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Technical efficiency of maize production in Swaziland: A stochastic frontier approach

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Maize farming in Swaziland is divided into subsistence farming on Swazi Nation Land (SNL) and commercial farming on Title Deed Land (TDL). Maize production on SNL accounts for only 10% of total agricultural output in Swaziland. While almost all households in SNL produce maize, the country has never reached self-sufficient levels in maize production. For the past 40 years, Swaziland has not been able to meet the population's maize requirements. Currently, the domestic shortfalls of maize are covered by imports through the National Maize Corporation. Swaziland continues to experience a downward trend on maize production, while maize demand has been increasing. This study was aimed at estimating technical efficiency of maize production and determining the factors affecting technical efficiency in Swaziland. The stochastic frontier approach was used to estimate the technical efficiency of 127 farmers and the two-limit Tobit model was used to determine the factors affecting technical efficiency of the farmers. The results revealed that there is a wide variability in the production of maize since technical efficiency ranged from 14.5 to 93.3% with a mean of 80.0%. The most important contributors to the maize production process were the amount of seeds, fertilizer, pesticides and labour used per hectare. Technical efficiency was found to be positively associated with farmers' age, having off-farm income, farmers' experience, intercropping and use of hybrid seeds. The gamma, (γ), was 68% and significant at 1% indicating that the variation in maize output was due to factors within the control of the farmers. It is recommended that the government needs to provide input subsidies so that farmers can use more inputs to improve their technical efficiency.

Key words: Technical efficiency, maize production, stochastic frontier function, Cobb-Douglas production function.

INTRODUCTION

Maize is one of the most potential cereals crop grown globally, and is the third after wheat and rice in total food grain production (Anupama et al., 2005). Due to its high adaptability and productivity, the cultivation of maize spread rapidly around the globe and is currently being produced in most countries of the world. Maize farming in Swaziland is divided into subsistence farming on Swazi Nation Land (SNL) and commercial farming on Title Deed Land (TDL). Maize production on SNL accounts for only 10% of total agricultural output in Swaziland. While almost all households in SNL produce maize, the country has never reached self-sufficient levels in maize production (Magagula et al., 2007). For the past 40 years, Swaziland has not been able to meet the population's maize requirements (National Maize Corporation, 2010). Currently, the domestic shortfalls in maize are covered by imports through the National Maize Corporation.

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According to FAO/WFP (2005), maize production in Swaziland is generally on a downward trend. The Lowveld shows a particularly steep secular decline and even in the Highveld, the agro-ecological zone with the highest agricultural potential, the trend is downward. Hence, this study seeks to estimate the level of technical efficiency of maize production and identify the socio-economic characteristics that influence technical efficiency of maize farmers in Swaziland. The measure of technical efficiency tends to increase output without using more conventional input (Khai and Yabe, 2011). Improving technical efficiency is an important factor of productivity growth especially in developing countries like Swaziland where resources are scarce. Farell (1957) defined technical efficiency (TE) as the ability of a firm to produce maximum output from a given level of resources, or attaining a certain output level of output using a minimum quantity of inputs, given a certain technology. Oyewo and Fabiyi (2008) defined efficiency as the act of achieving good results with minimal effort. It is the act of harnessing material and human resources and coordinating these resources to achieve better management goal. Efficiency is measured by comparing the actual realized value of the objective function against what is attainable at the frontier. Therefore, the analysis of TE provides important information about farmers and the ability to improve the productivity of their farming operations, thus, competitiveness (Abdulai and Tietje, 2007).

The stochastic production frontier models (SPF) developed by Aigner et al. (1977) and Meeusen and Van den Broeck (1977) are parametric approaches to estimate technical efficiency. This study used the stochastic frontier approach. Frontier production functions are important for the prediction of technical efficiencies of individual firms in an industry and their applications have involved both cross-sectional and panel data (Battese and Coelli, 1991). The stochastic frontier model decomposes the error term into a two-sided random error that captures the random effects outside the control of the firm and the one-sided efficiency component. The stochastic frontier production function forms include the Cobb-Douglas, constant elasticity of substitution and translog production functions and any deviations from the frontier are attributed to inefficiency (Chirwa, 2003). Stochastic frontiers assume that part of the deviations from the frontier is due to random events (reflecting measurement errors and statistical noise) and part is due to firm specific inefficiency (Battese, 1991; Coelli et al., 1998).

The Cobb-Douglas functional form is widely used to represent the relationship of an output to inputs. Bravo-Ureta and Pinheiro (1997) stated that the Cobb-Douglas functional form is used to specify the stochastic production frontier since the methodology employed requires that only the production function is dually made. Khai and Yabe (2011) argued that there are many functional forms for estimating the physical relationship between inputs and output, but the Cobb-Douglas functional form is preferred to other forms, especially, if there is three or more independent variables in the model. It was also preferred because it is widely used in farm efficiency analysis (Bravo-Ureta and Pinheiro, 1997; Ahmed et al., 2002). However, it is recognized that the Cobb-Douglas function is restrictive since it imposes that the marginal rate of substitution of all input pairs are independent of other inputs (separability) and that all elasticities of substitution are equal to one.

METHODOLOGY

The study area, sampling and data collection procedure

The study was conducted at the Manzini, Hhohho, Shiselweni and Lubombo regions covering the Highveld, Middleveld and Lubombo plateau ecological zones. The Lowveld was not considered in this because the climate in this region is not conducive for maize production. The Highveld receive the highest amount of rainfall followed by the Middleveld and Lubombo, respectively. The Middleveld is divided into wet Middleveld and dry Middleveld. The Lubombo Plateau receives rainfall amounts between the wet and dry Middleveld.

Sampling procedure

The target population of the study was maize producers that supplied the National Maize Corporation (NMC) during 2011 (N=203). A stratified simple random sampling was used to extract the sample for this study. The farmers were first stratified according to the NMC collection centres (depots), Matsapha, Entfonjeni, Maduluni and KaLanga. The Krejcie and Morgan (1970) table for determining sample size (S) of a randomly chosen sample from a given population (N) was used to set the sample size of 127 farmers. The farmers studied from each stratum were selected randomly. Table 1 presents the number of farmers selected from each stratum to form the final sample size.

Data collection

The study used personal interviews that were guided by a structured questionnaire to collect the data. The data collected include socio-economic characteristics of the farmers, input and output data, problems encountered in production and farmer's views on how to improve maize production in Swaziland. A pre-test survey was conducted to check and improve the validity and reliability of the questionnaire before data were collected. The instrument was also reviewed by experts in the department of Agricultural Economics and Management at the University of Swaziland.

Data analysis

The data obtained were analyzed using both descriptive and inferential statistics. Means, standard deviations, percentages and frequency counts were used in analyzing socio-economic characteristics of the farmers, input and output variables, the distribution of efficiency levels, the problems encountered by maize farmers and their views on how to improve maize production in

Table 1. Number of farmers sampled per depot.

District	Name of depot	Population per depot	Sample per depot
Hhohho	Ntfonjeni	57	36
Shiselweni	Madulini	59	37
Lubombo	KaLanga	23	14
Manzini	Matsapha	64	40
Total		203	127

Swaziland. Multiple regression analysis of the Cobb-Douglas stochastic production function was done to compute the elasticities of production and technical efficiency of the farmers using the FRONTIER 4.1 computer programme. The factors affecting technical efficiency were determined by regressing a two-limit Tobit model using the STATA 10 computer programme.

Analytical framework

The stochastic frontier production function was adopted to measure the technical efficiency of farmers. The model was first proposed by Aigner et al. (1977). The advantage of this approach is that the disturbance term captures noise, measurement error, inefficiency component and exogenous shocks beyond the production unit (Nyagaka et al., 2010). The stochastic frontier production required for estimating farm level technical efficiency is specified as:

$Y_i = f(X_i; \beta) + \varepsilon_i$; where $i = 1, 2, \ldots n$

Here Y_i is output, X_i denotes the actual input vector, β is a vector of production elasticity coefficients and ε is the error term that is composed of two elements, that is:

$\varepsilon = V_i - U_i$

where: V_i is the symmetric disturbance assumed to be identically, independently and normally distributed as N $(0, \sigma^2_v)$ given the stochastic structure of the frontier. The second component U_i is a one-sided error term that is independent of V_i and is normally distributed as $(0,\sigma^2_u)$ allowing the actual production to fall below the frontier but without attributing all short falls in output from the frontier as inefficiency.

The stochastic frontier production function in which the Cobb-Douglas function was proposed by Battese and Coelli (1995) and confirmed by Yao and Liu (1998) is the best functional form of the production frontier; hence, it was used for data analysis in this study. The technique assumes that farmers may deviate from the frontier not only because of measurement errors, statistical noise or any non-systematic influence, but also because of technical inefficiency.

Technical efficiency of an individual firm is defined in terms of the ratio of the observed output to the corresponding frontier output, given the levels of inputs used by that firm (Battese, 1991). Thus the technical efficiency of firm *i* in the context of the stochastic frontier production function is specified as:

$TE_i = Y_i/Y_i^* = f(X_i ; \beta) \exp(V_i - U_i)/f(X_i; \beta) \exp(V_i) = \exp(-U_i) TI_i = 1 - TE_i$

Since observed output is always less or equal to the maximum feasible output ($Y_i \leq Y_i^*$), the technical efficiency index (TE_i) is bound between 0 and 1, such that $0 < TE_i \leq 1$ (Cabrera et al., 2010). When technical efficiency is equal to one ($TE_i = 1$), it indicates that a farmer is producing on the frontier with the available resources and technology and the farmer is said to be technically efficient. If TE_i is less than the frontier ($TE_i < 1$), it implies that the farmer is not producing on the production frontier for a given technology and resources. Such a farmer is said to be technically inefficient.

Aigner et al. (1977) suggested that the maximum-likelihood estimates of the parameters of the model be obtained in terms of the parameterization, $\tilde{\sigma}^2 \equiv \sigma^2 v + \sigma^2$ and $\lambda \equiv \sigma/\sigma_v$ rather than using the non-negative parameter, λ (that is, the ratio of the standard deviation of the N $(0,\sigma^2)$, distribution is involved in specifying the distribution of the non-negative U_i's to the standard deviation of the symmetric errors, V_i).

On the other hand, Battese and Corra (1977) proposed the parameters, $\gamma = \sigma^2/\sigma^2_s$ to be used, because it has values between zero and one, whereas the γ parameter could be any non-negative value. The parameter, γ, is associated with the variance of the inefficiency effects. When close to one it can be concluded that there are technical inefficiency effects associated with the production process of the farmer. The second step used in the analysis was a censored regression model, the two-limit Tobit model. The structural equation in the Tobit model is:

$y_i^* = X_i\beta + \varepsilon_i$

where: y_i^* is a latent variable that is generated by a classical linear regression model, and *β* is the corresponding vector of explanatory variables. The model errors ε_i are assumed to be independent, N $(0, \sigma^2)$ distributed, conditional on the X_i. The observed y_i is defined as 1 if $y_i^* > 0$ and 0 if $y_i^* \leq 0$.

Model specification

The empirical analysis was based on the estimation of a Cobb-Douglas production function in which both the output and inputs were expressed in logarithmic form. The Cobb-Douglas production functions for the study is defined by the general model, Y, to a given set of resources, X, and other conditioning factors are given as follows:

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} e^{V-U} \quad (1)$$

where: Y = Maize output (kg/ha); X_1 = Amount of seeds used (kg/ha); X_2 = Amount of fertiliser used (kg/ha); X_3 = Total amount of pesticides used (kg/ha); X_4 = Labour used (man-days/ha); X_5 = Farm size used for maize production (ha); V_i = Random error associated with measurement errors in the yield of maize; U_i = are non-negative random variables associated with technical inefficiency of production by farmers, assumed to be independently distributed, such that the $_i$ technical inefficiency effects for the ith farmer growing maize is normally distributed with mean, μ and variance σ^2; β_0 is a constant and β_1, β_2, β_3, β_4, and β_5 are

Table 2. Descriptive statistics for variables used in the study.

Variable	Unit	Sample mean	Standard deviation	Min. value	Max. value
Maize output	Kg/ha	598.39	934.95	10.0	9750.0
Seeds used	Kg/ha	12.30	11.2	5.0	121.0
Fertiliser used	Kg/ha	127.74	86.70	14.0	595.0
Pesticides used	Kg/ha	1.10	0.62	0.2	5.0
Labour used	Man- day/ha	30.58	26.62	5.350	149.4
Farm size	Ha	2.36	1.43	0.42	9.5
Farmer's age	Years	51.35	12.66	21.0	79.0
Farmer's experience	Years	20.28	11.70	2.0	50.0
Formal schooling	Years	8.41	4.66	0.0	18.0
Household size	Persons	6.57	4.20	2.0	40.0
Characteristics of farmers				**Frequency**	**Percent (%)**
Off farm income					
No				50	39. 4
Yes				77	60.6
Seed type					
Hybrid seeds				74	58.3
Non-hybrid seeds				53	41.7
Farming system					
Monocropping				63	49.6
Intercropping				64	50.4

elasticities to be estimated.

In order to be able to use the least squares procedure for estimating, the function is linearized and comes up with the following regression specification:

$$lnY_i = \beta_0 + \beta_1\, lnX_{1i} + \beta_{2i}\, lnX_{2i} + \beta_{3i}\, lnX_{3i} + \beta_{4i}\, lnX_{4i} + \beta_{5i}\, lnX_{5i} + (V_i - U_i) \quad (2)$$

where; the subscript i indicates the ith farmer in the sample (i = 1, 2, 3 ...n)

A two-limit Tobit regression model was used to determine the relationship between the socio-economic characteristics of the farmers and the computed indices of technical efficiency. The implication is that if a socio-economic characteristic of a farmer shows a positive impact on technical efficiency, it will have a negative relationship with technical inefficiency. The two-limit Tobit model was adopted because technical efficiency of an individual maize farmer is the ratio of the observed output to the corresponding frontier output. Therefore technical efficiency scores lie within the range of 0 to 1, which are the two known limits of the model. The Tobit model is developed as follows:

$$Y_i^* = \beta_0 + \beta_{1i}Z_{1i} + \beta_{2i}Z_{2i} + \beta_{3i}Z_{3i} + \beta_{4i}Z_{4i} + \beta_{5i}Z_{5i} + \beta_{5i}Z_{5i} + \beta_{6i}Z_{6i} + \beta_{7i}Z_{7i} \quad (3)$$

where: Y_i^* = Technical efficiency (ratio); Z_1 = Farmer's age (years) Z_2 = Off-farm income (0 = No; 1 = Yes); Z_3 = Formal schooling (years); Z_4 = Farmer's experience (years); Z_5 = Household size (persons); Z_6 = Seed type (0 = hybrid; 1 = non-hybrid); Z_7 = Farming system (0 = monocropping; 1 = intercropping).

RESULTS AND DISCUSSION

Summary statistics for variables used in the study

The summaries of statistics for variables used in the study are presented in Table 2. The results showed that the average maize yield per farmer is 598.93 kg/ha with a standard deviation of 934.951 and a range of 9740ka/ha. This shows a wide variation between the farmers. The average amount of seeds, fertiliser and pesticides used were 12.30, 127.74 and 1.097 kg/ha respectively. The ranges were 5.0 kg/ha to 121.0 g/ha for seed, 14.0 kg/ha to 595.0 kg/ha for fertilizer and 0.2 to 5 kg/ha for pesticides used.

The mean labour and land used for maize production were 30.58 man-days/ha and 2.36 ha, respectively. The amount of labour used ranged from 5.350 man days/ha to 149.39 man days/ha, with a standard deviation of 26.62. Land used for maize production ranged from 0.42 to 9.5 ha with standard deviation of 1.43. This also suggests that there is variability in the maize production process in terms of labour and land used.

The average age of the maize farmers was 51.4 years. This means that most of the people involved in maize production are old and the average experience was 20.28 years. The average years of formal schooling for the sample was 8.41 years and the average household size

Table 3. Maximum-likelihood estimates for the parameters of the stochastic production function.

Variable	Unit	Stochastic frontier estimates	t-ratio
Intercept	kg/ha	4.469**	9.553
ln seed	kg/ha	0.227*	1.648
ln fertiliser	kg/ha	0.173*	1.812
ln pesticide	kg/ha	0.221*	1.732
ln labour	Man-days/ha	0.177*	1.851
ln farm size	Ha	-0.084	-0.689
Variance parameters			
Sigma square		1.218**	3.516
Gamma (γ)		0.684**	6.056
Log-Likelihood		- 129.248	

**, Significant at 0.01 level; *, significant at 0.05 level.

was 6.57 people. Only 39.4% of the farmers did not have off-farm income. About 58.3% of the farmers used hybrid seeds compared to the 41.7% that used non-hybrid seeds. This was expected since some farmers do not have income to buy the hybrid seeds. There was a balance between farmers practising monocropping (49.6%) and those farmers practising intercropping (50.4%).

Technical efficiency

The maximum likelihood parameter estimates of the stochastic production function are presented in Table 3. The estimate for the variance parameter, γ, associated with the variance of the inefficiency effects for this study is 0.684 and is statistically significantly at 1% level of significance. This means that there is significant technical inefficiency effects associated with the production of maize in Swaziland. The variance parameter implies that the one-sided random inefficiency component strongly dominates the measurement error and other random disturbances indicating that about 68% of the variation in maize output from the frontier is due to factors that are within the control of the farmers. Therefore, the null hypothesis is rejected.

All the input elasticities were positive and statistically significant at 5% level of significance, with the exception of land. Seed had the highest effect on productivity with elasticity equal to 0.227. It implies that increasing the amount of seeds used by 1% will increase output by 0.227%. The next highest elasticity was 0.221 for pesticides, followed by labour (0.177) and fertilizer (0.173). Farm size had an elasticity of -0.084, implying that a 1% increase in the amount of land used will reduce output by 0.084%. The reason for this finding might be that 50.4% of the farmers intercropped their maize, which reduced the land allocated to maize as compared to what the farmers reported. However, the variable is not statistically significant.

Distribution of technical efficiency

The frequency distribution of the estimated technical efficiency indices are presented in Table 4. The predicted technical efficiency indices varied from 0.145 to 0.933 with a mean of 0.800. This indicates that each farmer can, in principle, increase maize yield by 20% using the current input quantities. Table 4 also shows that about 64.5% of the farmers achieved technical efficiency levels of 80 percent and higher. This is comparable to the average (84%) presented by Bravo-Ureta et al. (2007) in their meta-regression analysis of technical efficiency in agriculture. About 95% of the farmers operate above 60% level of technical efficiency. This implies that a large number of maize farmers achieve higher levels of technical efficiency, although the problem of technical inefficiency still exists.

Table 5 reveals that the farmers at Ntfonjeni had the highest average technical efficiency of 83.94%, but the range of 26.5% indicates that there is still room for improvement in the production of maize. The farmers in all the regions achieved average technical efficiency scores above 75%. The widest range of 78.8% is evident between farmers supplying the Matsapha depot. This means that there are more technical inefficiency problems in this region followed by KaLanga (62.4%) and Madulini (47.7%).

Factors affecting technical efficiency

Table 6 presents the Tobit regression model results. The analysis produced a log likelihood estimate of 118.616, indicating that the explanatory variables better explain the dependent variable of technical efficiency. All variables had positive signs except seed type. The variables year

Table 4. Frequency distribution of technical efficiency.

Level of technical efficiency (percentage)	No. of farmers (N =127)	Percentage of farmers	Cumulative percentage
> 85	44	34.6	34.6
> 80 ≤ 85	38	29.9	64.5
> 75 ≤ 80	22	17.3	81.8
> 70 ≤ 75	11	8.7	90.5
> 65 ≤ 70	5	3.9	94.4
> 60 ≤ 65	1	0.8	95.2
> 55 ≤ 60	1	0.8	96.0
> 50 ≤ 55	1	0.8	96.8
> 45 ≤ 50	1	0.8	97.6
> 40 ≤ 45	1	0.8	98.4
> 35 ≤ 40	0	0.00	98.4
> 30 ≤ 35	0	0.00	98.4
> 25 ≤ 30	1	0.8	99.2
> 20 ≤ 25	0	0.00	99.2
> 15 ≤ 20	0	0.00	99.2
≤ 15	1	0.8	100
Sample size (N)	127		
Average TE (%)	80.0		
Min. TE (%)	14.5		
Max. TE (%)	93.3		

Table 5. Distribution of average technical efficiency by region.

Ecological region	Depot	Average technical efficiency (%)	Min. TE (%)	Max. TE (%)
Highveld	Madulini	83.94	66.0	92.5
Middleveld	Matsapha	79.67	43.4	91.1
Lubombo	KaLanga	78.79	27.0	89.4
Middleveld	Ntfonjeni	78.03	14.5	93.3

Table 6. Two-limit Tobit model estimates for factors affecting technical efficiency.

Variable	Coefficient`	Robust std. error	t-Value	Sig.
Constant	0.495**	0.066	7.55	0.000
Age	0.002**	0.001	3.09	0.003
Off-farm income	0.173**	0.031	5.52	0.000
Schooling	0.000	0.002	0.11	0.915
Experience	0.004**	0.001	4.85	0.000
Household size	0.000	0.002	0.12	0.903
Seed type	-0.083**	0.018	-4.68	0.000
Log likelihood	0.039*	0.019	2.00	0.048
Farming system	118.616			
N	127			

**, Significant at 0.01 level, *, significant at 0.05 level.

of schooling and household size had coefficients equal to technical efficiency. The variable farmer's age, off-farm income, farmer's experience and seed type were zero, implying that they do not have any effect on statistically

Table 7. Problems reported by maize farmers in Swaziland.

Problems	Frequency
Low rainfall and high temperatures	67
Delayed ploughing because there are few tractors for hires	49
Do not have enough income to support my agriculture	37
High cost of fertilisers and pesticides	28
Livestock disturbing crop	17
Unfavourable NMC prices	12
Tractors hire expensive	9
Pests and diseases	7
Stealing of maize from the fields and cribs	7
Lack of labour (for example, due to sickness)	6
Do not have enough arable land for production	4
Input sellers far from farmers/farms leading to high transportation cost	3
Lack of skills/knowledge	3
Resilient weeds	3
Poor storage facilities	2
Strong winds	2
Livestock removed late from the fields in spring	1

significant at 1% level of significance, while farming system was statistically significant at 5%. Off-farm income is the most important factor affecting technical efficiency with the highest coefficient of 0.173. This indicates that having an off-farm income increases the chances of a farmer to improve the technical efficiency index by 0.173. Farmers with off-farm income are able to solicit enough farming inputs than those that do not have off-farm income. This identifies lack of off-farm income to be a source of technical inefficiency in the maize production process in Swaziland.

The variable seed type had a coefficient of -0.083 in favour of those farmers using non-hybrid seeds over hybrid seeds. This means using non-hybrid seeds increases the chances of a farmer to reduce the technical efficiency index by 0.083. The implication is that using hybrid seeds increases the chances of a farmer to increase technical efficiency by 0.083. Therefore, using non-hybrid seeds was identified as the second important source of technical inefficiency. Practising intercropping increases the chances of a farmer to increase technical efficiency by 0.039 as compared to the practice of monocropping. The coefficients for farmer's age and experience were 0.002 and 0.004, respectively.

Problems encountered by maize farmers in Swaziland

Table 7 indicates that low rainfall and high temperatures are the most important problems encountered by maize farmers in Swaziland. Since the early 1990s, Swaziland has been suffering from recurrent periods of drought, which has a negative impact on the growth and performance of crop plants. This may be the reason why farmers at Matsapha depot achieved the lowest average technical efficiency of 78.03%. The farmers at Matsapha depot were expected to be more technically efficient than those at KaLanga (because Matsapha experiences climatic conditions better suitable for maize than KaLanga), but they were found be less efficient. Other significant problems included the delayed ploughing (because there are not enough tractors for hire), lack of income to support farming needs, high costs of fertilizer and pesticides, unattended livestock (especially cattle that eat and destroy the maize crop) and the poor National Maize Corporation pricing system. All these problems had a negative impact on the technical efficiency of the farmers. A farmer who is faced with these problems had reduced chances of achieving higher technical efficiency scores no matter how knowledgeable and capable the farmer would be.

Farmers' views on how to improve maize production in Swaziland

Table 8 shows that sixty-nine farmers out of the one hundred and twenty-seven farmers believe that the Government of Swaziland can support the farmers by subsidizing farming inputs. Lack of funds (off-farm income) was determined as an important source of technical inefficiency; hence, subsidizing farming inputs can reduce the average maize production cost and allow farmers to be able to solicit enough farming inputs. This would possibly increase the chances of the farmers to increase their technical efficiency. Other highly ranked farmers' views on how to improve maize production

Table 8. Farmers' views on how to improve maize production.

Farmers' views	Frequency
Government input subsidies	69
Government should provide more tractors through RDAs	31
Government should help farmers by harvesting water for irrigation	25
Increase National Maize Corporation buying prices	15
Provide effective extension service to support farmers	14
Build more Regional Development Areas to provide tractors	-
and input closer to farmers	9
Fencing of grazing lands and herding	8
Land redistribution to ensure that farmers have enough land for production	7
Form farmer associations/unions to support farmers	5
Government should liberalise the maize market	3
Establish farmers' motivational programmes	2
National Maize Corporation should be involved in helping farmers	2
Government should provide low interest loans to maize farmers	1
Farmers should practice winter tillage	1
Farmers should practise minimum tillage to conserve soil moisture	1
More research should be done on maize production	1
Government should assist farmers with good storage facilities	1

include provision of more government tractors through Rural Development Areas (RDAs) to eliminate the problem of delayed ploughing and planting, harvesting irrigation water to eliminate the problem of low rainfall, improving the prices offered by the nutritional maize corporation to motivate maize farmers and providing more well planned, visionary and supervised extension services to the farmer to empower them with knowledge and skills required for good production.

CONCLUSION AND RECOMMENDATIONS

The study was set out to estimate the technical efficiency levels of a sample of 127 maize farmers using the stochastic frontier production function analysis. The study also determined the factors affecting technical efficiency of farmers using the two-limit Tobit model. Farmer specific technical efficiencies were computed using 2010/2011 season cross-sectional data. The empirical results showed that there is a significant variation between the sampled farmers. The estimated farmer-specific technical efficiency indices ranged from 14.5 to 93.3% with a mean of 80.0%. This indicates that the farmers can, on the average increase their maize output by 20% with the current input quantities, if they can operate at full technical efficiency. The variable seed had the highest effect on technical efficiency followed by pesticides, labour and fertilizer, respectively. The results also showed that farmers at Ntfonjeni (Highveld) were most efficient, followed by farmers at Madulini (Middleveld), KaLanga (Lubombo) and Matsapha (Middleveld), respectively.

The analysis of the determinants of technical efficiency revealed lack of off-farm income, use of non-hybrid seeds and practice of monocropping to reduce the chance of farmers to increase technical efficiency. The variable years of formal schooling and household size were found to have no effect on technical efficiency, while farmer's age and experience were positively associated with technical efficiency.

Farmers reported low rainfall and high temperatures as the most important problems and harvesting water for irrigation was suggested as a solution. The problem of delayed ploughing could be solved by government providing more tractors to the farmers through RDAs. The farmers are of the view that government input subsidies could reduce the cost of production, thus, improving maize production. Farmers also reported that unattended livestock destroy their crop, hence, reducing their yields. The low National Maize Corporation prices was reported as a demotivating factor to farmers and might be the cause of medium and large scale farmers switching to other crops like sugarcane. Farmers can increase their technical efficiency by increasing the amounts of hybrid seeds, pesticides, labour and fertilizer used. They should also motivate their children to be involved in maize production. There is need for the government of Swaziland to subsidize farming inputs, provide more tractors through RDAs and provide well planned and supervised extension services to the farmers.

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