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Analysis of Technical Efficiency of Tomato Production in Adamawa State, Nigeria

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Abstract

The study examined the technical efficiency of tomato production in Guyuk Local Government area of Adamawa State, Nigeria. Data were collected from 100 farmers using purposive and simple random sampling with aid of structured schedule.The result of the stochastic frontier production function analysis shows that the variance parameters, that is the sigma squared (δ^2) and the gamma (γ) were statistically significant at 1% level for tomato production. The coefficient of farm size and seed were positive and significant at 1% level while family and hired labor was negative and insignificant. Profit level can be increased by increasing the farm size and quantity of seed, and decreasing the use of manual labor. Mean efficiency were 0.69, Farmers operated at 31.03% below frontier level due to variation in technical efficiency. The inefficiency model shows that the coefficient of Age, Gender and family size have negative apriori sign and in consonance with the apriori expectation. Better use of technology dissemination was suggested to enhance the production level at farmers field and optimum utilization of resources.

Highlights

- More than 57 percent farms are operating below 70 percent efficiency which indicates the scope for efficiency improvement.
- Overuse of human labor and herbicides was found on tomato farms.

Keywords: Technical Efficiency, Stochastic, Frontier Production Function, Adamawa spate.

Agricultural industry was accorded scanty attention after the discovery of oil in commercial quantity in Nigeria. This has created a gap between the demand and supply of domestic food requirements. Consequently the country has found it increasingly difficult to feed her teeming population and supply the local industries from the domestically produced food and raw materials. Tomato (Lycopersicon esculentum) is the second most important vegetable crop next to potato. Presently the world production of fresh tomato is about 150.5 million tons from 4.58 million hectares. (FAO 2012).

In Nigeria, tomato is mainly cultivated in the northern part of the country where it forms an important part of the farming systems. The growth of tomato production depends on the need to improvement in either in productivity or through area expansion. The increase in tomato production in Nigeria is mainly contributed by expansion of area. The productivity growth may be achieved through either

technological progress or efficiency improvement (Coelli, 1995). Several studies indicated that the existing low levels of technical efficiency hinder efforts to achieve progress in production (Belete *et al*., 1991; Seyoum *et al*., 1997). The application of green manuring and combined use of inorganic nutrients and bio-fertilizers improves technical efficiency and profitability in long run (Thimmareddy et.al.2013) . Despite the significant growth in tomato production, there are huge inefficiency in the production system of tomato production. An improvement in the efficiency of production system will have direct positive impact on agricultural growth, nutritional security and rural livelihood in a country like Nigeria, where tomato is one of the major crops.

Under these circumstances it is important to know that whether the producers have the same or different levels of technical efficiency. The study therefore, tries to measure the technical efficiency under different farm in Adamawa State of Nigeria.

Methodology

Data and Sampling Design

The Adamawa State, one of the largest tomatos producing state of Nigeria was selected purposively. There are twenty-one (21) Local Government Area (LGA) of Adamawa state. Out of twenty-one (21), Guyuk Local Government Area (LGA) of Adamawa state being one of the highest tomatos producing area was selected purposively for the study. The Local Government Area consists of 10 wards namely; Banjiram, Bobini, Chikila, Guyuk, Kola, Dukul, Bodeno, Rokoro, Purokayo and Dumna. It has an estimated land area of 871.9 km^2 with an estimated population of 177,785 people out of which 90, 422 are males while 87,363 are females based on 2006 census (CBN, 2007).

Guyuk local government area being one of the largest producers of tomato was selected purposively. Five wards viz. Banjiram, Dumna, Mada, Rokoro and Purakayo out of ten wards having high production proportion were selected purposively. From each selected ward two villages were purposively selected to give ten villages. Finally, ten farmers were randomly selected to give a total sample of one hundred (100) respondents.

Farming is the major occupation of the people of the area with sorghum and tomato as main crops. Other crops cultivated in the area include maize, rice, millet, sweet potatoes, cassava, cowpea and cotton.

Data for the study were derived from primary source. The data were collected with the use of a structured schedule from 100 farmers.

Analytical Tools

The stochastic frontier production model was independently proposed by Aigner *et al.*, (1977) and Meeusen and Van den Broeck (1977). It employs a Cobb-Douglas production function to simultaneously estimate the random disturbance term (V_i) which is outside the control of the production unit and the inefficiency effects (U_i) as proposed by Battese *et al.*, (1996).

The stochastic frontier production function used in this study was specified as follows:

$LogY_i = B_o + B_1 \log X_1 + B_2 \log X_2 + B_3 \log X_3 + \ldots\ldots\ldots\ldots B_6 \log X_6 + V_i - U_i$ …..(1)

Y = Output of tomato in kg

X_1 = Farm size in hectares

X_2 = Quantity of fertilizer applied in kg

X_3 = Quantity of tomato seed planted in kg

X_4 = Quantity of herbicides used in litres

X_5= Amount of family labour used in man-days

X_6 = Amount of hired labour used in man-days

X_7 = Expenses on ploughing (tractor and animal traction)

V_i = Random noise (white noise) which are $N(0,\delta^2, V)$

U_i = Inefficiency effects which are non-negative, half normal distribution $N(0,\delta^2, U)$

The technical efficiency of tomato production for i^{th} farmers, defined by the ratio of observed product as to the corresponding frontier production associated with no technical inefficiency, is expressed by;

TE = Exp $(-U_i)$ so that $O \leq Te \leq 1$……..……..(2)

Variance parameters are $\delta^2 =$

$\delta^2_V + \delta^2_U$ and $\gamma = \delta^2_U / \delta^2$ .....(3)

So that O≤ γ ≤1

The inefficiency model is defined by,

$U_i = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7$……..(4)

Where,

U_i = inefficiency effect

Z_1 = Age of farmer (in years)

Z_2 = Literacy level (in years)

Z_3 = Farming experience (in years)

Z_4 = Extension contact (1 contacted, 0 otherwise)

Z_5 = Gender of the farmer (1 female and 0 for female)

Z_6 = Family size (total number of person in household)

Z_7 = Access to formal credit (binary)

δ^2, δ_o, γ, βs are unknown parameters that were estimated.

The potential level of output was derived by averaging the yield of ten highest farmers. The maximum likelihood estimate (MLE) for all the parameters of the stochastic frontier production function and the inefficiency model defined above and the technical efficiency was obtained using the Frontier 4.1 computer programme (Coelli, 1994; Ajibefun, 1998).

Results and Discussion

Stochastic Frontier Production Function and Inefficiency Model Result

The maximum likelihood estimates of the stochastic frontier production function and inefficiency model results are presented in Table 1 and 2. The estimate for parameters of the stochastic frontier production function indicates that the elasticity of output with farm size was positive and approximately 0.634 and it was statistically significant at 1% level. This implies that a one percent increase in area under tomato production will raise output of tomato by 0.634% this shows that land is a very important factor in tomato production. This finding is at tandem with the findings of Eyo and Igben (2002); Maurice *et al.,* (2005); Odoh and Folake (2006), that land has positive sign and statistically significant.

The production elasticity of seed is 0.447 it was statistically significant at 1% level, this also, implies that a one percent increase in seed under tomato production will raise the output of tomato production by 0.447% So seed is also a very important factor of production. The significant and positive sign of seed variable also indicated that a moderate increase in population of tomato on the field will increase the yield provided that, the farm is not overpopulated beyond the recommended tomato carrying capacity that will lead to competition for nutrients which will lower the yield. This finding is in consonance with the work of Shehu *et al.*, (2007a) and Ogundari (2008), who found that seed is an important factor in production.

The production elasticity of fertilizer was 0.017 it was not statistically significant. The production elasticity for herbicide was -0.014 and was significant for at 10% level, the coefficient for family labour (-0.014) and hired labour (-0.003) were negative and insignificant, which is contrary to *apriori* expectation signs. The negative effect and the insignificance of family and hired labour may be attributed to the over dependence of respondents on manual labour as well as over use of the variable inputs. This is a common feature of agricultural production in the developing countries like Nigeria. A unit increase in labour tends to increase the cost of tomato production and consequently reduces the output. This findings therefore is an indication that labour is the most critical variable input in tomato production in the study area which reduce the output of tomato farmers.

Determinants of Technical Inefficiency

Table 2 presents the coefficients of inefficiency function which explain levels of technical inefficiency among the respondents. It should be noted that the signs of the coefficient in the inefficiency model are interpreted in the opposite way and such a negative sign means that, the variable increase efficiency and positive sign mean that it decreases efficiency (Adebayo, 2007). The coefficient of age (-0.994) had negative sign and inconsonance with *apriori* expectation. It was statistically significant and different from zero at 5%. This implies that increase in the age of the farmers by one unit (year) will increase the efficiency of the farmers.

The estimated coefficient for years of farming experience

was (0.467), it was statistically significant at 1% level. The tomato production has a positive coefficient, implying that, respondents' with high years of farming experience, are not more efficient than those with lower years of farming experience. This is an indication that years of farming experience was not a critical factor of inefficiency among respondents who cultivated tomato in the study area.

The estimated coefficient for extension contact is 0.002 for respondents involved in tomato production; it had contrary sign of positive and was statistically insignificant. Its contrary sign may be attributed to the poor extension services experienced by respondents since the withdrawal of funding by the World Bank to the Agricultural Development Programme (ADP) in Adamawa as it is in other states of the federation.

The coefficient of gender and family size are (-0.028) and (-0.255) both the coefficient for gender and household size had the negative *apriori* expectation and was statistically insignificant. This implies that increase in family size by one unit (Adult) will increase the efficiency of the farmer.

The estimated sigma square (δ^2) in Table 1 was large (0.589) and significantly different from zero. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term. The variance ratio of gamma (γ) which was associated with the variance of technical inefficiency effect in the stochastic frontier was estimated to be 0.99 production system. This indicates that 99 of the total variation in tomato output for the farmers were due to differences in technical efficiency (TE). This also implies that the

Table 1. Maximum Likelihood Estimate of the Cobb-Douglas Stochastic frontier production function and inefficiency model for tomato farmers

Variable	*Parameter*	*Coefficient*	*t-value*
Constant	β_0	2.667	22.553***
Farm size (X_1)	β_1	0.634	6.251***
Fertilizer (X_2)	β_2	0.017	0.780
Seed (X_3)	β_3	0.447	5.009***
Herbicide (X_4)	β_4	-0.014	-1.168*
Family labour (X_5)	β_5	-0.014	-0.930
Hired labour (X_6)	β_6	-0.003	-0.373
Inefficiency model			
Constant	δ_0	1.554	2.308***
Age	δ_1	-0.994	-2.068**
Literacy level	δ_2	0.036	0.830
Farming experience	δ_3	0.467	3.108***
Extension contact	δ_4	0.0002	0.006
Gender	δ_5	-0.028	-0.772
Family size	δ_6	-0.256	-1.600
Variance parameters			
Sigma squared	δ^2	0.589	4.595***
Gamma	γ	0.999	7180.188***

ordinary least squares estimates may not be adequate enough to explain the inefficiency variation among the respondents hence the use of stochastic frontier production function.

Technical Efficiency of tomato Farmer in the study area

The technical efficiency in Table 2 was derived from MLE result of the stochastic production function. The result shows that the TE of the respondents was less than 1 (100%) hence the variation in TE exits among respondents. It means that, all the respondents produced below maximum efficiency. The minimum efficiency of tomato producers was 0.3779, while their maximum efficiency was 0.9980; and the mean efficiency was 0.6897. The distribution of the farm efficiency in tomato production shows that, majority (75%) of them operated above 59% of their maximum efficiency and 41% operated between 40-59%. Yield profitability and efficiency were found heist in Andhra Pradesh , India in case of Bt cotton (Ashok *et.al.,* 2012).

Table 2. Frequency Distribution of Technical efficiency rating of the tomato farmers

Efficiency	Frequency	Percentage
<0.40	4	4
0.40 – 0.49	12	12
0.50 – 0.59	9	9
0.60 – 0.69	32	32
0.70 – 0.79	16	16
0.80 – 0.89	16	16
0.90 – 1.00	11	11
Total	100	100
Minimum efficiency		0.3779
Maximum efficiency		0.9980
Mean efficiency		0.6897

Source: Computed from Stochastic Frontier Result

Conclusion

It may be concluded from the study that under the given socio-economic and farm conditions (including technology), the production of tomato can be increased by more than 31 percent. Profit on the far can also be enhanced by reducing the human resources, which are over employed on the farm. It is suggested that the Government of Nigeria should strengthen the technology dissemination work in order to increase the efficiency of farmers. A policy should also be framed to transfer the surplus human resource from agricultural sector to another sector, which will increase the profitability of farms and improve the labor efficiency.

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