survey 2009, ***estimates are significant at 1% level

However, labour cost, transportation cost and capital cost (cost of fertilizer, herbicides, seed and annual depreciation) are positive implying that the cost function monotonically increases in input prices (i.e., increasing input prices in the same proportion). The estimated coefficient in the explanatory variables in the model is shown in Table 2 for the cost inefficiency is of interest and has important implication. The negative coefficient for age and farm size implies the age of the farmers and the farm size in maize production are more cost efficient than the younger ones meaning that the age and farm size increases in the study area the cost inefficiency of the farmers decreases. This is in conformity with the assumption that farmers age affects the production efficiency, since the farmers different ages have different farm sizes. The positive coefficient of literacy level indicates that farmers level of cost efficiency tend to decline with education. This is in contradiction with the assumption that educational level of the farmers will have positive effect on the level of efficiency as the embody skill that can improve their overall efficiency. The estimated gamma (γ) of 0.910 in the lower part of Table 2 were highly significant at 1% level of the measurement error and other random disturbance, thus indicating that 91% of the variation in the total cost of production among the sampled farmers was due to difference in their cot efficiencies.

Sigma-squared (σ^2) are on the other hand is 0.775 and is statistically significant at 1% level. Since the fig is significantly different from zero, it indicates a good fit and correctness of distributional form assumed for the composite error term. Table 3 shows summary of cost efficiency scores for the maize farmers in the study area. Cost efficiency is estimated as C_{EE} = expU_i, the mean cost efficiency of the farmers was estimated as 1.04, meaning an average maize farmer has cost that are about 4% above the minimum defined by the frontier. In other words 4% of their costs are wasted relative to the practiced farms producing the same output (maize) and facing the same technology. The higher the value of C_{EE} the more inefficient the farmer is.

Table 3: Cost efficiencies of the sampled maize farmers

Efficiency level	Frequency	Relative efficiency	Percentage (%)
1.00-1.02	41		22.8
1.03-1.05	118		65.6
1.06-1.08	15		8.3
1.09-1.11	5		2.8
1.12-1.15	0		0.0
1.16-1.18	1		0.5
Total	180		100.0
Minimum		1.00	
Maximum		1.18	
Mean		1.04	
Mode		1.04	

Field survey, 2009

However, frequencies occurrence of the predicted cost efficiency between 1.00 and 1.05 representing about 88.4% of the sampled farmers implies that the majority of the farmers are efficient in producing a given level of output using cost minimizing input ratio which reflects the farmer's tendency to minimize resource wastage associated with production process from cost perspective.

The result of the hypothesis as shown in Table 4 by correlation coefficient showed that fertilizer, herbicides and hired labour are highly significant at 1% level and positively related to maize output. This implies that increase in the amount used to these variables will lead to increase in maize output. Seed and family labour are however not significant.

The study examines economics of scale and cost efficiency in maize production in Mubi North local government in Adamawa state. A multistage sampling technique was used to select 180 farmers in the study area.

Data were collected and subjected to inferential statistics (OLS) and the stochastic frontier production model which was used to determine the relationship between the dependent variable (maize output), the independent variables and the technical inefficiency in farmers operation in the study. A Cobb Douglas functional firm was used to impose the assumption that return to scale and economics of scale are equivalent measures if and only if the production function is homothetic.

Sigma (σ^2) was 0.077 which represents good fit and correctness of the distributional form assumed for the composite error term. Gamma (γ) was 0.910 which shows 91% of the variations in output is due to difference in the farmer's cost efficiency.

Finding showed that 88.4% of the farmers were close to the frontier level achieving scores of about 4% lower in term of cost difference in relation to the best practiced technology. However, the level of observed cost efficiency has been showed to be significantly influenced by age and farm size. This means that as the farmers' age and farm sizes increases, there will be a corresponding increase in the ability of the farmers to efficiently allocate prices or cost to inputs used.

Table 4: Correlation coefficient between maize output and input used by the farmers

Input	Correlation coefficient	Decision rule
Fertilizer	0.323***	Reject H_O
Herbicide	0.412***	Reject H_O
Seed	0.134	Accept H_O
Hired labour	0.422***	Reject H_O
Family labour	-0.047	Accept H_O

***Coefficient significant at 1% level. Field survey, 2009

CONCLUSION

It is observed that the maize farming in the study area is profitable and economics of scale exist. The closeness of the average cost efficiency (C_{EE}) of 1.04 to unity is an indication that, although, farmers are small scale resource poor, they are efficient in the use of their resources and that any expansion in their present level of production will bring down the cost of production per output. The prevailing economics of scale obtained for the study is in accordance with result of Ogundari *et al.* (2006) that indicated higher relative efficiency for small farms.

RECOMMENDATIONS

Based on the finding in the study area, the following are recommendated. More effort should be intensified on the part of extension agent in educating the farmers so as to boast their efficiencies in maize production.The farmers should be encouraged to keep records also, they should be thought the recommended quantities of agrochemicals and improved seed to use on their farms in order to achieve optimum yield. This will help the farmers to make better farm plans in the future so as to increase output as well as profit. The useful policy recommendations made by agricultural researchers should be implemented by the government. This will go along way in contributing towards the achievement of self sufficiency in the nation.

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