# Are Zimbabwe's Fast Track Land Reform Farms more Technically Efficient than Communal Farms?

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## Abstract

In an attempt to address a racially skewed land distribution and alleviate rural poverty, Zimbabwe has, since its independence, pursued redistributive land reform programmes. The latest phase of these programmes is the Fast Track Land Reform Programme (FTLRP) launched in 2000 to accelerate compulsory acquisition and resettlement of land. This paper uses data on FTLRP beneficiaries and a control group of unsuccessful communal applicants to examine the programme's impact on the technical efficiency of its beneficiaries. To account for possible systematic selection into FTLRP, we employ a probit selection equation and estimate a corrected Cobb-Douglas stochastic frontier function model. The resultant inefficiency model estimates reveal that FTLRP beneficiaries are more technically efficient than communal farmers. Further, there exist a nonlinear relationship between farm size and technical efficiency. Fencing parcels and livestock holdings is found to improve technical efficiency suggesting that alleviating resource constraints would enhance technical efficiency of smallholder agriculture.

**Keywords:** Fast Track Land Reform Programme, agricultural productivity, technical efficiency, Zimbabwe
**JEL:** D24, Q12, Q15, Q18

## 1 Introduction

Land reform has been used by governments in both developed and developing countries as the main policy tool to redress excessive historical inequalities in land ownership. This is of particular relevance in Sub-Saharan Africa where the colonial legacy left a disproportionate distribution of fertile lands in the hands of a few white settlers and marginalized the indigenous African population (LAHIFF, 2003). As a result the need to address imbalances in land ownership motivated many people to participate in the liberation wars leading to independence in a number of Sub-Saharan African countries. Up to this day, many governments are pressured to identify an ideally faster African land reform model that seeks to achieve historical justice, especially given that over 60% of the population derive their livelihoods from smallholder agriculture and rural economic activities (OWUOR and SHEM, 2009). Proponents of redistributive land reforms argue that besides redressing unequal distribution of asset (land) ownership, redistributive land reforms could also alleviate poverty, create jobs, and improve farm productivity and efficiency (DEININGER et al., 2008 and WORLD BANK, 2008). These would subsequently improve economic growth in the long term.

Despite such general consensus on the benefits of land reform, however, whether reform farms enjoy increased technical efficiency is central to the question of whether there are actual farm-level productivity benefits of land redistribution. One strand of literature maintains that smaller farms are more efficient than their larger size counterparts, as evidenced by the existence of inverse farm-size productivity relationships (CARTER, 1984; DEININGER et al., 2008). This assertion that smallholder farms are more efficient has further justified the need for land reforms in Sub-Saharan Africa. However, while a number of studies have examined the technical efficiency of agricultural enterprises in developing countries (BATTESE and COELLI, 1995), particularly in African countries (SEIDU et al., 2006; OWUOR and SHEM, 2009), research on how redistributive land reforms impact farm technical efficiency is limited and knowledge of farmers' production and technical efficiency levels remains inadequate particularly in Sub-Saharan Africa (OKOYE et al., 2008).

This paper seeks to contribute to the limited literature that assesses empirically factors affecting technical efficiency in smallholder agriculture, with a particular focus on efficiency differentials caused by land reforms in the African context. It compares the technical efficiency of land reform and non-land reform farms. The paper focuses on the most recent phase of Zimbabwe's redistributive land reform programme, the Fast Track Land Reform Programme (FTLRP), launched in 2000 with the primary objective of accelerating both land acquisition and redistribution of at least five million hectares of land.

The FTLRP has been widely criticized both in its design and execution (CHITIGA and MABUGU, 2008). However, whether the reform has impacted on the welfare of smallholder farmers (as it is intended to) lies in careful analyses of various aspects of access, equity and efficiency. Analysing the technical efficiency in communal and reform lands is closely related to the debate involving the efficiency-equity trade-off in the Zimbabwean agriculture. Very limited empirical literature on the impacts of FTLRP exists. CHITIGA and MABUGU (2008) analyse the impact of the land redistribution in Zimbabwe on poverty, inequality and productivity, using a Computable General Equilibrium (CGE) approach coupled with a micro-simulation model. The improvement in productivity is found to be very modest. ZIKHALI (2008) also analyses the impact of the FTLRP on productivity and soil conservation investment. The paper finds that smallholder FTLRP farms are more productive than their communal counterparts. Further results show that tenure insecurity associated with FTLRP land negatively impacts farm investments, which could partly explain the nationwide decline in agricultural production following the FTLRP. However, none of these studies compare the efficiency of FTLRP against communal land.

There is, however, scant technical efficiency analysis on Zimbabwe's pre-2000 land reforms. For example, MUSHUNJE et al. (2006) the technical efficiency of 44 cotton farmers from Mutanda resettlement scheme of Manicaland province in Zimbabwe using data for the 2001/2002 cropping year. The paper found that technical efficiency declines with farm size and the education level of the household head while it increases with increased family size and age of household head. Notably, pre-2000 land reforms enjoyed international support and were better planned than the FTLRP. Thus, the FTLRP calls for a separate analysis since its impacts would potentially be different from pre-2000 land reform programmes. Accordingly, this paper aims to identify the socio-economic and physical farm characteristics as determinants of technical efficiency in communal and FTLRP farms. We draw on existing empirical literature providing micro-evidence on the impact of land reform and employ a stochastic frontier production framework, originally proposed by AIGNER, LOVELL and SCHMIDT (1977) and MEEUSEN and VAN DEN BROECK (1977). The stochastic frontier production analysis involves an unobservable random variable associated with the technical inefficiency of production of individual farms in addition to the random error in a traditional regression model. In addition, given that beneficiaries of FTLRP might differ systematically from non-beneficiaries, we use a two-stage procedure that corrects for potential self-selection bias in our efficiency analysis. Results from the analysis reveal FTLRP beneficiaries to be more technically efficient than their counterparts in the communal areas.

Our study differs fundamentally from MUSHUNJE et al. (2006) in several aspects. First, this paper employs samples from a different resettlement scheme – Mazowe district of Mashonaland Central province in Zimbabwe. Second, we use more recent sample data, collected in 2007 covering beneficiaries of the FTLRP. Third, these data are at micro-level, specifically covering a larger parcel-level sample. Micro-level data are preferable than aggregate or national level data that constrain the policy relevance of such studies as they fail to distinguish the types of land reform and their outcomes (DEININGER et. al, 2008 and ZIKHALI, 2008). Fourth, the study involves mixed cropping farming systems i.e. it includes all crop products. Finally, our analysis uses the traditional communal farmers who applied for land under the FTLRP but were rejected as the control group.

The findings of the study are crucial in informing Zimbabwean policymakers in their attempt to correct the mistakes made within the FTLRP and formulate strategies to resuscitate the smallholder agricultural sector. Moreover, such an analysis would shed light into the technical efficiency implications of one of the sub-Saharan African land reform models and provide lessons for possible land and/or agrarian reforms in other countries. As MUMDANI (2008) argues, similar radical land redistributions in Zimbabwe are possible elsewhere; for instance, since 2000 South Africa is facing growing militancy by land activists such as the Landless People's Movement (LAHIFF, 2003).

The next section provides a brief background on Zimbabwe's land reform programmes. Section 3 presents the theoretical framework and estimation strategy used in the study. A discussion of the data used in the empirical estimation is done in section 4 while the results are presented and discussed in Section 5. Section 6 concludes.

## 2 An Overview of Land Reforms in Zimbabwe

Upon attaining independence in 1980, Zimbabwe inherited a flourishing dualistic agricultural sector skewed in favour of the white settlers. The white settlers owned large-scale commercial farms, consisted of less than 1% of the population yet occupied 50% of all agricultural land, of which 75% of the land was located in fertile agricultural productive areas (SHAW, 2003). In contrast, indigenous Africans occupied the small-scale communal agricultural sector with communal ownership vested in the state with chiefs bestowed the rights to reallocate the land to individuals.

At the onset of independence, the government pursued land resettlement under the guidelines of the 1979 Lancaster House constitution which restricted land acquisition only to the 'willing-buyer willing-seller' principle for the first decade following independence. The market based land redistribution was implemented in line with the government policy of reconciliation for 17 years, 1980-1997. Britain sponsored grants worth US$44 million to Zimbabwe's government during the 1980s to facilitate the land reform program. As a result, about 430,000 hectares were acquired each year between 1980 and 1996 (MOYO, 2004). Farm land owned by white settlers shrunk from 50% of agricultural land in 1980 to 29% in 1986 (MOYO, 1995). In spite of the achievements, the redistribution process was slow and below target. These developments are in line with evidence which indicates that the 'willing-buyer willing-seller' principle – where willing white commercial farmers sell land to the government for redistribution – had limited success in South Africa (1994-2006), Kenya (1960-2006) and Namibia (1990-present). This is because few white commercial farmers sold their land, which led to low resettlement rates and contributed to high poverty rates especially among the rural population whose livelihoods depend on land.

The overall picture was that post-independence policies perpetuated a dualistic agricultural sector. The market liberalization or capitalism policy shifts in the 1990s strengthened agricultural trade or exports through granting concessions to commercial farm operators. These policies only helped maintain the status quo. They did not fundamentally change the highly unequal and dualistic nature of property relations in the country's agricultural sector (LAHIFF, 2003). Similarly, the policies did not deliver significant material benefits to the rural population and instead withdrew all the subsidies the rural population enjoyed. Intuitively, a better land reform programme was needed.

In cognisant of this, Zimbabwe launched the Fast Track Land Reform Programme (FTLRP) in June 2000 to accelerate land acquisition and resettlement. It was aimed at immediate compulsory acquisition of land for resettlement primarily from large-scale white commercial farms, few private companies and absentee landlords to the overcrowded communal areas, the landless and general citizens. Its implementation was a result of government's reaction to the unruly war veterans' seizure of land that began in 1997 and the collapse of discussions over land reform between government, the United Nations Development Program and the British government in 2000 (CHITIGA and MABUGU, 2008). The collapse of talks eroded hopes for a negotiated solution to the land crisis. Therefore, government formalized the seizures through passing the 'compulsory land acquisition law' in 2000 which became a de facto successor of the 'willing-buyer willing-seller' principle.

The FTLRP was based on two models: model A1 and model A2. Model A1 aims to relieve the congested communal areas and the land-constrained farmers in communal areas who largely produce for subsistence. Conversely, model A2 is a commercial resettlement scheme comprising small-, medium- and large-scale commercial resettlements intended to create a cadre of African (black) commercial farmers. Thus, model A2 is open to any Zimbabwean citizen able to reimburse the government for the incurred costs.

The analysis in this paper is confined to model A1 as it is fairly comparable to existent communal farms. Hence, we focus on the difference in parcel level technical efficiency between farmers who have benefited from the FTLRP under the Model A1 scheme and communal farmers.

# 3 Theoretical Framework and Estimation Strategy

This section gives a brief background on the technical (in)efficiency analysis followed by the stochastic frontier production function framework which is the underlying econometric framework the study employs.

## 3.1 Technical Inefficiency Analysis

Technical efficiency is generally defined as the ability to minimize input use in the production of a given output vector (KOOPERMAN, 1951). This definition led to the development of different methods of measuring and/or estimating the relative technical efficiencies of firms. The essence of measuring technical efficiency lies in the fact that profit maximization requires a firm to produce the maximum output given the level of inputs employed (i.e. be technically efficient), use the right mix of inputs in light of the relative price of each input (i.e. be input allocative efficient) and produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) (KUMBHAKER and LOVELL, 2000). The level of technical efficiency of a particular firm is characterized by the relationship between observed production and some ideal or potential production (GREENE, 1993).

The measurement of firm level specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. In the case where a firm's actual production point lies on the frontier it is considered perfectly efficient. But if it lies below the frontier it is technically inefficient, with the ratio of the actual to potential production defining its level of efficiency.

Following HERRERO and PASCOE (2007), we estimate the stochastic production frontier, where the output of a firm is a function of a set of inputs, inefficiency and random error. The important task is to relate inefficiency to a number of factors that are likely to be determinants, and measure the extent to which they contribute to the presence of inefficiency. In line with this, this study focuses on Zimbabwe's Fast Track Land Reform and its impacts on farm efficiency. The estimation strategy specifies the Cobb-Douglas functional form and the model for the technical inefficiency effects in the stochastic frontiers. The results are expected to provide meaningful insights into the underlying factors driving efficiency differentials in FTLRP and non-FTLRP or communal farms.

### 3.2 Technical Efficiency using the Stochastic Frontier Model

Similar to most studies on Africa's farm technical efficiency (SEYOUM et al., 1998; AHMED et al., 2002; OKOYE et al., 2008) we adopt COELLI et al.'s (1998) and KUMBHAKAR and LOVELL'S (2000) stochastic frontier production function specified as:

(1) $$Y_i = f(x_i, \beta)e^{v_i - u_i}$$

where $i$ represents farmer $i = 1,2,\cdots,I$ who use a vector of $x > 0$ inputs to produce $Y > 0$ outputs and $f(x_i, \beta)$ and $e^{v_i - u_i}$ represent the deterministic and stochastic part of the production frontier, respectively. $\beta$ denotes the vector of parameters to be estimated. $v_i - u_i$ is the composite error term which is asymmetric. The two-sided 'noise' component $v_i(v \sim N(0, \sigma_v^2))$ and the one-sided efficiency component $u_i \geq 0$ with half-normal distribution $u_i(u \sim N|(0, \sigma_u^2)|)$ are assumed to be independent of each other.

Let $\sigma_v^2$ and $\sigma_u^2$ denote the variances of the parameters: symmetric ($v$) and one-sided ($u$) error terms, where $\lambda = \sigma_u^2 / \sigma_v^2$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The maximum likelihood or corrected ordinary least squares (COLS) estimation of equation (1) yields estimators for β and λ. The parameter λ is an indicator of the relative variability of the two sources of variations. If λ is closer to zero the symmetric error term dominates the variation between the frontier/ maximum attainable levels of output and the observed level of output. Put differently, a value of λ close to zero implies that the discrepancy between the observed and the maximum attainable levels of output is dominated by random factors outside the control of the producer. Otherwise, the more λ is greater than one the more the production is dominated by variability emanating from technical inefficiency.

Taking natural logarithms of the stochastic production frontier model in equation (1), the equation can be rewritten as:

(2) $$ln Y_i = ln f(x_i, \beta) + v_i - u_i$$

Assuming that $z = z(z_1, z_2, ..., z_n)$ represent the vector of exogenous factors affecting technical inefficiency, the stochastic frontier production function is specified as:

(3) $$ln Y_i = ln f(x_i, z_i, \beta) + v_i - u_i$$

In our production function the conventional agricultural inputs, $x_i$, considered include labour, area of land cultivated, manure, area of land under soil conservation structures and traction defined as the number of days a household used to plough the parcel using either oxen and/or a tractor. In addition, exogenous parcel level characteristics, specifically the predominant soil type on the parcel, are also hypothesized to impact production levels. Regional dummies defined by the chief of the region are also included to capture location specific determinants of agricultural output.

The variables included in the vector $z_i$ are access to external assistance and extension services, age, education and gender of the household head, number of livestock held by the household, farm size and whether the parcel is fenced or not. The choice of the variables was largely based on economic arguments as well as existing empirical literature on factors affecting both production levels and inefficiencies. External assistance (for example subsidised inputs from the government) is used to proxy access to credit in an environment of imperfect credit markets such as rural Zimbabwe. Access to credit offers a characterization of the degree of market development or competitiveness. Access to extension services captures the availability of farming advice that could enhance technical efficiency of farmers. The size of livestock holdings captures household wealth.

### 3.3 Determinants of Inefficiency and Sample Selection Issues

One empirical issue addressed in our technical efficiency analysis is the possibility that farms are not randomly selected into reform and communal lands. For the $i^{th}$ farm, the likelihood of belonging in the reform category is given by:

$$(4) \qquad P_i = \begin{cases} 1 & if\ \gamma S_i + \varepsilon_i > 0 \\ 0 & otherwise \end{cases}$$

where $P_i$ is an indicator variable equal to 1 if the land is a reform land, $S_i$ is a vector of demographic characteristics including age, gender of the household head, and numbers of male and female adults, livestock holdings as a proxy for wealth and whether or not the household head was involved in farming prior to the launch of the FTLRP in 2000 and $\varepsilon_i$ is the error term. $\gamma$ is the vector of parameters to be estimated.

Taking into consideration the selection bias implies that the inverse mills ratio can be included as a correcting factor in the stochastic production frontier equation. This transforms equation (3) into:

$$(5) \qquad ln Y_i = ln\, f(x_i, z_i, \beta) + v_i - u_i + imr$$

where *imr* stands for the inverse mills ratio.

The data used in estimating equations (3) and (5) is presented in the following section.

# 4 Data, Survey Area and Descriptive Analysis

The primary objective is to test the technical efficiency of FTLRP beneficiaries relative to communal farmers. The sampling frame was restricted to Mazowe district, one of the seven districts in the Mashonaland Central province in Zimbabwe. The district was of natural interest since it is one of the most productive arable areas in Zimbabwe targeted for land reforms. The district is split into 29 wards, 13 of which are located in Chiweshe communal areas.

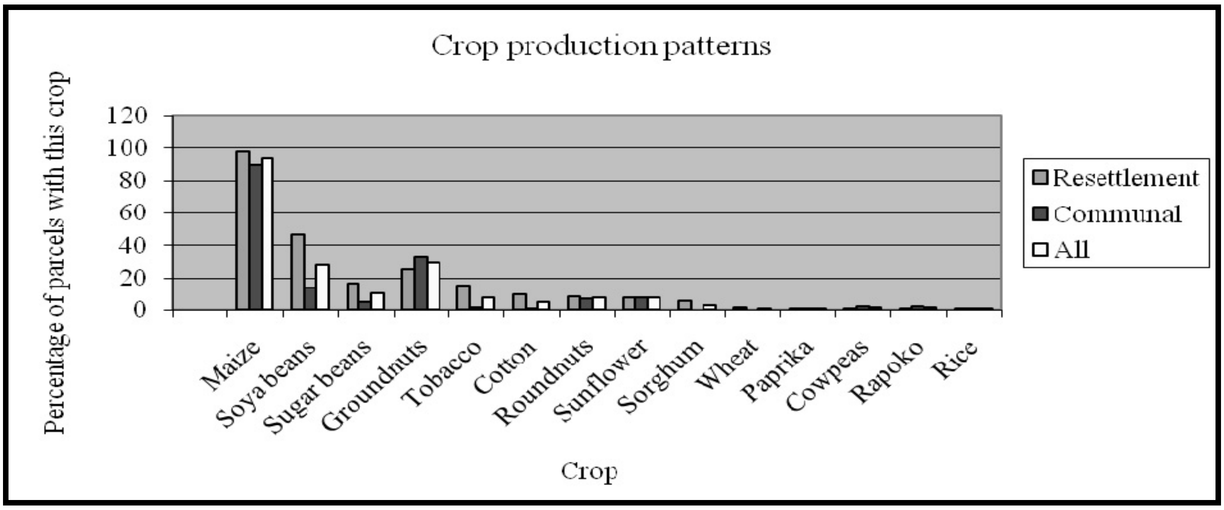
The data was collected in May 2007 for 334 parcels[1] of 255 randomly selected households belonging to three different chieftainships – Chief Chiweshe, Chief Makope and Chief Negomo. The sample comprises 103 communal households (operating 182 parcels) and 152 FTLRP beneficiaries (operating 152 parcels). Around 46% of the surveyed parcels used in the analysis were acquired through the FTLRP while the rest are found in communal areas. The sample is restricted to FTLRP beneficiaries and communal farmers who applied for land under the FTLRP but were rejected. The choice of the control group is restricted to unsuccessful communal applicants to enable a more reliable comparison between beneficiaries and non-beneficiaries that minimizes self-selection bias. An alternative of a random control group of communal households – made up of applicant and non-applicant households – is likely to provide biased estimates of the benefits of land reform. Presumably, out of choice, these households decided not to participate in the programme because they were not eligible. Moreover, it could be that they were doing relatively well or were apprehensive about the FTLRP.

## 4.1 Production Output and Input Summary Statistics

The differences in the cropping patterns between the FTLRP and communal groups are illustrated in figure 1 below. Results from two-tailed sample tests indicate that significant cropping differences between the two groups prevail with regards to maize, soya and sugar beans, tobacco, cotton, sorghum, and wheat.

[1] A parcel is defined as a contiguous piece of land on which one or more different crops can be cultivated.

**Figure 1. Crop production patterns: FTLRP versus communal farmers**




Source: own survey data (2007)

Although the parcels are multi-cropping systems, data reveals maize ─ the country's staple food ─ as the major crop, produced on 90% and 97% of surveyed communal and FTLRP parcels respectively. The pooled sample of the surveyed parcels also showed 93% of the parcels had maize. This could mean that food security has become more of a priority given the harsh economic environment. Apart from food security reasons, the trends observed in Figure 1 above are also consistent with evidence that shows that under the FTLRP the four main commercial field crops, which include wheat, tobacco, soybeans and sunflower, have experienced reduced area plantings due to low uptake and use of land as well as inexperience and lack of resources on the part of new farmers (MOYO, 2004).

Our analysis is based on multi-output parcels necessitating some form of aggregation of physical output based on for example monetary measures. The hyperinflationary environment in Zimbabwe makes price information unreliable. As a result the aggregation of the value of production is based on South African producer prices[2]. Table 1 below reports both input usage and the output differences between the two groups. Due to the fact that only 2% of communal farmers use tractors, we used oxen and tractor days to construct an overall indicator of traction days, *Traction,* using Principal Components Analysis (PCA). PCA is used here to statistically weigh oxen and tractor days in order to calculate aggregate index of traction (JOLLIFFE, 1986). We retained components with an eigenvalue greater than one.

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[2] The exchange rate between the South African rand and the U.S. dollar at the time of data collection was: 1 ZAR=9.07 USD.

**Table 1. Input usage and output of FTLRP and communal farmers**

| | Communal | FTLRP | *t*-tests | Pooled |
|---|---|---|---|---|
| **Output** | | | | |
| Value of total output per hectare | 587.27 | 2404.53 | *** | 1414.29 |
| Total maize output per hectare, in kilograms | 892.87 | 2400.89 | *** | 1579.16 |
| **Input** | | | | |
| Fertiliser, kg per hectare | 101.70 | 249.55 | *** | 168.99 |
| Oxen days per hectare | 1.21 | 1.70 | *** | 1.43 |
| Tractor days per hectare | 0.02 | 0.27 | *** | 0.16 |
| Traction per hectare | 0.82 | 1.39 | *** | 1.16 |
| Manure, kg per hectare | 572.03 | 95.66 | *** | 355.24 |
| Labour, people per hectare | 3.16 | 2.13 | *** | 2.69 |
| Soil conservation per hectare | 106.87 | 55.04 | *** | 83.28 |

*Difference significant at 10%; ** significant at 5%; *** significant at 1% level of significance.
Source: own survey data (2007)

The average value of output per hectare for the whole sample is around Rand 1,414. The average value of output is more than three times higher per hectare for FTLRP, with a mean of Rand 2,404 compared to Rand 587 for the communal farmers. This difference has high statistical significance. In terms of maize yields, summary statistics indicate that the average maize output per hectare is 2,400 kg for the FTLRP parcels, 893 kg in communal areas and 1,579 kg for the whole sample. Comparing this to the national statistics in 1999, just before the launch of the FTLRP, we realise that while the figure for the FTLRP group exceeds that of 1999 for the communal areas (1,024 kg), it falls far short of the average for the commercial farming sector (4,393 kg) (MUDIMU, 2003). This comparison should, however, be done cautiously since these 1999 yield figures in the commercial farming sector were achieved over many years while the FTLRP farmers have been operating for less than ten years.

Statistics on input usage between the two groups suggest that the observed output differences are partly due to the two groups' differences in input usage. As reported in table 1 the FTLRP subsample use significantly more fertilisers and oxen while communal farmers try to substitute by using manure, labour and soil conservation structures intensively.

In addition, the output differences between the two groups could be due to some unobserved differences in parcel characteristics between the two groups that enhance the productivity of inputs in the FTLRP group. For example, under colonial rule commercial farmers had access to more fertile land, implying that the accuracy in explaining observed output differentials depends partly on how effectively and exhaustively we are able to control for soil quality indicators.

### 4.2 Statistical Analysis of Household and Parcel Characteristics

In addition to production data, the questionnaire contained detailed questions on households' socio-economic indicators and parcel characteristics. We present the summary statistics for these household and parcel level variables in table 2 below. Two-sample *t*-tests are also performed to test for differences between the FTLRP and the communal groups.

**Table 2. Descriptive statistics of parcel and household level variables**

| Variable | Description | Communal (n=431) | FTLRP (n=161) | *t*-tests | Pooled (N=592) |
|---|---|---|---|---|---|
| **Parcel characteristics** | | | | | |
| Parcel size | Size of the parcel, in hectares | 4.06 | 6.41 | *** | 5.13 |
| Clay soil | Predominant soil type clay (1=yes, 0=no) | 0.07 | 0.02 | ** | 0.05 |
| Clay-loam soil | Predominant soil type clay-loam (1=yes, 0=no) | 0.28 | 0.44 | *** | 0.35 |
| Sandy soil | Predominant soil type sandy (1=yes, 0=no) | 0.56 | 0.20 | *** | 0.40 |
| Red soil | Predominant soil type red (1=yes, 0=no). The reference soil type variable | 0.09 | 0.34 | *** | 0.20 |
| Parcel fenced | Parcel fenced (1=yes, 0=no) | 0.53 | 0.09 | *** | 0.33 |
| **Household level characteristics** | | | | | |
| Farm size | Farm size in hectares | 7.96 | 6.41 | ** | 7.04 |
| Male | Gender of the household head (1=male, 0=female) | 0.73 | 0.78 | | 0.76 |
| Male adults | Number of male household members older than 15 years | 1.86 | 1.99 | | 1.92 |
| Female adults | Number of female household members older than 15 years | 2.30 | 1.97 | * | 2.15 |
| Age in 2000 | Age of the household head in year 2000 | 46.46 | 38.96 | *** | 43.04 |
| Age | Age of the household head | 52.32 | 45.96 | *** | 48.53 |
| Education | Number of years of formal schooling of the household head | 8.43 | 9.19 | * | 8.88 |
| Livestock holdings in 2000 | Livestock holdings in the year 2000 (in Tropical Livestock Units) | 3.77 | 2.09 | *** | 3.00 |
| Livestock holdings | Livestock holdings (in Tropical Livestock Units) | 4.22 | 3.48 | | 3.78 |
| Non-farmer in 2000 | Household head engaged in non-farming before FTLRP (1=yes, 0=no) | 0.02 | 0.50 | *** | 0.24 |
| Extension | Access to extension services (1=yes, 0=no) | 0.75 | 0.90 | *** | 0.84 |
| External assistance | Receipt of government o other institutional assistance (1=yes, 0=no) | 0.21 | 0.82 | *** | 0.58 |
| Makope | Chief Makope (1=Chief Makope). The reference chieftainship variable | 0.26 | 0.13 | *** | 0.18 |
| Chiweshe | Chief Chiweshe (1=Chief Chiweshe) | 0.11 | 0.47 | *** | 0.32 |
| Negomo | Chief Negomo (1=Chief Negomo) | 0.63 | 0.40 | *** | 0.49 |

*Difference significant at 10%; ** significant at 5%; *** significant at 1%.

Source: own survey data (2007)

The summary statistics demonstrate that on average, FTLRP beneficiaries have a significantly higher parcel size than communal farmers. However, they have smaller farm sizes. This is due to the fact that FTLRP farms are not fragmented in the sense that each FTLRP household has one parcel which is then also reflected as the farm, whereas multiple parcel ownership is reported in the communal group.

The head of a FTLRP household is typically 6 years younger and has one more year of schooling (more educated). While the incidence of female-headed households is higher in the FTLRP group, this difference is insignificant. However communal households have significantly more female adults, on average, than FTLRP households. In addition, 50% of the beneficiaries had a household head who was engaged in non-farm activities before the programme.

A larger proportion of FTLRP households (90%) have access to extension services compared to communal households (75%), lending support to the criticisms that extension services have been traditionally confined to resettlement farmers. In addition the descriptive statistics reveal that FTLRP have higher chances of getting external farm assistance for example through subsidised farm inputs from the government: 82% of FTLRP reported getting external assistance while this is only 21% in the communal group.

## 5 Empirical Results and Discussion

As argued earlier, an inefficiency analysis that fails to correct for the possibility in the sample might lead to biased estimates. This is because beneficiaries of FTLRP might differ systematically from non-beneficiaries. Although the sample used tries to minimise this by comparing the beneficiaries to communal farmers who applied for resettlement but were rejected, this might not fully capture self-selection into the program. Following HECKMAN (1976), we use the inverse Mills ratio to correct for this selection bias. This entails pursing a two-stage procedure in our efficiency analysis: the first step estimates a probit model on whether or not a household is selected into FTLRP. The estimated parameters are used to calculate the inverse Mills ratio, which is then included as an additional explanatory variable in the inefficiency model.

### 5.1 Selection into the FTLRP

Selection into the FTLP was arguably based on situations that prevailed before the start of the programme. However, the major challenge given the cross-sectional nature of our data is obtaining variables that capture this. Fortunately, the questionnaire had questions on livestock holdings and occupation of the household head in the year

2000. We also control for education of household head, number of male and female adults. Variables that capture the situation at the time of the survey are not included in the probit model as there could be concerns that they might have changed between the start of the programme and the time the data was collected.

The results from the probit analysis are presented in table 3 below. They reveal the existence of selectivity regarding who participates in the FTLRP.

**Table 3. Probit estimates for selection into the FTLRP**

| Variables | Coefficient | Robust Std. Error |
|---|---|---|
| Male | 0.006 | 0.211 |
| Age in 2000 | -0.031*** | 0.007 |
| Education | -0.027 | 0.033 |
| Male adults | 0.165** | 0.077 |
| Female adults | -0.007 | 0.052 |
| Livestock holdings in 2000 | -0.026 | 0.027 |
| Non-farmer in 2000 | 2.375*** | 0.296 |
| Constant | 0.697 | 0.506 |
| Observations | 320 | |
| Log-likelihood | -138.877 | |
| Overall correct predictions (%) | 81 | |

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.

Source: estimation based on own survey data (2007)

The FTLRP's decongestion objective implies that we would expect priority to be given to communal households when it comes to selection into the FTLRP. In contrast, results indicate that households in which the household head was engaged in non-farm activities prior to the commencement of the FTLRP were more likely to have benefited from the programme. This could frustrate the programme's decongestion goal.

The FTLRP also tended to favour younger household heads possibly reflecting government efforts to provide young heads with a source of livelihood (land). On the other hand, our findings suggest that efforts to increase women's access to land within the FTLRP may have been ineffective, in line with concerns posed by GOEBEL (2005); the more male adults in a household, the more likely it is to benefit from the FTLRP. In Zimbabwe rights to land have been customarily reserved for men hence the more men a household has, the greater the comparative advantage with regards to land access.

## 5.2 Stochastic Production Frontier Analysis

Table 4 below presents results from a maximum-likelihood estimation of a Cobb-Douglas stochastic frontier production function. Two models are estimated and presented. The first model (model *a*) does not correct for self-selection while the second model (model *b*) corrects for self-selection using the inverse mills ratio calculated from the probit estimation presented in table 3 above. In both models the dependent variable in the production function is the value of total agricultural output, in South African rands.

**Table 4. Maximum-likelihood estimation of a Cobb-Douglas stochastic frontier production function**

| | *a* | | *b* | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Std. Error** | **Coefficient** | **Std. Error** |
| **Stochastic frontier model** | | | | |
| Log of fertiliser | 0.140*** | 0.032 | 0.147*** | 0.032 |
| Log of labour | 0.421*** | 0.135 | 0.405*** | 0.138 |
| Log of soil conservation | 0.003 | 0.004 | 0.003 | 0.004 |
| Log of manure | -0.022 | 0.019 | -0.018 | 0.020 |
| Log of land (parcel size) | 0.770*** | 0.219 | 0.799*** | 0.220 |
| Log of traction | 0.059 | 0.097 | 0.045 | 0.097 |
| Clay | 0.790** | 0.336 | 0.768** | 0.339 |
| Clay-Loam | -0.201 | 0.170 | -0.213 | 0.174 |
| Sandy | 0.107 | 0.184 | 0.002 | 0.190 |
| Chiweshe | -0.558*** | 0.204 | -0.597*** | 0.210 |
| Negomo | -0.557*** | 0.173 | -0.623*** | 0.174 |
| Constant | 7.197*** | 0.710 | 7.097*** | 0.727 |
| **Inefficiency model** | | | | |
| Reform | -1.859*** | 0.319 | -2.267*** | 0.433 |
| Inverse mills ratio | | | -0.593 | 0.387 |
| Parcel fenced | -0.493** | 0.195 | -0.478** | 0.204 |
| External assistance | 0.082 | 0.196 | 0.261 | 0.216 |
| Extension | -0.127 | 0.218 | -0.208 | 0.233 |
| Livestock holdings | -0.101*** | 0.027 | -0.098*** | 0.029 |
| Male | -0.100 | 0.192 | -0.132 | 0.203 |
| Age | 0.008 | 0.006 | 0.008 | 0.007 |
| Education | 0.019 | 0.030 | 0.019 | 0.032 |
| Farm size | -0.065* | 0.037 | -0.072* | 0.039 |
| Farm size squared | 0.002** | 0.001 | 0.002** | 0.001 |
| Constant | 3.267*** | 0.716 | 3.158*** | 0.775 |
| $\sigma^2$ | 1.464*** | 0.190 | 1.491*** | 0.210 |
| $\gamma$ | 0.794*** | 0.109 | 0.79*** | 0.105 |
| Log-Likelihood | -503.608 | | -474.038 | |
| Mean technical efficiency | 21.79% | | 23.77% | |
| Observations | 334 | | 316 | 316 |

Note: * significant at 10%; ** significant at 5%; *** significant at 1%.
Source: estimation based on own survey data (2007)

As reported in table 4, the estimate of $\gamma$ in the stochastic production function is large (equal to 0.79) indicating that the inefficiency effects are highly significant in analysing output of the sampled farmers. This parameter ($\gamma$) represents the share of deviation from the frontier that can be attributed to inefficiency while the rest is attributed to noise (COELLI et al., 1998). In this case the value of 0.79 indicates that around 79% of the two components disturbance term was represented by technical inefficiency. Further, the high significance of this parameter leads to a rejection of the null hypothesis that the deviations from the frontier are only attributable to random noise. This implies that the stochastic production frontier model with an inefficiency component is a valid specification. Further, the significance of the parameter $\sigma^2$ suggests that a conventional production function does not adequately represent the data (HJALMARSSON et al., 1996).

Though the coefficient for *Inverse mills ratio* in model *b* is insignificant at 10 %, it is almost significant (i.e. significant at 12%) suggesting that self-selection bias is marginally driving the inefficiency differences between the FTLRP beneficiaries and communal farmers. Hence, the discussion of the results is based on the second estimation which corrects for self-selection.

### *5.2.1 Determinants of Agricultural Production*

Our interest in this analysis has been to investigate whether there are any production and technical efficiency differences between FTLRP beneficiaries and communal farmers.

Results from the production frontier model underscore the significance of conventional inputs – specifically land, chemical fertilisers, and labour – in agricultural productivity. Land seems to be the factor that impacts production levels the most, having the highest elasticity of 0.80, followed by labour at 0.41 and chemical fertiliser as 0.15. The significance of the chemical fertilizer variable is consistent with the evidence that soils in Zimbabwe are inherently of low fertility and require regular fertiliser application (FAO, 2006). Having maize as the main produce, the significant chemical fertilizer variable could also be capturing the fact that under rain-fed conditions, maize in Africa tends to be highly fertiliser responsive (Heisey and Mwangi, 1997, cited in MWANGI, 1997).

Considering the inputs controlled for (land and fertiliser, manure, traction and soil conservation) we find a returns to scale value of around 1.43 suggesting for increasing returns to scale. A $\chi^2$ test failed to reject the presence of increasing returns to scale but only at 12% level of significance ($\chi^2(1)$ =2.47).

Further, the results underscore the significance of parcel characteristics in conditioning output levels. In particular, parcels in which clay soils are the predominant soil type are found to produce higher levels of output than parcels with predominantly red soils.

The significance of chieftainship dummies indicates that agricultural production might be better suited in some climatic areas and environmental factors such as rainfall, which varies across locations, may affect yields.

*5.2.2 Fast Track Land Reform Programme and Parcel Level Technical Inefficiency*

Table 5 below reports mean efficiency scores for the FTLRP and communal group, based on model *b*.

**Table 5. Summary statistics of efficiency estimates from the stochastic frontier model**

| Efficiency score | Communal | FTLRP | Pooled |
|---|---|---|---|
| Mean | 0.133 | 0.373 | 0.238 |
| Standard deviation | 0.116 | 0.211 | 0.202 |
| Minimum | 0.001 | 0.003 | 0.001 |
| Maximum | 0.633 | 0.826 | 0.826 |

Source: estimation based on own survey data (2007)

Both tables 4 and 5 above suggest that FTLRP beneficiaries are more technically efficient than communal farmers, even after controlling for potential self-selection bias. The average level of efficiency is 24% for the pooled sample. Considering the sub-samples, we find that the average efficiency for the FTLRP beneficiaries is 37% and this is 24% higher than the average efficiency estimated for the communal group. A two-tailed sample test indicates that this difference is significant at 1% level of significance.

The estimation results (in table 4) provide evidence that the more livestock a household has, the more technically efficient they become. Since livestock holdings are an indicator of wealth, this result suggests that poor households face significant constraints in their efforts to increase technical efficiency of their parcels. Resource constraints (poverty) imply that households may not have enough resources to invest in their land which could make them less efficient. This suggests that policies aimed at alleviating poverty would help improve technical efficiency in smallholder agriculture.

We also find evidence that parcels that are fenced are more technically efficient. This could be due to the fact that fencing parcels reduces the risk of losing crops through for example theft and damage due to animals tramping on the crops.

The nonlinear effect of farm size on efficiency indicates that: technical efficiency improves as farm size increases but up to a certain threshold after which it declines. A

$\chi^2$ test rejected the null hypothesis that farm size and its square are jointly insignificant at 10% level of significance ($\chi^2(1)$ =3.47). Results indicate that this threshold is around a farm size of 18 hectares. Since this is far below the maximum farm size in the sample (which is 51.8 hectares) we can conclude that for the surveyed parcels, technical efficiency first improves and later falls with farm size. This is in support of RAO and CHOTIGEAT (1981) who indicate that with multiple cropping, large farms could, in principle, be compensating for less labour per hectare with fertilisers to surpass the land productivity of small farms. However, our results suggest that this is only up to a certain threshold.

## 6 Conclusion

This paper contributes to the empirical literature on the impacts of land reform on agricultural production and technical efficiency with a specific focus on the impact of Zimbabwe's Fast Track Land Reform Program (FTLRP). In particular, we contrast farmers who benefited from the programme with farmers in communal areas who applied for land under the FTLRP but were rejected. Communal areas were traditionally reserved for black subsistence farmers. Our analysis thus makes important contributions to understanding efficiency differentials between FTLRP and communal farms. A unique dataset from Mashonaland Central province of Zimbabwe was employed to estimate the Cobb-Douglas stochastic frontier model whose technical inefficiency effects were assumed to be influenced by the household's socio-economic characteristics. The inefficiency analysis controlled for the possibility of bias into the FTLRP using Heckman's selection procedure.

Production function estimates suggest that labour, fertilizer, parcel size (land) and soil type matter for crop output. The resultant inefficiency analysis indicates that FTLRP beneficiaries are more technically efficient than communal farmers.

Farm size is found to have a nonlinear effect on technical efficiency, with technical efficiency improving with increased farm size but up to a certain threshold after which it declines. This finding calls for caution in assuming linear relationships when exploring farm size-productivity or farm size-efficiency relationships. Such assumptions could give misleading results that might misinform policy.

The significance of resource availability (labour, land and fertiliser) in agricultural production as well as the finding that livestock holdings and fencing parcels improve technical efficiency implies that policies aimed at alleviating resource constraints are likely to have a positive impact on agricultural production and technical efficiency of smallholder agriculture. Further, these results suggest that in terms of policy making, policies aimed at increasing production and technical efficiency of resource constrained farmers should not be crafted in isolation from policies that reduce poverty.

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