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STOCHASTIC FRONTIER ANALYSIS OF HOT PEPPER PRODUCTION AMONG SMALL-SCALE FARMERS IN DUTSIN-MA LOCAL GOVERNMENT AREA OF KATSINA STATE, NIGERIA

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ABSTRACT: *This study used the Stochastic Frontier model to analyze hot pepper production among small-scale farmers in Dutsin-ma Local Government Area, Katsina State. Purposive and proportionate random sampling techniques were used to select 121 hot pepper farmers from whom the data was collected using a structured questionnaire. The data was analyzed using descriptive statistics, gross margin analysis, and stochastic frontier production function model. The result of the study shows that hot pepper production activity is dominated by male (99.2%) and married (95.0%) farmers whom are middle aged (Mean = 39 year) and most of them (about 53%) have household size of 1-10 persons, and an average farming experience of 13 years with a farm size average of 1.5 hectares. Majority of the hot pepper producers are engaged in its production for income generation while only few among them have access to credits. The result of the gross margin analysis (GM) shows that hot pepper farmers incurred total variable cost (TVC) of NGN138,703.6, and a return of NGN164,513.4 that yielded the profit of NGN25,809.8 per hectare of production and a return on investment of 1.28. The average technical efficiency (TE) of the farmers was found to be 80% among hot pepper farmers in the study area. Moreover the result of the frontier analysis shows that seed, labor and fertilizer are significant inputs determining hot pepper output. In addition to that inefficiency components of the frontier analysis revealed education, access to extension service, cooperative membership, Years of farming experience, farm size, and household size to be the significant determinants of efficiency of hot pepper production in the study area. The result also revealed that farmers in the study area are faced with major challenges of high costs of production inputs and problems of pests and diseases.*

KEYWORDS: Stochastic frontier, Analysis, Hot pepper, Production, Small-scale farmers.

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INTRODUCTION

Pepper *(Capsicum spp)* is one of the widely used foods and the most widely grown spice crop in the world (Idowu-agida, Nwaguma & Adeoye, 2010; Kim, Park & Kim, 2014). It was ranked third among the world's most important vegetable crops, after tomato and onion (Peet, 2006), and considered the first spice to have been used by humans (Hill, Ashrafi, Reyes-Chin Wo, Yao, & Stoeffel, 2013). Its origin extends from Mexico in the North to Bolivia in the South of Latin America, where it has been part of the human diet since about 7500 BC (Purseglove, Brown, Green & Robbins, 1981).

Pepper *(Capsicum spp)* is a genus of plant from the nightshade family Solanaceae. Some of these plants are used as spices, vegetables or drugs. They are commonly called hot pepper, red, green pepper or just pepper, originated in America and are grown worldwide (Dimelu, 2010). According to Dimelu (2010), pepper is an important source of vitamins and minerals thus forming an essential component of the human diet. Pepper is a rich source of vitamins A, B and C and a therapeutic agent for cancer. As a result of this, there had been increased trade activities surrounding this commodity. They are frequently used both chopped or raw in salads or cooked in stir fries or other mixed dishes. They can be preserved by drying or pickling. Dried pepper may be reconstituted whole or processed into flakes or powder (Abel, 2009). Extracts can be made and incorporated into hot sauces. In many households, pepper provides countless needs such as enhancing diets intake, storing of grains and mild drugs. Bosland and Votava (2000) reported that pepper is used for flavoring, adding taste in food, coloring cosmetics and imparting heat to medicine by manufacturing industries. It is also used as an ornamental plant and the red powdered pepper is used for coloring flamingos in the zoo. Baluk and Daniel (2009) stressed that pepper is used as pepper spray and tear gas for weapons. He further reported that pepper fruits vary in sizes, shape, color, flavor and pungency and the variation reflected in their nutritional composition.

The demand for pepper is rapidly increasing and there is a great need for increased production (Abayomi, Aduloju, Egbewunmi & Suleiman, 2012). The efficiency with which farmers use resources and technologies available to them are imperative in Nigerian agricultural production. Non-consideration of this has resulted in low farm income which has weakened the financial position of smallholder farmers who produce most of the crops in Nigeria (Mgbenka *et al*., 2015). Low farm income has led to poor funding of their economic activities; The implication of production efficiency is that there is scope for further increase in output from existing hectares of crop if resources are accurately exploited (Rahji & Omotesho, 2006). Similarly, the measurement of the productive efficiency in agricultural production is an important issue because it gives pertinent information for making sound management decisions in resource allocation. Except for a few descriptive studies, econometric analysis has yet to be conducted to examine the production function for hot pepper cultivation and its potential for future improvement. The production of pepper in Nigeria has been affected by different constraints that minimize the production of pepper. The output obtained in the production has been declining every year and the production is still carrying on again and again. The main objective of this study is to examine the economic analysis on hot pepper production among hot pepper farmers in Dutsinma Local Government Area, Katsina State. The specific objectives are to examine the socio-economic characteristics of hot pepper farmers, estimate the cost and returns of hot pepper production, estimate the technical efficiency of hot pepper production, determine socio economic factors influencing the technical efficiency of farmers and describe the problems associated with hot pepper production in the study area.

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METHODOLOGY

Description of the Study Area

Dutsin-Ma LGA lies at latitude 12°26'N and longitude 07°29'E. It is bound by Kurfi and Charanchi LGAs to the north, Kankia LGA to the east, Safana and Dan-Musa LGAs to the west, and Matazu LGA to the southeast. Dutsin-Ma LGA has a land size of about 552.323 km2 with a population of 169 829 as at 2006 national census (Nigerian Population Commission, NPC, 2012). The people are predominantly farmers, cattle rearers and traders. The climate of the area is tropical continental, which is dry (Koppen's Aw), with the total annual rainfall ranging from 700-800mm (Ibrahim & Saifullaih, 2016). Generally, the topography is gently undulating with an elevation of between 526m-547m with scattered ironstone hills and outcrops overlying basement complex rocks and characterized by sandy drift plain (Chukwujekwu, 2010). The drift deposits of the soil are more coarse resulting in light brown sandy soil that is reddish in color with medium fertility and easily worked. The study area has experienced a rapid population growth with an estimated total population figure of about 9, 000 people (Independent Nigeria Electoral Commission. INEC, 2015).

Sampling Procedure

Two-stage sampling technique was employed in the selection of respondents for the study. The first stage was a purposive selection of five communities in Dutsin-Ma LGA due to high concentration of hot pepper production in the area. While second stage involved proportionate random selection of requisite respondents as determined by using Yamane formula from the sample frame of farmers that produces hot pepper (which was obtained from the five villages selected during the reconnaissance survey for the study). A random number sampling was used to finally select farmers from the sampling frame. This led to selection of 121 respondents for the study as shown in Table 1 below.

Yamane formula as used by Anokye (2020) is given as $n = N/1+N(e)^2$

Where: n = required sample size N = total population e = degree of accuracy expressed as proportion. Therefore: the required sample size will be $n = 174/1+174(0.05)^2$
$n = 121$.

Table 1: Sampling Summary

Villages	Farmers population	Required sample size
Z/ Dantakiri	30	24
Takatsaba	40	28
Gago	27	19
Ruwan Gamji	42	29
Tabobi	31	21
Total	174	121

Source: *Field Survey, 2023*

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Method of Data Collection

Primary data was collected using a structured questionnaire. The data collected include Socio-economic characteristics of the farmers, cost of inputs used in the production of hot pepper and problems faced by farmers in the production process.

Data Analysis

The analytical tools that are to achieve the objectives of this study were: descriptive statistics, gross margin analysis, and stochastic frontier production function model.

Gross Margin Analysis

Gross margin (GM) analysis tool was used to estimate the costs and return in hot pepper production. The total variable cost and total revenue was estimated. The difference between the two is the gross margin (GM). The gross margin analysis was used based on the assumption that fixed costs in small scale farming are negligible (Olukosi & Erhabor, 2006). And these follow the study by Adeleke, Matanmi and Ogunniyi (2008).

Gross margin is calculated as:

$$GM = TR - TVC \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where:

GM = Gross margin (N/ha)

TR = Total revenue (N/ha)

TVC = Total variable cost (cost of seed, cost of fertilizer, cost of agrochemical and cost of labor).

The Stochastic Frontier Production Function Model

The stochastic frontier production function has the advantage of allowing simultaneous estimation of individual technical efficiency of the farmer as well as identifying determinants of technical efficiency (Battese & Coelli, 1977). The Cobb-douglas is commonly used in the estimation of the stochastic frontier production function because a logarithmic transformation provides a model which is linear in the logarithms of the inputs, hence the Cobb-Douglas as form is very easy to estimate. The Cobb-Douglas stochastic frontier production function is expressed as:

$$\ln Y = a_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta 5 \ln X_5 + \beta_6 \ln X_6 + (Vi - Ui)$$

Where:

ln = The natural logarithm

Y = yield (kg/ha) of hot pepper

a_o = Intercept (constant term)

$a_1 - a6$ = Regression coefficients to be estimated.

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X_1 = Seed (kg)

X_2 = Labour (man-hour)

X_3 = Fertilizer (kg)

X_4 = Herbicides (ltr)

X_5 = Pesticides (ltr)

Vi = Error term not under the control of farmers

Ui = Error term under the control of farmers (technical inefficiency)

The determinants of technical efficiency were modeled in terms of the socio-economic factors that assumed to affect the technical efficiency of production of farmers. The model to identify determinants of efficiency is specifically expressed as:

$$Ui = \beta o + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + \beta 5X5 + \beta 6X6 + \beta 7X7 + \beta 8X8 + ei$$

Where:

Ui= Technical inefficiency

β_o = Constant

β_1 -β8 = Regression coefficients

X_1 = Age (years)

X_2 = Household size (Number of persons)

X_3 = Farming experience (years)

X_4 = Educational level (years)

X_5 = Farm size (ha)

X_6 = Extension visits (number of times each farmer had extension contact in a Year)

X_7 = Membership of cooperatives (years)

ei = Error term

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RESULTS AND DISCUSSION

Socio-Economic Characteristics of the Respondents

The survey of the sampled farmers in Table 1 showed that Majority (over 70%) of the farmers are between 31-50 years. The average age of the farmers was 39 years. This shows that the farmers are strong and agile and would likely be more efficient than the aged farmers in agricultural production. This is in support of the findings of Rahji and Ometesho (2019) that farmers of this age group can influence the adoption of improved agricultural practices, which can equally influence a high level of pepper productivity. The study also revealed that the majority of the hot pepper farmers (99.2%) are male. This could be attributed to the culture and norms of people in the study area; which implies that male pepper producers dominated production activities. In addition to that majority of the farmers (95.0%) are married. The dominance of married people in any crop production business has a positive effect on the business and raises money to cater the family needs (Darykong, 2010). The study also shows that the majority of the farmers (62.1%) has a household size of between 1 – 10 persons, with an average household size of 9 persons, implying that there is an appreciable source of family labor. According to the report of Mohammed (2015), there is a positive and significant relationship between household size and farmers‟ efficiency in production. Since the production of the crop is not mechanized, farmers depend solely on human labor which is an important variable in agricultural production. Table 2 results for educational status showed that a good number of the farmers had formal education, ranging from primary (30.6%), secondary (30.6%) and tertiary education (9.1%), while (29.8%) of them had no formal education. As reported by Amaza (2013), education has a positive and significant impact on farmers' efficiency in production. This literacy level will greatly influence the decision making and adoption of innovation by farmers, which may bring about an increase in production of the crop. The farming experience of the farmers in Table 2 shows that the majority (over 50%) of the farmers had between 1-20 years of experience, while farmers average years of farming experience was 13 years in the study area. The size of farm holdings of the respondents for hot pepper production is shown in Table 4.5 below, the findings shows that 90% of the farmers have a land area for production of 0.5 – 2.0 hectares of land, meanwhile their average farm size is 1.5 hectares. This implies that the production of hot pepper in the study area is carried out predominantly by small-scale farmers. Table 2 result of the study further showed that, there is very limited access to extension services in the study area as only few (13.2%) of the farmers have access to extension services and they are Productivity would be higher when farmers belong to cooperative associations Ekong (2020). The survey result also shows that only few (8.1%) of the farmers belong to farmers cooperatives.

Table 2: Distribution of Socioeconomic Characteristic of Hot Pepper Farmers

Characters	Frequency	Percentage
Age of the farmers		
19-30	21	17.4
31-40	53	43.8
41-50	44	36.4
51-60	3	2.5
Mean	39	

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Household size		
1-5	25	12.7
6-10	50	41.3
11-15	38	31.4
16-20	7	5.7
21-25	1	0.8
Mean	9	
Farm size		
0.5-1.0	61	50.4
1.1-2.0	48	39.6
2.1-3.0	8	6.6
3.1-4.0	2	1.7
4.1-5.0	2	1.7
Mean	1.5	
Farming experience		
1-10	58	48.0
11-20	53	43.1
21-30	9	7.4
31-40	1	0.8
41-50	0	0
Mean	13	
Sex		
Male	120	99.2
Female	1	0.8
Marital status		
Married	115	95.1
Widowed	1	0.8
Single	5	4.1
Educational status		
No formal education	36	29.8
Primary education	37	30.6
Secondary education	37	30.6
Tertiary education	11	9.1
Extension contact		
Contact	16	13.2
No Contact	105	86.8
Membership of cooperatives		
Members	11	9.1
Non-Members	110	90.9

Source: *Field Survey, 2022*

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Cost and Returns of Hot Pepper Production in the Study Area

The result of the analysis of the cost and returns for a hectare equivalent of small-scale hot pepper production in the study area is presented in Table 3. The result also shows that fertilizer cost constituted a greater proportion of the costs incurred in hot pepper production process accounting for 50.7% while labor account second with 18.7% of the cost, whereas pesticide and herbicide account for 16.9% and 10.2% respectively and seed only account for 3.5% of the production cost. The result indicated the hot pepper farmers have a total revenue of NGN164,513.4 per hectare while the total variable costs incurred was NGN138,703.6 per hectare; giving, a gross margin of NGN25,809 per hectare. Also, the table shows that the return per naira invested for hot pepper farmers was 1.28. These results indicate that hot pepper production is a profitable venture in the study area which is in line with the findings of Suleiman and Isah (2010) that hot pepper production responds to production inputs.

Table 3: Cost and return of hot pepper production per hectare (ha)

Inputs/items (ha)	Quantity	Amount(NGN)	Percentage cost
Variable cost			
Seed (kg)	2.5	4839.5	3.5
Fertilizer (kg)	197.9	70278.1	50.7
Pesticide (ltr)	4.1	23550.8	16.9
Herbicide (ltr)	3.5	14106.9	10.2
Labour (Mdays)	17.0	25928.3	18.7
TVC		138703.6	100
Total revenue	299.2	164513.4	
Gross margin		25809.8	
Return on investment		1.28	

Source: *Field Survey, 2022*

Technical Efficiency (TE) Score of Hot Pepper Producing Farmers

The results of the efficiency scores indicate that there were no wide ranges of differences in TE among Hot pepper farmers. The average TE was found to be 80.59% which indicated that, if sample farmers in the study area operated at full efficiency level, households would have increased their output by 19.10% using the existing resources and level of technology. In other words, it implied that on average sample households in the study area can increase their output by 19.10% to get the maximum output capacity.

Table 4: Technical efficiency (TE) Score of Hot Pepper producing farmers in the study area

Mean	Std. Dev.	Minimum	Maximum
0.805931	0.153354	0.470742	0.992478

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Stochastic Frontier Analysis Determinants of Hot Pepper Production Efficiency

The result for stochastic frontier analysis determinants of hot pepper production efficiency was shown in table 5. The significant value of Wald chi2 (5) 684.45 and Lambda 0.8080 at 1% level of confidence as well as 45% inefficiency component of the composite error term shows the overall fitness of the unrestricted production model using stochastic frontier model approach. In the frontier component of the model, the coefficients of the production function are interpreted as elasticity. The highest coefficient value of inputs used in pepper production as indicated in table 5 are seed (0.12), insecticide (0.019), labor (0.013) and fertilizer (0.0012) in which seed, labor and fertilizer are found to be significant at 1% level of confidence while insecticide is significant at 10% level of confidence. The finding is similar to what was found by Shehu *et al.* (2010) who observed that the estimated coefficient of inputs was positive as expected and significant at 1% level. Although herbicide (-0.014) is not significant, the negative coefficient implies over utilization of herbicide. The result further indicated that seed, insecticide and labor are the main determinants of hot pepper production in the study area. If there is a one percent increase in seed, insecticide, fertilizer and the size of labor, it will result in a corresponding increase in hot pepper production by 1.2%, 0.19%, 0.012%, and 0.13%, respectively. This implies that there was a potential for hot pepper producing farmers to continue to expand their production in the study area.

The inefficiency components of the models revealed education, access to extension service, cooperative membership, years of farming experience, farm size, and household size to be the significant determinants of efficiency of hot pepper production in the study area. The negative coefficient of education (-1.24970) that is significant (P<0.01) implies that the higher the level of education of the farmer the more efficiency the farmer will have in chili pepper production. This finding is in line with findings of Amaza (2013) and Mohammed (2015). Also for the household size (-0.205), the negative and significant (P<0.01) coefficient implies that the higher the number of household members, the better the production efficiency. This however contradicts with the findings of Zalkuwi (2010) that there is a positive and significant relationship between household size and farmers‟ efficiency in production. Moreover, the positive and significant (P<0.01) coefficient of years of farming experience (1.11) implies that farmers that are producing hot pepper for a long time tend to be less efficient in the production; this also disagrees with findings of Mohammed (2015). This may be because younger farmers adopt innovative production technology faster than old farmers. Meanwhile, the positive and significant (P<0.01) coefficient of farm size (0.066) implied production inefficiency among farmers with large farm size; this may be because of underutilization of production inputs in larger farm size. Moreover, the positive and significant (P<0.05) coefficients of cooperative membership (2.472) and access to extension service (1.4405) imply that the services by extension agent and cooperative groups result to inefficiency of hot pepper production in the study area this may be because of the weakness of extension services and poor coordination of cooperative groups in the study area.

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Table 5: Determinants of Hot Pepper Production Efficiency in the Study Area

Variables	Coefficient	Standard Error	P-Value
Frontier Components			
Seed	0.1189	0.0163	0.000
Fertilizer	0.00121	0.00026	0.000
Herbicide	-0.0135	0.014488	0.351
Insecticide	0.01998	0.01124	0.076
Labour	0.01307	0.00284	0.000
Constant	4.80322	0.05798	0.000
Inefficiency Components			
Education status	-1.24970***	0.31245	0.000
Access to extension	1.4405	0.5865	0.014
Membership of cooperative	2.472***	0.6628	0.000
Age of the Farmer	-1.4797	1.1562	0.201
Household size	-0.20465***	0.0585	0.000
Farm size	0 .066***	0.2165	0.000
Years farming experience	1.111***	0.2165	0.000
Constant	-4.01456	0.9348	0.000
Lambda	0.8080	0.0626	0.000
Log likelihood	43.0660		0.000
Wald chi2(5)	684.45		0.000

Source: *Field Survey, 2023.*

Problems Encountered in Production Period

Problems encountered by hot pepper farmers in their production were presented in table 6. Two major problems were recorded as mentioned by the farmers in the study area. Results show that the majority (80.2%) of the farmers in the study area faced high cost of inputs for production, whereas only few (19.8%) of the farmers were complaining about the issues of pests and disease. The finding is in line with that of Mohammed (2015) who reported high cost of inputs as a major production challenge among hot pepper farmers in Kaduna State, Nigeria. This shows that farmers in the study were seriously faced by these problems which required action to increase their production efficiency.

Table 6: Problems Encountered by Farmers (majorly)

Item	Frequency	Percentage
Pest and disease	24	19.8
High cost of inputs	97	80.2
Total	121	100

Source: *Field Survey, 2023.*

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CONCLUSION AND RECOMMENDATIONS

Hot pepper production was found to be a profitable enterprise among farmers in the study area. Although the farmers have an average efficiency level of the hot pepper production, they still have a chance to increase their yield by 20%. High cost of production and pest and diseases incidences were also revealed to be the major constraint faced by farmers in the hot pepper production. Based on the findings of this study, the following recommendations were offered:

1. Trainings on the adoption of improved practices and innovated technologies should be provided to the farmers so as to increase their production efficiency
2. Government should provide measures that will ease the farmers' access to credits so as to purchase available inputs for their production despite the cost attached.
3. Improved seeds that are resistant to pests and diseases shall be made available to farmers so that issues of pest and disease incidence in Hot pepper production can be mitigated.
4. There is also a need for farmers to get involved into cooperatives which can be achieved through extension campaigns organized by governments.

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