TECHNICAL EFFICIENCY OF RESETTLEMENT FARMERS OF ZIMBABWE

by

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ABSTRACT

This paper examines the technical efficiency of the resettlement sector of the agricultural system in Zimbabwe. The land reform programme aims to redistribute land from large-scale commercial farmers to the small-scale peasantry sector so as to reduce rural poverty. Since such an agrarian reform could result in higher output, higher labour absorption, and a more equitable distribution of income, it is important to assess the level of efficiency of the beneficiaries of this programme. The stochastic frontier function model of the Cobb-Douglas type was used to determine the technical efficiency of a group of 44 cotton farmers from Mutanda resettlement scheme of Manicaland province. Technical inefficiency effects are estimated and are assumed to be a function of other observable variables related to the farming operations.

The results reveal some technical efficiency levels of the sample farmers that are varied widely, ranging from 22 per cent to 99 percent, with a mean value of about 71%. The technical inefficiency effects are found to be significant at the 25 per cent level. Technical inefficiency of cotton production decreased with increased family size and age of the head of household, but increased with farm size and education level of head of household.

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1. INTRODUCTION

The measurement of farm efficiency is an important area of research both in the developed and developing world (Tadesse and Krishnamoorthy, 1997). Odulaja and Kiros, (1996) mentioned that at least 73 % of all rural Africans are small-scale farmers, but despite the fact that such a high percentage of the population farms, food demand cannot be met from this source. The population growth rate is about 3,3 % but agricultural growth is lagging behind at 1,5 % per year (La-Anyame, 1985). This suggests that policy interventions should always be linked to efficiency.

The study will look specifically at the technical efficiency of the resettled farmers. Most of the empirical literature dealing with farm efficiency in developing countries has been concerned exclusively with the measurement of technical efficiency (Bravo-Ureta and Evenson, 1994). However, by focusing only on technical efficiency, we ignore the gains in output that could be obtained in the short run by also improving allocative efficiency.

The analysis of efficiency, in general, focuses on the possibility of producing a certain level of output from given resources. Production efficiency is usually analyzed by separately examining its two components: technical and allocative efficiency (Wang *et al.*, 1996). Technical efficiency may be defined as obtaining the maximum output from a given set of physical inputs. Technical inefficiency arises when actual or observed output from a given input mix is less than the maximum possible. Allocative efficiency, on the other hand, is defined as the ability to choose optimal input levels for given factor prices (Xu and Jeffrey, 1997). Wang *et al.* (1996) observed that allocative efficiency is evaluated from the producer's profit maximization point of view. It does not necessarily reflect social costs and therefore is not necessarily efficient in the sense of social cost benefit assessment. Economic or total efficiency is the product of technical and allocative efficiency.

Agricultural policies like land reform can be analyzed from efficiency measurements. As argued by van Zyl *et al.* (1996), the efficiency for land reform is that the redistribution of agricultural land to small holders will increase, or certainly not reduce, total factor productivity and efficiency in the long term.

2. AN OVERVIEW OF THE RESETTLEMENT SECTOR OF ZIMBABWE

The communal areas in Zimbabwe were not only over-populated, but 75 % of the population lived in dry farming areas where agriculture is risky. Less than 20 % the communal areas could be considered good agricultural environments. The agrarian structure was in need of reform and the government began to address agricultural subsidies and land equity issues.

The resettlement sector is a product of the government's land reform programme and it was created after independence in 1980 when the government embarked on the land reform/land redistribution programme where some of the land that belonged to the large-scale commercial sector was being transferred to smallholder farmers. By 1998, about 71 000 families were resettled on 3 498 444 hectares of land, most of them under a pattern, referred to as 'Model A' whereby individual households receive 5 or 6 hectares of land for cultivation, plus access to common grazing areas. Slightly over 60 % of them were from communal lands, the rest being former refugees, the landless and the unemployed.

Table 1: Land distribution by natural region (overall) compared with land acquired for resettlement (000ha)

Natural Region (NR)	Total land area (ha)	Land acquired for resettlement (ha)	% of Total	% Distribution by NR
I	700	30	4,3	0,9
II	5 860	590	10,1	17,9
III	7 290	1 240	17,4	37,7
IV	14 789	810	5,5	24,6
V	10 440	620	6,1	18,8
Total	39 079	3 290	8,4	100,0

Source: MLARR (2001)

A number of problems, which include the Lancaster House Constitution, which tied the government's hands by entrenching property rights, resulted in poor, infertile lands being made available for resettlement. It is evident that the government has continued to resettle people in semi-arid areas, which make it difficult for them to be self-sufficient and have food security (Table 1).

On 15 July 2000 the government of Zimbabwe launched the "Fast Track" resettlement programme which saw over half of the remaining 4 500 farms being acquired for resettlement.

About 400 000 people benefited under the A1 model and about 54 000 people under the A2 scheme (The Herald, 2003).

3. DATA COLLECTION

Zimbabwe is divided into eight administrative provinces. Manicaland province, which borders with Mozambique, was purposively selected for three reasons. Firstly, this province has the highest population density, which means high demand for land for resettlement. Secondly, it has the largest number of resettled households. This is because many farms were abandoned during the war since this province experienced the war more intensely than most of the other provinces. Thirdly, it is the only province that has all five natural (agro-ecological) farming regions.

According to Battese (1998), it may not be feasible for the researchers to attempt to collect data on all possible crops grown by the farmers. This is especially the case where farmers in the region grow a wide variety of crops. Hence it may be necessary to target the analysis to one or two of the most important crops produced in the region. This study is focusing on only cotton producers because Zimbabwe small-scale farmers produce more than 80 % of the entire marketed crop.

The farm level data was obtained from a cross-sectional survey of 44 small-scale farmers randomly sampled from the Mutanda resettlement area during the 2001/2002 cropping year. The dependent variable used in all the production function analyses is the total physical output in tonnes. Six main explanatory variables are used in the production frontiers model used in this study. They are land area under cotton, fertilizer, seed, labour, number of cattle owned and the cost of pesticides.

4. SOCIO-ECONOMIC CHARACTERISTICS OF THE HOUSEHOLDS

The descriptive household statistics of variables used in the study are presented in Table 2. They include the sample mean and the standard deviation for each of the variables.

The farms are of the same size as each farmer was given 5 hectares of land. The average percentage of area devoted to cotton is about 78%, which indicates the importance of the cotton crop to the sampled farmers. It shows that these resettled farmers, although small scale, they now operate commercially. They produce cotton for sale and then buy maize, the staple food, from the market. Mean output per hectare is 1,26 tonnes, which is above the national average output of 0,94 t/ha in 2001 for small-scale farmers but below the 1,59 t/ha for large-scale farmers in the same year. Labour is highly utilized by these farmers, with a mean average of 368 man-days. This is not surprising because cotton is a highly labour intensive crop. With an average family size of 4,4 members it implies that a quantity of hired labour is used. The average age of the head of household of the sampled farmers is 50 years. The mean level of education for the sampled farmers is 7 years. All of the farmers had at least primary school education which suggests that all the farmers are functionally literate.

Table 2: Descriptive socio-economic statistics of household variables used in the study

Variables	Resettlement Area Cotton Producers (N=44)	
	Mean	Std Dev
Output (tons/ha)	1,26	0,45
Farm size (ha)	5,00	0,00
Cotton area (ha)	4,42	1,33
% Land devoted to cotton	78,14	19,50
Seed (kg)	108,00	49,32
Labour (man days)	368,32	103,21
Capital (cattle numbers)	4,24	2,22
Insecticides (ZW$)	10498,50	7895,62
Fertiliser (kg)	1428,51	378,40
Age of household head (years)	50,44	1,23
Family size (numbers)	4,43	1,81
Education (years of schooling)	7,12	1,12

4. THE ECONOMETRIC MODEL

A number of variables are known to affect agricultural production. As a result it is important to use models, which relate production of farmers to these variables for better understanding of the functional relationships.

In this study, the focus was on cotton, which is the main cash crop for small-scale farmers in Zimbabwe. The specification of the production function used is of the Cobb-Douglas stochastic frontier type. According to Bekele *et al*. (2002), the basic stochastic frontier model was first proposed by Alginer, Lovell and Schmidt (1977) and Mueesen and van de Broeck (1977). Various other models have been suggested and applied in the analysis of cross-sectional and panel data on producers. Reviews of applications in agriculture are given by Battese (1992), Bravo-Ureta and Pinheiro (1993) and Coelli (1995).

Huang and Liu (1994) specified a neutral stochastic frontier production function, in which the technical inefficiency effects were specified in terms of various farm-specific variables and interactions among these variables and the input variables in the frontier. Battese and Coelli (1995) proposed a stochastic frontier production function for panel data, in which the technical inefficiency effects were specified in terms of various explanatory variables, including time.

In this study a stochastic frontier production functions, of the Cobb-Douglas type, using the FRONTIER 4.1 program of the type proposed by Batttese and Coelli (1995) were estimated for the sampled resettled cotton farmers of Manicaland province of Zimbabwe. For purposes of exposition, the Cobb-Douglas model is given in terms of cotton involving six input variables and four explanatory variables for the inefficiency effects in the stochastic frontier.

The general model for this study relating production, Y, to a given set of resources X, and other conditioning factors is given as follows:

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} X6^{\beta 6}$$

Where X_1	=	Land devoted to cotton
X_2	=	Seed used in kg
X_3	=	Fertilizer used in kg
X_4	=	Family and hired worker days used in cotton production
X_5	=	Capital
X_6	=	Expenses on pesticides, in Zimbabwe $
U	=	Disturbance term
Y	=	Annual total farm output of cotton

β_0 is a constant and β_1, β_2, β_3, β_4, β_5, and β_6, are elasticities to be estimated

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

$$\ln Y_i = \beta_{0i} + \beta_{1i} \ln X_{1i} + \beta_{1i} \ln X_{2i} + \beta_{3i} \ln X_{3i} + \beta_{4i} \ln X_{4i} + \beta_{5i} \ln X_{5i} + V_i - U_i$$

Where the subscript i indicates the i-th farmer in the sample (i=1,2,3,……n):

Output (Y) is the total quantity of cotton harvested in that year and is measured in tonnes

Land (X_1) is the area of the farm(s) devoted to the production of cotton. It is measured in hectares.

Seed (X_2) certified and home produced, is considered and is measured in kg.

Fertilizer (X_3) includes both basal and top dressing fertilizers. Although some smallholder farmers use animal manure, this has been left out for problems of aggregation. It is measured in kg.

Labour (X_4) is the total of cotton activity. It is expressed in adult equivalent days per hectare and is the sum of family labour and hired labour.

Capital (X_5) used Coudere and Marijse's (1991) argument. There is not much variation in the types of equipment these farmers' possess. They all have a plough and a number of hoes. To represent capital the number of cattle, which is used for draught power, is used. Cattle are used as a proxy for capital for these farmers. It is a form of wealth as well as a source of draft power.

Pesticides (X_6). Cotton producers use some pesticides and the cost was used. It is measured in Zimbabwe ($) dollars

The V_i's are random errors associated with measurement errors in the yields of cotton reported or the combined effects of input variables not included in the production function, where v_i's are assumed to be independent and is obtained by truncation (at zero) of the normal distribution with mean, v_i and variance, σ^2 such that

$$\mu_i = \delta_o + \delta_i Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta d_4 Z4i + \delta_5 Z_{5i}$$

Where Z_{1i}, Z_{2i}, Z_{3i}, Z_{4i} and Z_{i5i} are values of explanatory variables for the technical inefficiency effects for the i-th farmer. The δ-coefficients are unknown parameters to be estimated, together with the variance parameters, which are expressed in terms of land size (Z_{1i}), family size (Z_{2i}), age (Z_{3i}) and education (Z_{4i}) as defined below.

LAND SIZE	=	the total number of hectares held by the farmer
FAMILY SIZE	=	total number of members of the household
AGE	=	the age of the household head
EDUCATION	=	the number of years of schooling completed by the household head

The Battese and Coelli (1995) model, which is estimated using the computer program, FRONTIER 4.1, is used to analyse the data. The maximum – likelihood estimates of the parameters of the frontier model are estimated, such that the variance parameters are expressed in terms of the parameterisation:

$$s_s^2 = s_v^2 + s \quad \text{and} \quad \gamma = s^2 / s^2_s$$

Where the γ-parameters have a value between zero and one.

5. RESULTS OF THE EMPIRICAL ANALYSIS

Table 3 shows the estimated coefficients of the production function and their corresponding levels of statistical significance. Three out of the six variables are significant. The estimate of the γ-parameter in the stochastic production function is large, which means the inefficiency effects are highly significant in the analysis of the output of the sampled farmers.

5.1 Elasticities of production

An elasticity of production coefficient for an individual input expresses the percentage increase (decrease) in output that will result if the particular input is increased (decreased) by one percent, holding all other inputs constant (Truran and Fox, 1979). The output elasticities of land, fertilizer, capital and pesticides are positive as expected. This shows that they are critical inputs in the production of cotton. The coefficient of labour is surprisingly negative although significant.

The elasticity for pesticides is the largest, with a value of 0,94. This indicates that if the amounts of money spend on pesticides were to be increased by one percent, and then the total production of cotton is estimated to increase by 0,94 per cent *ceteris paribus.* A one per cent increase of either land or fertilizer would result in an increase of over 0,7 per cent in total output. This shows that land has relatively large influence on cotton output as compared to other inputs like capital. As far as labour is concerned, a one per cent increase in labour will result in a 0,38 per cent fall in total output of the sampled farmers. This is quite surprising since cotton is labour intensive and the family sizes are relatively low. The negative coefficient means the sampled farmers are over utilising the labour input. The same goes for the seed input. The negative elasticity estimate for seed implies that as the quantity of seed sown by the sampled farmers increases there tends to be reduction in cotton production. Farmers seem to be sowing too much seed or possibly the germination rate is poor such that farmers tend to over sow or at times re-sow the seeds. If the farmers are sowing too much seed then this may result in disease outbreak as insects are being harboured. Spraying is also difficult if plants are overcrowded and boll formation is poor resulting in lower output.

Table 3: Maximum-likelihood Estimates for the Parameters in the Cobb-Douglas Stochastic Frontier Production Function for Cotton Farmers.

Variable	**Parameter**	**Coefficients**	**Standard error**	**T-ratio**
Stochastic Frontier				
Constant	β_0	1,4960***	0,9979	1,4991
Land	β_1	0,7438**	0,3991	1,8636
Seed	β_2	-0,1416	0,7846	-0,1805
Fertiliser	β_3	0,7084	0,5497	0,9384
Labour	β_4	-0,3845*	0,1064	-3,6137
Capital	β_5	0,1375	0,4998	0,2752
Pesticides	β_6	0,9433**	0,4951	1,9052
Inefficiency Model				
Constant	δ_0	0,1332	0,9850	0,1346
Farm size	δ_1	0,5062***	0,4500	1,1249
Family size	δ_2	-0,1853	0,1738	-0,1903
Age	δ_3	-0,5562	0,8235	-0,6754
Education	δ_4	0,7071	0,9595	0,7368
Variance parameters	σ^2	0,2278***	0,2099	1,0853
	γ	0,9999	0,1076	0,9297
Log (Likelihood) Function	0,1454			
Average Technical Efficiency	0,7159			

* significant at 5% level ** significant at 10% *** significant at 20%

5.2 The technical inefficiency effects

The estimate for the variance parameter, γ, associated with the variance of the inefficiency effects is close to 1. Since it is significantly different from zero, it can be concluded that there are technical inefficiency effects associated with the production of cotton by the sampled farmers.

The estimated coefficients of the explanatory variables in the model for technical inefficiency effects are of interest and have important implications. As shown in Table 3, the coefficients of farm size and education are positive. This means that the two variables positively influence inefficiency. As these farmers operate larger pieces of land they become less technically efficient. This can be explained by noting that before these farmers were resettled they used to operate small farms. Now they have larger pieces of land they tend to be less technically efficient. Although education was expected to have a negative influence on technical inefficiency the opposite was found. This is possibly because there is not much difference between the educational levels of the sampled farmers. All the farmers were found to be functionally literate. It is also possibly important to look at levels of informal education.

The coefficients for family size and age are negative which implies that they negatively influence inefficiency. It is expected that older farmers tend to be more conservative and less receptive to modern and newly introduced technology. In this case the opposite is true. The older farmers tend to be more efficient. This is possibly because they are more experienced in the production of cotton. One other possible reason is that older farmers have more resources at their disposal, which includes capital (cattle). Family size also tends to negatively influence efficiency. This suggests heavy reliance on family labour since family members are expected to provide the bulk of the labor force.

5.3 Technical efficiencies

The frequency distribution of the predicted individual technical efficiency estimates is presented in Table 4. The predicted technical efficiencies differ substantially among the sampled farmers ranging between 22,2% and 99,9%, with the mean technical efficiency estimated to be 71,6%. This implies that, on average, sampled cotton farmers of Mutanda resettlement scheme are producing cotton at over 70% of potential (stochastic) frontier production levels, given the levels of their inputs and technology currently being used.

From Table 4, it is evident that there is a wide gap between the lowest and highest level of estimated technical efficiency. This means there is some room for effecting improvements in the technical efficiencies of some of the farmers. In general, the farmers are technically efficient with 43% having technical efficiencies above 80%. Only about 16% of the farmers reflected poor technical efficiency performance, i.e. below 50 %.

Table 4: Frequency distribution of technical efficiency in the stochastic cotton production function

Level (%)	Number of farms N = 44	Percentage of farms	Cumulative Percentage
<50	7	15,9	15,9

51-60	4	9,2	25,1
61-70	7	15,9	41,0
71-80	7	15,9	56,9
81-90	13	29,5	86,4
91-100	6	13,6	100,0
Mean = 71,6	Minimum = 22,2	Maximum = 99,9	

6. CONCLUDING REMARKS

The empirical results obtained from the sampled farmers indicate that land, labour and pesticides significantly influence cotton output. An increase in land area under cotton would result in greater production of cotton to the farmers. Farmers should be encouraged to use more fertilizer and pesticide sprays to enhance cotton output.

The results also indicate that the farmers are over utilizing both seed and labour inputs. Less seed should be sown to avoid the overcrowding of plants. This makes it difficult to spray the plants and it encourages pest infestations. Boll formation by the plants is also negatively affected and this reduces overall output. These farmers are resource poor and are possibly substituting labour for capital since there is still room for the farmers to use more capital and increase output.

The results further indicate that farm size significantly influences technical inefficiency. Increasing the farm size has a positive effect upon the technical inefficiency of production. It is assumed that such farmers are used to operating small farms and have insufficient resources to produce cotton with technical efficiency. As family size or age of head of household increase there would be a decrease in technical inefficiency. This seems to suggest that farmers rely heavily on family labour. Also older farmers are more responsive to technological change possibly because they have more capital than young farmers and they are more experienced.

The results depict a wide gap between the farmers who are quite poor in their technical efficiency performance (22,2%) and the highly technically efficient ones (99%). There is room for farmers to learn from their peers who are more efficient. If any extension work is to be extended to these farmers it is important to include the other farmers who are more technically efficient.

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