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Resource Use Efficiency: A Stochastic Frontier Production Analysis of Smallholder Broiler Farmers in Capricorn District, Limpopo Province

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ABSTRACT The objective of the paper was to determine the level of resource use efficiency by smallholder broiler farmers. Primary data was used and the stochastic frontier production analysis was applied to determine efficiency in levels in broiler production by smallholder farmers. The results of the estimates showed that all the inputs used were significant at one percent. The overall return to scale is greater than one indicating that resources are under- utilized. The result also revealed that the estimated farm level technical efficiency ranged from eight to ninety-seven percent with a mean of seventy-five percent on average indicating that smallholder broiler farmers in the study area can improve technical efficiency by twenty-five percent. The study recommends that extension officers should increase the frequency of contact with individual broiler farmers and implement policies that will promote access to credit and transport as a means to helps farmers use their resources efficiently.

INTRODUCTION

The problems of food insecurity and hunger in recent years have continued to attract the attention of research experts and governments worldwide. According to FAO (2015), progress towards food security requires that food is available, accessible and in sufficient quantity and quality to contribute towards human development. The most critical concern in the global food basket crises is protein, especially of animal origin. Isika et al. (2006) recommended poultry production as a strategic source of animal protein in human nutrition due to its potential for high productive capacity, short generation interval and its competence in nutrient transformation to high quality animal protein.

In South Africa, the poultry industry consists of layers and broilers and the country's broiler subsector had an estimated production growth rate of twenty-six percent between 2005 and 2010 (DAFF 2011). Commercial broiler production dominates the industry accounting for about 93.6 percent of the total country's broiler meat production and the rest made up of smallholder broiler meat producers (DAFF 2011). Across the developing world, the majority of the poor and most of the hungry live in rural areas where family farming and smallholder agriculture is prevailing and has the potential to increase productivity considerably and reduce poverty and hunger significantly (FAO 2015). According to FAO (2010), the definition of smallholder farmers varies from one region of the world to another. However, all smallholder farmers have a common feature, which is production for family consumption and sale of extra surplus and are characterized by relatively higher labor to capital ratio compared to commercial farmers. Most of the products produced by smallholder farmers are sold to local customers with a lower degree of processing compared to large commercial farmers who have access to retail and export markets (Louw et al. 2011). In the South African context, Kirsten and Zyl (1998) defined smallholder farmers in general as farmers whose scale is too small to attract the provision of services they need to significantly increase their productivity. Omotosho and Ladele (1998) defined smallholder poultry farmers to have a flock size of 1000 chickens or less.

In Limpopo province of South Africa, large scale broiler meat producers are estimated at 404 (199 producers and 205 contract growers), which

is less than smallholder broiler farmers, which are estimated at around 1554 province wide. Broiler industry in Limpopo province is also considered to be one of the major employers in the agricultural sector, and approximately ten percent of all agricultural sector workers in and within the province are employed in the broiler industry. Out of these workers, more than sixty percent are engaged in smallholder broiler farming as owners or employees (DAFF 2011). This is due to the fact that smallholder broiler productions are relatively labor intensive compared to commercial broiler productions. In this province, smallholder broiler farmers' accounts for around thirty percent of the total supply and are mostly located in deep rural areas.

The smallholder broiler farmers are characterized by poor production resources, low production quantities hence slow growth, mainly for those located under Capricorn District (Baloyi, 2010). Previous studies done on poultry production efficiency locally (South Africa) and internationally (Louw et al. 2011; Ng'eno et al. 2010; Ukwuaba and Inoni 2012; Echebiri et al. 2006) have outlined production inefficiencies as a major problem to the productivity of large scale poultry farmers but inadequate studies have been done on smallholder broiler farmers especially in the Limpopo Province of South Africa to ascertain their level of resource use efficiency.

The study utilizes the stochastic frontier production function, which combines production theory and farm efficiency with the main objectives being profit maximization, output maximization, utility maximization, cost minimization or even the combination of the above (Nicholson 1978). During the production process most producers are concerned with improving technical efficiency to maximize productivity hence, profitability. Technical efficiency aims at maximizing a farmer's benefits while minimizing cost of production inputs (Hardwick et al. 1988).

Objective of the Study

The objectives of the study were to determine the level of resource use efficiency, and to identify the socio-economic factors that contribute towards resource use efficiency by smallholder broiler farmers in Capricorn District (Limpopo province). The study hypothesizes that socio-economic factors do not contribute to resource use efficiency of smallholder broiler farmers in Capricorn District.

MATERIAL AND METHODS

The study was carried out in Capricorn District, which is situated at the center of Limpopo Province. The province covers an area of about 12.46 million hectares with the estimated population of 5.404 million in 2011 (StatsSA 2012). Capricorn has an estimated total population of 1.26 million and the target population of the study was all smallholder broiler farmers in Capricorn District. The selection of smallholder broiler farmers was done using disproportionate stratified random sampling procedure and the strata being gender. This was to ensure both males and female farmers are equally represented even though they are not proportional in size. According to the Department of Agriculture in Limpopo, the total number of estimated smallholder poultry farmers was 1554 and of this number, 330 were estimated to be in the Capricorn District. Sixty-one of the smallholder broiler farmers in the Capricorn District were interviewed using a structured questionnaire. In the study socio-economic characteristics were analyzed using percentiles and frequencies while the level of resource use efficiency and socio-economic characteristics that contribute to resource use efficiency of smallholder broiler farmers were analyzed using stochastic frontier production function.

Model Specification (Stochastic Frontier Model) Used in the Study

The interest in measuring technical efficiency originated in 1957 by M.J Farrell, whom in his model distinguished between technical and allocative efficiency. This model was known as a deterministic non-parametric frontier. Aigner et al. (1977) also proposed the stochastic frontier production function stating that maximum output may not be obtained from a given combination of inputs because of the effects of inefficiency. Several extensions of Farrell deterministic model have been made by economists. Battese (1995) extended the model allowing simultaneous estimation of individual technical and allocative efficiencies of the respondent farmers as well as determinants of technical efficiency. The model is able to estimate the individual tech-

nical efficiency of the respondent smallholder broiler farmers as well as determinants of technical efficiency at the same time by assuming the presence of technical efficiency of production. The range of Technical Efficiency (TE) is 0 to 1. TE = 1 implies that the farm is producing at its production frontier and is said to be technically efficient (Battese and Coelli 1995). In this study technical efficiency is an estimate of resource use efficiency by smallholder broiler farmers. Stochastic Production Model can be written as:

$Y = f(X_a; B_i)\, e^E$

Whereby:

Y = Quantity of broilers produced

X_a = A vector of input and other explanatory variable quantities

B_i= A vector of unknown parameter to be estimated

e=Error term

E=Stochastic disturbance term consisting of two independent elements which are U_i and V_i, where by $E = U_i + V_i$

U_i= One-sided efficiency component with a half normal distribution.

V_i=The non-negative unobservable random variables associated with the technical efficiency of broiler production.

The random error E represents random variations in the economic environment facing the production units, reflecting chance such as weather, disease outbreak and variable input quality, measurement errors, and omitted variables from the functional form (Aigner et al. 1977). Then the frontier of the farm is given by:

$Y = f(X_a B_i) + E$

Efficiency measures for each farm can be calculated as:

$U_i = f(Z_b; d_1)$

Whereby:

Z_b = Vector of farm specific factors

d_i = Vector of parameters

Both parameters of stochastic frontier and the efficiency effects model can be consistently estimated by maximum likelihood procedure. The function is summarized as follows:

$\ell nY = B_0 + B_1 - n X_1 + B_2 - n X_2 + B_3 - n X_3 + B_4 - n X_4 + B_5 - n X_5 + (U_i + V_i)$

Whereby:

Y = Number of chickens produced (Number of chickens/ year).

X_1 = Quantity of day old chicks (Number chicks purchased/ year).

X_2 = Amount of labor employed for production (Man hours/ year)

X_3= Cost of vaccines, drugs and chemicals (Rands/ year)

X_4 = Quantity of feeds (Kilograms)/ year)

X_5 = Total area of broiler housing (M^2)

B_i = Coefficients of unknown parameters to be estimated

U_i= One-sided efficiency component with a half normal distribution.

V_i=Random variability in the production that cannot beinfluenced by the farmer.

U_i= The deviation from maximum potential output attributable to resource use efficiency.

According to Battese and Coelli (1995), the variances of the parameters V_i and U_i, are σ_v^2 and σ_u^2 respectively and the overall variance of the model is given as σ^2, which can be calculated as: $\sigma^2 = \sigma_v^2 + \sigma_u^2$. In this study the measure of total variation of output (broilers) from the frontier, which can be attributed to technical efficiency is measured by lambda (λ). Microsoft Excel software was used to log all of the input data before creating a data file for the program to use. STATA 10 was used to analyze the data and to find the coefficients of unknown parameters by maximum likelihood estimates.

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RESULTS AND DISCUSSION

The results and interpretations and findings from the study were presented in the following two subheadings, namely, socio-economic characteristics of smallholder broiler farmers and stochastic frontier production function results.

Socio-economic Analysis of Smallholder Broiler Farmers

Socio-economic variables of broiler farmers in Capricorn District, which could be relevant in influencing output, were analyzed using percentiles and frequencies and the results are presented in Table1.

As can be seen from Table 1, the results indicated the majority of the smallholder broiler farmers are of age 40 years and above and constitute 93.4 percent while only 6.6 percent are below the age of 30 years. The implication maybe that most of the youths migrate to urban areas in search of formal employment opportunities and better life, which they deem to be more rewarding than smallholder broiler production in the villages.

Table 1: Socio-economic characteristic of smallholder broiler farmers

	Frequency	*Percentage (%)*
Age		
≥30	4	6.5
31-50	40	
65.5		
51≤	17	27.9
Total	61	100
Gender		
Male	13	21
Female	48	79
Total	61	100
Marital Status		
Single	21	34
Married	40	66
Total	61	100
Edu-background		
Formal education	56	91.8
No formal education5	8.2	
Total	61	100
Level of Involvement		
Full time	55	90
Part time	6	10
Total	61	100
Flock Size Kept		
100-500	22	36
501-1000	39	64
Total	61	100
Access to Credit		
No access	58	95
Access	3	5
Total	61	100
Government Support		
No support	55	90
Support	6	10
Total	61	100

Source: Computed by Author from Survey Data 2013

The study also shows that, seventy-nine percent of the interviewed farmers were female while twenty-one percent were male. This finding reflects that smallholder broiler production in the study area is dominated by older female farmers and there is low participation of young, male farmers. Some of the interviewed female farmers in the study area indicated that they have domestic responsibilities causing them to venture into broiler production fulltime. The study also found that about ninety percent of the interviewed smallholder broiler farmers practice broiler production fulltime whilst ten percent are parttime broiler farmers. According to Echebiri et al. (2006), famers who participate fulltime are likely to make efficient use of production resources because they are paying full attention to the business. This finding contradicts the outcomes of recent studies on broiler production (see Ugwumba and Lamidi 2011; Ukwuaba and Inoni 2012), which reported male dominance in smallholder poultry production in North African countries.

The study further shows that majority of the respondents (66%) are married and that broiler production is a supplementary source of income to support their dependents. Furthermore, the majority of the farmers (91.8 %) in the study area have acquired different levels of education through primary, secondary or tertiary qualifications. As a result, smallholder broiler farmers who have acquired any form of formal education are relatively more efficient in the utilization of resources as compared to those who have got no formal form of education. This finding is supported in a study by Ogolla and Mugabe (1996), which showed that smallholder farmers who are formally educated are expected to have a higher level of resource use efficiency than farmers who do not have any form of formal education. However, Ugwumba and Lamidi (2011) have argued that experience in production and educational level of smallholder broiler farmers in North African countries positively contributes to resource use efficiency.

The study also revealed that sixty-four percent of the farmers keep a flock size of 500 to 1000 while thirty-six percent keep less than 500. Hence, the average stock size of these farmers was 706 birds/year in five production cycles. This finding is similar to that of Omotosho and Ladele (1998), which concluded that backyard poultry farms of 1000 birds/year and below are regarded as smallholder production. This implies that the interviewed respondents were all smallholder broiler farmers. In the study area, more than ninety percent of the interviewed farmers indicated that they neither have access to credit nor have received any form of government support with regard to financial support. Farmers who had credit access indicated that they acquired credit from informal sources.

Stochastic Frontier Production Function Results

The Maximum Likelihood Estimates (MLE) of the stochastic frontier production parameters of the five factors affecting broiler production were, numbers of days old chicks, labor, cost of medication, feed cost and area of broiler house

for smallholder broiler production. The results are presented in Table 2.

Table 2: Estimated Stochastic Frontier Production Function for smallholder broiler farmers

Variable	*Parameters*	*Coefficient*	*Standard error*
Intercept	β_0	0.240***	0.006
No of chicks	β_1	0.197***	0.036
Labour	β_2	0.762***	0.280
Cost of Meds	β_3	-0.145***	0.042
Feeds quantity (Kg)	β_4	0.572***	0.085
Area of house	β_5	-0.276***	0.070
Diagnostic statistics			
Sigma	ó ^{2}	0.4221812	0.0764453
	ó $_v$	4.67 e -07	0.0000427
	ó $_u$	0.64976	0.0588263
Lambda	ë	0.9999	0.0588262
Log Likelihood	-17.97237		

*** Significant at 1%
Source: Computed by Author from Survey Data 2013

From the analysis, the number of day old chicks was found to be positive and significant at one percent. The coefficient of number of chicks is 0.197 implying that one percent increase in the number of day old chicks will result in a 19.7 percent increase in the number of broilers produced per cycle given that other inputs are constant. This finding is consistent with the finding by Ng'eno et al. (2010) and Ukwuaba and Inoni (2012). Furthermore, the estimated amount of labor employed in man-hours was significant at one percent and positive. The 0.76 elasticity coefficient of labor indicated that a one percent increase in the number of man-hours employed would result in a seventy-six percent increase in the number of broilers produced given that other inputs are constant. This result is in agreement with the results by Ng'eno et al. (2010), Ukwuaba and Inoni (2012), which both concluded that the significance of labor is due to the fact that smallholder broiler farming is labor intensive.

Analysis on the cost of medication indicates that the amount spent on medication is negatively related to the number of broiler chickens produced and the estimate is significant at one percent. The coefficient of this estimate is -0.145, implying that the current expenditure by smallholder broiler farmers on medication is inadequate compared to their current level of broiler production. As a result, an increase of one percent in the expenditure on medication would result in an increase in the number of broilers produced by 14.5 percent all other factors remain constant. This finding is supported in a study by Echebiri et al. (2006), which indicated that medication is an important component in broiler production since they are more vulnerable to diseases compared to traditional free-ranging chickens. On the other hand, the coefficient of feed quantity used was found to be positive and significant at one percent. The implication is that an increase of one percent in quantity of feeds supplied to broilers would result in a 18.7 percent increase in the quantity of broilers produced given that other inputs are constant. This finding is consistent with the finding by Ng'eno et al. (2010).

Finally, analysis on the area of the broiler house was found to be negatively related to broiler output and is significant at one percent. As indicated by Ugwumba and Lamid (2011), the optimum growth space/bird and to reduce mortality in broiler production is 4.5m^2/bird. Any density less than or more than this will result to technical inefficiency. This implies that the current space/bird used by smallholder broiler farmers in the Capricorn District is inefficient and an increase in space of a broiler houses per number of birds would increase broiler production by 27.7 percent. This finding confirms the findings by Ng'eno et al. (2010) and Ukwuaba and Inoni (2012) that was conducted in North Africa. The findings from the two researchers indicated that floor space is positively related to number of broilers produced. However, some of the smallholder broiler farmers indicated that an increase in floor space results in production inefficiency especially in winter due to the cold.

Hypothesis Testing and Model Fitness

The presence or absence of technical efficiency in the study was tested using the important parameter of log likelihood in the half normal model function σ^2. If $\sigma^2 = 0$ there were no effects of technical efficiency and all deviation from the frontier function were due to noise (Aigner et al. 1977). From the table 2, the estimated value of $\sigma^2 = 0.422$, which significantly differs from zero.

The estimated lambda (λ) parameter is high and estimated to be 0.9999, which according to Aigner et al. (1977), can be interpreted to mean

that the differences between actual (observed) and frontier output amongst broiler farmer are dominated by technical efficiency. The results suggest that about 99.99 percent of the variation in broiler output among smallholder farmers in Capricorn District is due to other socio-economic factors and the differences in their technical efficiencies. Based on this finding, the first null hypothesis which states that socio-economic factors do not contribute to resource use efficiency of smallholder broiler farmers in Capricorn District was rejected.

Returns to Scale

The return to scale (1.11) was found by adding all the values of betas (β). The sum of β's was greater than one, indicating increasing return to scale. This meant that smallholder broiler farmers in the Capricorn District were underutilizing their resources. Therefore, this finding fails to reject the second null hypothesis, which states that smallholder broiler farmers in Capricorn District are not utilizing their resources efficiently. Input cost per unit was less than the return from output. This results tally with the results of Ng'eno et al. (2010), Ukwuaba and Inoni (2012) and Echebiri et al. (2006). Their different studies also found that poultry farmers in North African countries operated at increasing returns to scale, meaning that those farmers invested fewer inputs into their production. For farmers to achieve an optimum level of resource use efficiency, they will have to increase the amount of input used until a point where the marginal value product is equivalent to the marginal cost of that particular input. By utilizing resources optimally, farmers under this study area will realize an increase in productivity and hence profitability.

Distribution of Technical Efficiency in Broiler Production

The results of the frequency distribution of technical efficiency of smallholder broiler farmers were computed and the results are presented in Table 3.

From the analysis, the estimated technical efficiency varied with minimum and maximum values of eight percent and ninety-seven percent, respectively with an average of seventy-five percent. It indicated that the average farmer in the study area could save 22.6 percent [that is, 1-(75/97)] of costs and the most technical efficient could realize a 91.75 percent cost saving [that is, 1-(8/97)] compared with the technical efficient level of the most efficient farmer.

Table 3: Distribution of Technical Efficiency in Poultry Broiler production

Technical efficiency (%)	*Range*	*Frequency (%)*
0-20	8	13.11
21-40	0	0
41-60	0	0
61-80	1	1.63
81-100	52	85.24
Total	61	100

Maximum Technical Efficiency 97 %
Minimum Technical Efficiency 8 %
Mean Technical Efficiency 75 %
Source: Computed by Author from Survey Data 2013

CONCLUSION

Findings from this research showed that females are more involved in broiler production on a fulltime basis compared to their male counterparts. Most respondents in the study area have formal education since majority of them had more than primary education. The results of the stochastic frontier indicated that all factors involved in the broiler production were significant but not all were positive. The findings further indicated that smallholder broiler farmers under the study area were underutilizing their resources and the level of technical inefficiency can be improved by twenty-five percent. The implications are that smallholder farmers are inefficient in allocating their scarce resources and therefore need to increase the quantity of some inputs and reduce some.

RECOMMENDATIONS

The study recommends that males should be encouraged to actively involve themselves in small-scale broiler farming as much as their female counterparts and on a fulltime basis. Smallholder broiler farmers should increase their scale of operation, which distribute the over utilized labor to a large number of birds in order to be efficient. Extension officers should also be motivated to frequently visit these smallholder farm-

ers and introduce new packages of technologies and information that promote productivity and resource use efficiency of the broiler farmers.

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