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Full Length Research Paper

Technical efficiency in maize production by small-scale farmers in Ga-Mothiba of Limpopo province, South Africa

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This paper investigates the determinants of efficiency among small-scale maize producers in Ga-Mothiba of the Limpopo province in South Africa. Primary data were collected through the use of structured questionnaires from 120 maize farm households obtained in a purposive sampling procedure. Cobb-Douglas production function was used to analyse the technical efficiency. The results of the estimation showed that there were significant positive relationships between farm size and fertilizer with technical efficiency. The results of the study also revealed that there was a significant negative relationship between cost of tractor hours (the proxy for capital) and technical efficiency. The study further revealed that small-scale maize producers in Ga-Mothiba are experiencing decreasing returns to scale indicating that small-scale farmers are experiencing technical inefficiency in maize production. Therefore, the study generally suggests that government should adopt the strategy of on-farm training to small-scale farmers since these farmers mainly depend on trial and error when it comes to allocation of scarce resources such as fertilizer and seed. Moreover, farmers need to be trained on matters relating to fertilizer application, the amount of seed a farmer should apply per ha, and the importance of using hybrid seed and this definitely requires an improved extension delivery system.

Key words: Technical efficiency, maize production, small-scale farmers.

INTRODUCTION

South Africa has dual agricultural economy, comprising a well-developed commercial agricultural sector and a predominantly subsistence oriented agricultural sector. Covering 1.2 million square kilometres of land. South Africa has many climatic regions, ranging from Mediterranean to sub-tropical to semi-desert. Only about 13% of the country`s land surface area can be used for crop production, of which about 22% can be classified as high potential land (Agricultural Statistics, 2003). About 1.3 million hectares of land are under irrigation. The most important factor limiting agricultural production in South Africa is the scarcity of water. Rainfall is distributed unevenly across the country with almost 50% of water being used for agricultural purposes (Aliber, 2003, 2005). Primary agriculture in South Africa contributes about 2.5% to the gross domestic product (GDP) and about 8% to formal employment. However, the linkage of agriculture with the economy is strong such that the agro-industrial sector contributes about 12% to the GDP (Vink and D'haese, 2003). Although, South Africa has the ability to be self-sufficient in virtually all major agricultural products, recently, the rate of growth in exports has been slower than that of imports. Export of agricultural products has been about 9 million metric tonnes in 2002 when South African Rands depreciated dramatically. Major import products include wheat, rice, vegetable oils

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and poultry meat (Monde, 2003; DoA, 2003, 2005).

Maize is an important staple food crop in South Africa. Its consumption cuts across culture, age and regions. It is an important part of the diet of an average black South African judging from the high proportion consumed and it is widely planted by small-scale farmers in South Africa. South Africa is the main maize producer in the SADC region, with an average production of about 8.9 million metric tonnes a year over the past 10 years (Ortmann and Machethe, 2003). It is estimated that about 8 000 commercial farmers do produce maize. Maize is produced mainly in North West, the Free State and Mpumalanga Provinces. However, other provinces in South Africa also produce maize although, volume of production is lower as compared to the three provinces mentioned earlier. A total of 6.9 million metric tonnes of maize was produced in 2006/2007 on two million hectares of land (DoA, 2007).

Unfortunately, maize farming method by small-scale farmers in South Africa is still not advanced like the commercial farming sector. A number of researchers (Aliber, 2003, 2005; Monde, 2003; Ortmann and Machete, 2003; Vink and Haese, 2003; Speelman et al., 2008) observed that the main issue in the South African small-scale agriculture is that of low productivity. Some of the reasons identified include the absence of strong support mechanism in the policy formulation of the small-scale agricultural sector, inadequacy or absence of supportive infrastructural facilities like transport, communication and absence of an efficient and effective extension system that will aid in transmitting appropriate research findings to farmers for adoption. Moreover, access to agricultural credit by small-scale farmers is very limited if not totally absent. All these ultimately results in lower maize yield for the small-scale farmers. The current average yield of maize in the study area is approximately 3.5 tons. However, there is speculation that it is possible to push maize yield to 5 to 6 tons provided that small-scale farmers have access to improved varieties as a means to increasing maize yield. The other important issue that has attracted much attention is the possibility of improving maize yield with the existing resources and technology available to small-scale farmers. In view of this, the study is designed to examine the technical efficiency of small-scale maize farmers in the study area.

Technical efficiency is the ability of the farmer to achieve the maximum possible output with available resources. There is also allocative efficiency which refers to the ability to obtain optimal output for given resources' prices. The combination of both technical and allocative efficiencies gives rise to economic efficiency. Thus, the measurement of economic efficiency is not complete without the study of technical efficiency, which is the frontier production function that enables the measurement of technical efficiency of farmers (Elsamma and George, 2002; Sherlund et al., 2002; Binam et al., 2004; Abler and Sukhatme, 2006; Tchale and Sauer, 2007; Amos, 2007;Tchale, 2009). The present study, therefore, focuses on investigating on the technical efficiency level of small scale maize producers in the Ga-Mothiba area of Limpopo province. This investigation is important particularly in developing agriculture like South Africa.

METHODOLOGY

Study area

The study was conducted in Ga-Mothiba community in Capricorn District. The district which the study area falls is situated in Limpopo province. Capricorn district receives an average annual rainfall of 478 mm. In this area, farming is under smallholder systems and characterised by low level of production technology and small size of farm holding of approximately 1.5 ha per farmer and sometimes less than that. Production is primarily for subsistence with little surplus for market.

Sampling procedure and data collection

The study used purposive sampling techniques. The purposive sampling method was used to interview only households who produce maize, since the main purpose of the study was to analyse the technical efficiency level of small-scale maize producers. A sample size of 120 households was used in this study. Primary data were collected through filed survey and household's survey using structured questionnaire. The questionnaire was structured in such a way that the first part covers the socio-economic variables such as the age of the household head, size of the household, off-farm income and gender etc. The second part of the questionnaire dealt with the factors of production such as, land, labour, cost of tractor hours and materials use such as fertiliser and seed.

Analytical techniques

Both descriptive and quantitative method was used in the analysis of the study data. Cobb-Douglas production function model was used to analyse the variables that affects maize production, and this analytical technique helps to determine the technical efficiency level of small-scale maize producers in Ga-Mothiba. The theoretical Cobb-Douglas production function is expressed as follows:

$$Y = AL^{\alpha} K^{\beta} u$$

where, Y = output; A = constant; L = labour; K = capital; and U = disturbance term.

For constant returns to scale, the sum of the parameter coefficients, β and α must be equal to one (1). For increasing returns to scale, the sum of β and α must be greater than one, and for decreasing returns to scale, the sum of β and α must be less than one. In mathematical form, the returns can be expressed as follows:

$$\alpha = \frac{\delta Y / Y}{\delta L / L}$$

$$\beta = \frac{\delta Y / Y}{\delta K / K}$$

where β and α are the elasticities of production with respect to labour and capital. These are considered the most important

Table 1. Socio-economic characteristics of the respondents.

Variable	Mean	Standard deviation
Age (Years)	63.14	14.031
Capital (cost of tractor hours) (Rand)	392	77.173
Labour (man- days)	113	27.92276
HHS (numbers)	5.62	2.099
Farexp (Years)	23.86	12.555
Seeds (kg)	17.08	6.403
Farm size (ha)	1.1521	0.46776
Fertilizer (kg)	37.328	33.75

properties of the Cobb-Douglas production function. The Cobb-Douglas production function was used for its mathematical simplicity. The operational model for this study relating to the production of Y, to a given set of resources X, and other conditioning factors is given as follows:

$$Y= aX_1^{\beta 1}\ X_2^{\beta 2}\ X_3^{\beta 3}\ X_4^{\beta 4}\ X_5^{\beta 5}\ e$$

In order to use the Ordinary Least Squares procedure, the Cobb-Douglas production function has to be linearized using logarithms. Taking logarithms on both sides, the model will be:

$$Ln(Y_i) = B_0 + ln\beta_1X_1 + ln\beta_2X_2 + ln\beta_3X_3 + ln\beta_4X_4 + ln\beta_5X_5 + u$$

where output (Y_i) = is the total quantity of maize harvested in the study year (in Kg); Farm size (X_1) = is the area of the farm which is devoted to the production of maize and this variable is measured in hectares (ha); labour (X_2) = number of man-days per farm and is the sum of family labour and hired labour; Cost of tractor hours (X_3) = tractor hours cost used in farming operation and the variable is measured in Rands; fertilizer (X_4) = amount of both basal and top dressing fertilisers (kg); seed (X_5) = amount of seed used per hectare (kg); Ln (Natural logarithm and (u) disturbance term and B_0 represent the constant.

RESULTS AND DISCUSSION

Description of the socio-economic characteristic of maize farming households

The results from the descriptive statistics using the mean and standard deviation statistics are presented in Table 1. The results from Table 1 showed that the majority of small-scale farmers are older people. This literally means that the older one gets the more experience one will have with regard to farming. The average farming experience is about 24 years. This perhaps indicates that experienced farmers will be able to adapt to new changes and thereby, improve their production systems. It also shows that maize production has been in existence for a number of years as the majority of the small-scale farmers have been in maize production for more than 20 years. It is assumed that older farmers are more experienced in farming activities and are better able to assess the risks involved in farming than younger farmers. The average age of the farmers is 63.14 years old. This indicates that older people are the ones participating in agricultural production in general and in maize production in particular. The average cost of tractor is about R391.50 per ha. The average amount of family labour used is estimated to be 112.32 man-days per farm. Labour is the most important input for maize production, especially, with small-scale farmers. The household size plays an important role in maize production and most farmers depend mainly on family labour. The results show that the average household size is 5.62, which mathematically represent 6 members per household. This shows that farmers can have easy access to additional labour from family members. The average amount of seed used by the farmer per ha is about 17.08 kg. Farmers who apply fertilizers use about 33.75 kg on average per farm size. The average farm size in the study area is 1.15 ha.

Cobb-Douglas production function estimates of the parameters

Table 2 presents the estimated parameters results obtained from the Cobb-Douglas production function model. All the coefficients of the model have the expected signs except for cost of tractor hours and family labour which have negative signs. Farm size and fertilizer were positively significant at 1 and 5% respectively. Though, cost of tractor hours has significant influence but the effect is negative. This indicates that further usage will add less to maize output. This may be due to over utilization of tractor hours. For all the variables that have positive coefficient, it implies that as each of them is increased, maize output also increased. The magnitude of the coefficient of the significant variables indicates that farm output is inelastic to change in any of the variables used. Thus, a 1% increase in farm size will induce an increase of 0.276% in maize output of the farm households. Likewise, a 1% increase in fertilizer usage will induce a 0.24% increase in maize output increase in tractor hours and labour respectively would induce a 0.177 and 0.047% reduction in maize output. The results in Table 2 showed that the estimation of the production function resulted in adjusted R^2 of 0.564, indicating that the independent variables was included in the model

Table 2. Cobb-Douglas production function model results.

Variable	Estimates of parameter	Standard error of estimate	t-value
Constant	569.888	190.598	2.990
Farm size (ha)	0.276***	0.089	3.100
Fertilizer (kg)	0.247**	0.088	2.807
Cost of tractor hours (rand)	-0.177*	0.089	-1.989
Labour (man days)	-0.047	0.087	-0.540
Seeds (kg)	0.099	0.087	1.138
Sum of betas			0.398
Adjusted R^2			0.564

*, **, *** Significant at 10, 5 and 1% respectively.

Table 3. Elasticities of production and returns to scale.

Variable	Elasticities of production
Farm size	0.276
Family labour	-0.047
Fertilizer	0.247
Cost of tractor hours	-0.177
Seeds	0.099
Returns to scale	0.398

explaining about 56% of the variation in maize production in the study area. The low value of the adjusted R^2 could be attributed to exclusion of other socio-economic factors that were not considered in the analysis. However, according to Coudere and Marijse (1991), as cited by Mushunje and Belete (2001), an adjusted R^2 of 0.54 is a good result for the regression of cross- sectional data.

Elasticity of production and returns to scale

The parameter estimate in a Cob-Douglas production function is the elasticities and the sum gives the return to scale. If the sum of all the elastciities is more than one, it is increasing return to scale; if less than one, it is decreasing return to scale and constant return to scale if it is equal to one. A look at Table 3 shows that the sum of the elasticities for all variables is less than one that is, the farm households are operating at a point of decreasing return to scale. This is the rational stage at which production should normally take place because addition to output is positive with an increase in input utilization.

CONCLUSION AND RECOMMENDATION

Production of maize by small-scale farmers' in the study area in particular and in South Africa in general, plays a vital role in alleviating poverty and generating income. Therefore, high productivity and thereby, high technical efficiency level in the production of maize is critical to food security in South Africa.

The production function analysis revealed that inefficiency exists among maize farming households in Ga-Mothiba in the Limpopo Province of South Africa. Therefore, it is recommended that government should strengthen the strategy of on-farm training to small-scale farmers since these farmers mainly depend on trial and error when it comes to allocation of scarce resources.

It is also recommended that government should strengthen improved extension services delivery system while farm inputs such as fertilizer and improved seeds should be made available at low prices. This may tend to bring about increase in maize output.

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