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Fast Track Land Reform and Agricultural Productivity in Zimbabwe

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Abstract

In the year 2000, the government of Zimbabwe launched the Fast Track Land Reform Program (FTLRP) as part of its ongoing land reform and resettlement program. It seeks to address the racially skewed land distribution pattern inherited at independence in 1980. This paper used data on beneficiaries of the program and a control group of communal farmers to investigate the program's impact on the agricultural productivity of its beneficiaries. The data revealed significant differences between the two groups, not only in household and parcel characteristics, but also in input usage. The results suggest that FTLRP beneficiaries are more productive than communal farmers. The source of this productivity differential was found to lie in differences in input usage. In addition, we found that FTLRP beneficiaries gained a productivity advantage not only from the fact that they used more fertilizer per hectare, but also from attaining a higher rate of return from its use. Furthermore we found evidence that soil conservation, among other factors, had a significant impact on productivity. Our results also confirmed the constraints imposed on agricultural productivity by poverty, suggesting that policies aimed at alleviating poverty will have a positive impact on agricultural productivity.

Key Words: Land reform, agricultural productivity, Zimbabwe

JEL Classification: D24, Q12, Q15, Q18

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Introduction

Economic, egalitarian, and political motives are often used to justify the need for redistributive land reforms, defined as redistribution of land from the rich to the poor (Ghatak and Roy 2007). The main economic rationale for land reform lies in the inverse-farm productivity relationship, which argues that, for given technology levels, small farms are more efficient than large farms due mainly to fewer problems of supervision (Deininger et al. 2002). Moreover, since the utility gains realized by the poor are larger than the corresponding losses by the rich, redistributive land reforms can lead to distributional welfare gains. Equity considerations can also create the need for land reform, especially in countries where a significant proportion of the population relies on agriculture for its subsistence. In countries with a history of social injustice or exclusion with land ownership, political motives justify redistributive land reforms. Equity and political considerations have been the driving motives for redistributive land reforms in Zimbabwe. At independence in 1980, Zimbabwe inherited an agricultural sector characterized by duality and a racially skewed land ownership pattern. A modernized commercial large-scale farming sub-sector existed alongside a non-mechanized, traditional small-scale sub-sector. It is against this background that the government of Zimbabwe, since independence, has had to pursue a land reform and resettlement program premised primarily on the acquisition and redistribution of land.

The empirical evidence on the benefits of redistributive land reforms is mixed. Researchers such as Birdsall and Londono (1997) and Deininger and Squire (1998) argued that redistributive land reform can improve growth. Ghatak and Roy (2007), on the other hand, found

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an overall negative impact of land reform on agricultural productivity in their study on India (although some state-specific effects suggested heterogeneity in the impact of land reform across states). Land reform in Korea has been found to have increased agricultural production by enhancing economic incentives (Jeon and Kim 2000). These mixed results regarding the impact of land reforms on productivity stem from the fact that land reform is a package whose substance and implementation differ within and across countries, and thus will have a heterogeneous impact across different locations. This necessitates a need for location and program-specific empirical analyses of land reforms. Moreover, while most studies have focused on analyzing their impact on aggregate economic indicators, such as gross domestic product (GDP) per capita, there is also a need to consider their impact at the household level.

This paper seeks to provide micro-evidence on the impact of land reforms with a particular focus on the most recent phase of Zimbabwe's land reform program, the Fast Track Land Reform Program (FTLRP). The FTLRP was launched in 2000 with the primary objective of accelerating both land acquisition and redistribution. We used data on program beneficiaries and a control group of communal farmers, who cultivate land that under colonial rule was traditionally reserved for black subsistence farmers, to investigate the impact of the FTLRP on the agricultural productivity of program beneficiaries.

Macro-evidence indicates that the program has been accompanied by a contraction of the economy. In particular, agricultural production has plummeted since the program was initiated in 2000; in fact, by 2004, it had dropped by 30 percent (Richardson 2004). Given the importance of agricultural output in the viability of the manufacturing sector, the manufacturing sector also experienced a contraction and the whole economy had shrunk by 15 percent by 2003 (Richardson 2004). This is of concern especially given that prior to the FTLRP the agricultural sector employed more than 70 percent of the labor force and accounted for between 9 percent and 15 percent of GDP, and between 20 percent and 33 percent of export earnings (Chitiga and Mabugu 2008).

The negative macro-impact of the FTLRP on agricultural production could be attributed to a number of factors. The program has undermined land equity by taking land from private ownership and transferring it to newly resettled farmers, who lease the land from the government. Estimates indicate that commercial farmland lost around three-quarters of its aggregate value from 2000 to 2001 as a result of lost property titles (Richardson 2005). The FTLRP has also caused some tenure insecurity among its beneficiaries, which has translated into low land-related investments (Zikhali 2008) and has made the private sector less willing to bear the risk of accepting this land as collateral against financial loans. The program has replaced experienced farmers with less experienced ones who are geared towards subsistence production. In addition, capacity constraints faced by public extension agencies have made them unable to meet the increased demand for extension services.

Micro-evidence on the impact of the program on productivity requires comparing household productivity before and after the program. Unfortunately we are not able to do this due to data limitations. Thus, the paper does *not* investigate whether FTLRP beneficiaries are more or less productive than commercial farmers who cultivated the land prior to the FTLRP. Instead, it seeks to investigate productivity differentials between program beneficiaries and communal farmers. Similar analyses of Zimbabwe's earlier land reform programs suggested that the programs increased the income of the beneficiaries and reduced their income variability (Kinsey 1999). Deininger et al. (2004) found a positive, though modest, economic return to land reform programs prior to the FTLRP.

The following section provides a brief background on Zimbabwe's FTLRP. Section 2 presents the econometric framework and estimation strategy used in the study. A discussion of the data used in the empirical estimation and of the results is presented in section 3. Section 4 concludes the paper with policy implications.

1. Fast Track Land Reform in Zimbabwe

Zimbabwe inherited a thriving agro-based economy upon independence in 1980. However, the agricultural sector was characterized by duality and a racially skewed land ownership pattern. The white, large-scale commercial farmers (less than 1 percent of the population) occupied 45 percent of all agricultural land, of which 75 percent was found in the most agriculturally productive areas (Shaw 2003). Indigenous Africans, on the other hand, constituted the small-scale communal agricultural sector with communal land ownership vested in the state, and rights of usufruct allocated to an individual (usually a male) by a chief. This unbalanced access to land compelled the government of Zimbabwe to adopt land reform and a resettlement program premised on land acquisition and redistribution. The main long-standing objectives of this program have been to address the imbalances in land access while alleviating population pressure in the communal areas, extend and improve the base for productive agriculture in the smallholder farming sector, and bring idle or under-utilized land into full production, for example (Kinsey 1999).

Two broad phases make up the land reform and resettlement program. The first stretched from 1980 to 1997 and was based on a willing-seller/willing-buyer approach in line with the government's policy of national reconciliation and the restrictive Lancaster House Constitution.[1] However, in 1997 the government of Zimbabwe initiated a process of radical land reform premised on extensive compulsory land acquisition and redistribution (Moyo 2004). This marked the start of the second phase of the program. The FTLRP, on which our analysis is based, was officially launched in July 2000 as part of the second phase.

The main objectives of the FTLRP are to speed up the identification of not less than five million hectares of land for compulsory acquisition for resettlement, to accelerate the planning and demarcation of acquired land and settler emplacement on this land, and to provide limited basic infrastructure and farmer support services (Zimbabwe 2000; Moyo 2006). Compulsory acquisition was largely to be made from white commercial farmers, private companies, and absentee landlords. The program comprises two models: Model A1 is intended to decongest communal areas and is targeted at land-constrained farmers in communal areas. This model is based on existing communal area organization, whereby peasants produce mainly for subsistence. Model A2, on the other hand, is a commercial settlement scheme comprising small-, medium-, and large-scale commercial settlements, intended to create a cadre of black commercial farmers. This model is, in principle, targeted at any Zimbabwean citizen who can prove farming experience and/or resource availability and is based on the concept of full cost recovery from the beneficiary (Zimbabwe 2000). The bulk of the FTLRP is based on Model A1.

In principle, the tenure arrangements within the FTLRP entail permits for Model A1 beneficiaries and a 99-year lease with an option to purchase the land for Model A2 beneficiaries. In reality, however, FTLRP beneficiaries have been issued many different types of temporary licenses which the government intends to convert, in time, to permanent leases. This uncertainty regarding tenure arrangements within the FTLRP has been a source of tenure insecurity among FTLRP beneficiaries (Munyuki-Hungwe and Matondi 2006; Zikhali 2008). In addition, different sets of laws, administrations, and policies on multiple tenure systems have created grounds for conflicts that have impacted agricultural production adversely (Munyuki-Hungwe and Matondi 2006).

Under the FTLRP, the four main commercial field crops—wheat, tobacco, soybeans, and sunflowers—have experienced reduced area plantings and output levels due to low uptake and

[1] The Lancaster House Constitution obligated the government to acquire land on a willing-seller/willing-buyer basis during the first 10 years of independence.

poor use of land, as well as the inexperience and lack of resources on the part of new farmers (Moyo 2004). The main crops produced by smallholder farmers—maize, small grains, groundnuts, and cotton, among others—have also shown reduced output despite the marginal increase in area planted. In communal areas, maize yields halved from approximately 1.3 million tons per hectare in 1986 to approximately 0.8 tons per hectare in 2004 (FAO 2007).

In this paper, we focus on the difference in agricultural productivity between farmers who have benefited from the FTLRP under the Model A1 scheme and communal farmers. In communal areas, farmers acquire land either through inheritance, allocation by a traditional leader, buying, or renting.

2. The Econometric Framework and Estimation Strategy

Under perfect input and credit markets, a redistributive land reform is associated with productivity gains for its beneficiaries, since they gain an asset (land) that with perfect markets can be used as collateral against financial loans. Markets in Zimbabwe, as in most developing countries, are imperfect and the FTLRP has been associated with tenure insecurity which could negatively impact farm investments and subsequently farm productivity. This implies that beneficiaries may be less productive than communal farmers. On the other hand, evidence shows that resettled farmers have better access to inputs and government services (Deininger et al. 2002; Jowah 2005), which could give them a productivity advantage. The effect of the program on productivity on its beneficiaries relative to communal farmers is thus ambiguous.

Our interest was to study this more closely, i.e., to test for agricultural productivity differentials between FTLRP beneficiaries and communal farmers. Agricultural productivity is a measure of the total agricultural output that can be produced from a given set of inputs. It can be defined either as total output of a single product per unit of a single input or in terms of an index of multiple outputs relative to an index of multiple inputs. In this analysis, we measured productivity as the value of total agricultural output per hectare, i.e., land productivity. Land productivity is important in determining food production, land use incentives, and returns to landowners (Wiebe 2003).

Returns to agricultural land use are a natural measure to focus on in Zimbabwe, where land is a contentious issue as reflected by the centrality of land reforms in the socioeconomic and political sphere. Accordingly, we specified a productivity equation for a given household as:[2]

$$Yield_j = f(R_j, X_j) \ , \tag{1}$$

where $Yield$ is the value of total agricultural output per hectare for the *j*th parcel.[3] R is a dummy indicating whether or not the household obtained the parcel via the FTLRP, intended to capture whether or not FTLRP beneficiaries have a productivity advantage. X is a vector of exogenous parcel characteristics and inputs used. These include standard factors of production, i.e., labor used per hectare (we disaggregate this to the number of household members and hired workers who worked on a given parcel in the season under analysis); the household head's years of farming experience as an indicator of human capital; non-labor variable inputs, including the amount of chemical fertilizer and manure used per hectare; and traction power, capturing the number of days the household used oxen and/or a tractor to plow the parcel. We treated soil conservation as an input in agricultural production by including the area of contour ridges (a type of soil conservation structure) constructed in the last five years, per hectare.[4] We also included dummies for the slope of the parcel and soil type as exogenous parcel characteristics.

We assumed that the production function is given by a Cobb-Douglas production function, such that the equation to be estimated becomes:

$$\ln(Yield) = \beta_0 + \beta_1 R + \beta_2 \ln X + \varepsilon \ , \tag{2}$$

where β_0, β_1 and β_2 are parameters to be estimated and ε is an error term assumed to be independently, identically, and normally distributed with zero mean and constant variance (Wooldridge 2002).

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[2] The *j*th subscript is dropped henceforth.

[3] A parcel is defined as a contiguous piece of land on which more than one crop can be cultivated. Given that our analysis is based on multi-output parcels and the hyperinflationary environment in Zimbabwe, which makes price information unreliable, our aggregation of the value of production is based on South African producer prices.

[4] The decision to focus on contour ridges is guided not only by availability of data but also by their popularity as soil conservation technology in the study area. Contour ridges are earthen ridges that are widely used in southern Africa as a means of controlling soil erosion (Critchley et al. 1992).

The estimation strategy was to first use ordinary least squares (OLS) to estimate a Cobb-Douglas production function that utilizes the factors of production outlined above. Second, we explored whether any differences in asset productivity existed between FTLRP and communal households by including interaction terms for being a FTLRP beneficiary with the inputs, in line with Deininger et al. (2002).

One of the possible problems with the data concerns endogeneity of inputs. In other words, it could be that farmers choose their inputs in response to unobserved characteristics, which might cause observed output to deviate from predicted levels leading to biased and inconsistent estimates. Thus, the third strategy was to employ an instrumental variable estimation to tackle this problem. Specifically we employed the two-stage least squares (2SLS) framework where we regressed the endogenous input use on a vector of instruments and exogenous variables, such that:

$$\ln X_e = \alpha_0 + \alpha_1 \ln X_n + \alpha_2 \ln X_s + \mu \quad , \tag{3}$$

where X_e denotes the potentially endogenous inputs, X_n denotes exogenous inputs, X_s denotes the instruments, $\alpha_0, \alpha_1, \alpha_2$ are the vectors of parameters to be estimated, and μ is an error term. In the second stage, we used $\hat{\mu}$, the fitted values from equation (3), as an explanatory variable in equation (2), such that:

$$\ln(Yield) = \gamma_0 + \gamma_1 \ln X_e + \gamma_2 \ln X_n + \gamma_3 \hat{\mu} + \nu \quad , \tag{4}$$

where ν is an error term. To test for endogeneity of inputs, we used the Wu-Hausman F test, the null hypothesis being that the inputs are exogenous. We used the Anderson canonical correlation likelihood-ratio test to test for the identification of the model. The null hypothesis of the test was that the equation is under-identified, and its rejection indicates that the model is identified. The Hansen-Sargan test was employed to test for over-identification with the joint null hypothesis being that the instruments are valid.

We assume fertilizer use to be endogenous, since the government of Zimbabwe has been actively involved in the provision of subsidized fertilizers mainly to resettled farmers (Jowah 2005), and thus access to and subsequent intensity of fertilizer use could be correlated to unobservable characteristics that capture the underlying criteria used by the government in allocating subsidized fertilizers. The instruments we used were based on household socioeconomic and perception-based parcel characteristics. These included gender of household head, in line with the assertion that women are generally discriminated against in terms of access to productive inputs (Doss 1999); household composition, which is disaggregated to numbers of children and male and female adults; livestock holdings, as an indicator of wealth; contact with government-sponsored agricultural extension workers, since the distribution of government-subsidized fertilizers in Zimbabwe is mainly in their hands; access to remittances; distance to the nearest trading town, indicating both accessibility to markets and off-farm opportunities (which might relax liquidity constraints); social capital indicators; access to media; and farm size.

3. The Data, Empirical Results, and Discussion

Our primary objective was to test for agricultural productivity differentials between FTLRP beneficiaries and communal farmers. We based our empirical analysis on data from Mazowe District, one of the seven districts in the Mashonaland Central province in Zimbabwe. The land in the district belongs to natural regions 2 and 3 and is divided into 29 wards, 13 of which are found in Chiweshe communal areas.[5] The area is one of the most productive arable areas in Zimbabwe.

3.1 The Data

The data were collected in May 2007 for 592 land parcels of 383 randomly selected households falling under three different chieftainships. The sample includes 222 communal households (operating 431 parcels) and 161 households in resettlement areas (operating 161 parcels). FTLRP beneficiaries are found in resettlement areas. The questionnaire contained detailed questions on households' production accounts, socio-economic indicators, parcel characteristics, and the investments they had made in the last five years. Summary statistics for parcel level variables are reported in table 1, while table 2 reports statistics for household level variables. We also performed two-sample *t*-tests to test for differences between the FTLRP and the communal groups.

To capitalize on the gathered information we used principal components analysis (PCA) to aggregate the original off-farm activities variables (*Small scale, Natural resource, Employment,* and *Trade*), resulting in the variable *Off-farm*. We also used PCA to aggregate

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[5] On the basis of climatic pattern, altitude, and soil type, the country is classified into five agro-ecological regions with agricultural potential declining from natural region 1 to 5.

social capital indicators (*Cash assistance*, *Oxen assistance, Maize assistance*, and *Labor assistance*), resulting in *Social Capital*. Similarly, *Media* is from a PCA of variables on access to media (TV, radio, and newspapers). Thus, PCA is used here to statistically weigh the different indicators in order to calculate aggregate indices of off-farm activities, social capital, and access to information (Jolliffe 1986). In all cases, we retained components with an eigenvalue greater than one.

Summary statistics indicated significant differences with regards to both household and parcel characteristics. Around 27 percent of the surveyed parcels were acquired via the FTLRP, while around 73 percent constituted the communal farmer group. The FTLRP sub-sample used significantly more fertilizers, tractors, and oxen, while communal farmers tried to substitute by using manure and household labor intensively. Due to the fact that only 5 percent of communal farmers used tractors, we used oxen and tractor days to construct an overall indicator of traction days (*Traction)* using PCA. The output was more than three times higher per hectare for FTLRP, with a mean of ZAR 2,405 (South African rands) compared to ZAR 683, possibly because this group used more fertilizers, tractors, and oxen, among other factors. The focus of this analysis was to explore possible factors accounting for this difference. The cropping patterns across the two groups are presented in figure 1 below.

Figure 1

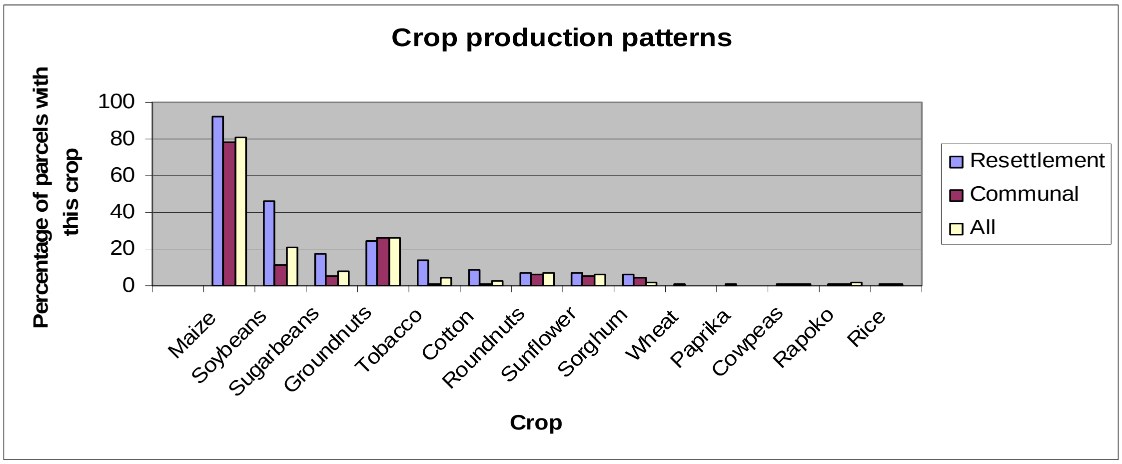

Table 1 Descriptive Statistics of Parcel Level Variables

Variable	Description	Communal (n=431)	FTLRP (n=161)	*t*-tests	Pooled (N=592)
Mode of acquisition					
FTLRP	Acquired the parcel under the FTLRP (1=yes, 0=no)				0.27
Communal	Parcel in the communal areas (1=yes, 0=no)				0.73
Production					
Yield	Value of total agricultural output per hectare (in South African rands, ZAR) (1 ZAR = 9.07 USD)	683	2405	***	1182
Maize	Maize output (in kg per hectare)	816	2401	***	1275
Inputs					
Fertilizer	Fertilizer used (in kg per hectare)	96	247	***	137
Fertilizer decision	Parcel received fertilizer in the last agricultural season (1=yes, 0=no)	0.78	0.92	***	0.82
Tractor days	Number of days household used tractor to plow in the last agricultural season per hectare	0.07	1.61	***	0.49
Oxen days	Number of days household used oxen to plow in the last agricultural season per hectare	3.23	9.80	***	5.02
Traction	Principal components score on tractor and oxen days per hectare	2.33	8.07	***	3.89
Manure	Manure used (in kg per hectare)	862.5	90.32	**	652.5
Household labor	Number of household members who worked on the parcel per ha	2.60	0.68	***	2.08
Hired labor	Number of workers hired (paid or unpaid) to work on the parcel per hectare	1.31	1.46		1.35
Soil conservation	Total length of contour ridges constructed in the previous 5 years (in m^2 per hectare)	91.05	48.63	***	79.51
Parcel characteristics					
Parcel size	Size of the parcel in hectares	3.55	6.38	***	4.32
Steep slope	Steep slope (1=yes, 0=no)	0.12	0.10		0.11

Moderate slope	Moderate slope (1=yes, 0=no)	0.44	0.73	***	0.52
Light slope	Low slope (1=yes, 0=no). *The reference slope variable.*	0.44	0.17	***	0.37
Clay soil	Predominant soil type clay (1=yes, 0=no)	0.05	0.03		0.02
Clay-loam soil	Predominant soil type clay-loam (1=yes, 0=no)	0.27	0.44	***	0.32
Sandy soil	Predominant soil type sandy (1=yes, 0=no)	0.57	0.20	***	0.47
Red soil	Predominant soil type red (1=yes, 0=no). *The reference soil type variable*	0.11	0.34	***	0.17
High fertility	Highly fertile (1=yes, 0=no)	0.14	0.07	***	0.11
Moderate fertility	Fairly fertile (1=yes, 0=no)	0.43	0.45		0.44
Infertile	Infertile (1=yes, 0=no). *The reference soil fertility variable*	0.43	0.49		0.44
Deep soils	Very deep soils (1=yes, 0=no)	0.27	0.27		0.27
Moderately deep soils	Fairly deep soils (1=yes, 0=no)	0.44	0.67	***	0.50
Shallow	Shallow soils (1=yes, 0=no). *The reference soil depth variable*	0.29	0.06	***	0.23

Note: *Difference significant at 10%; ** significant at 5%; *** significant at 1%.
Source: Author's survey data, 2007.

Table 2 Descriptive Statistics of Household Level Variables

Variable	Description	Communal (n=222)	FTLRP (n=161)	*t*-tests	Pooled (N=383)
Farm size	Farm size in hectares	6.91	6.38		6.69
Male	Gender of the household head (1=male, 0=female)	0.71	0.78		0.74
Age	Age of the household head	52.57	46.25	***	49.91
Education	Number of years of formal schooling of the household head	8.01	9.17	***	8.50
Experience	Number of years of farming experience of the household head	22.54	13.11	***	19.93
Male adults	Number of male household members older than 15 years	1.83	1.95		1.88
Female adults	Number of female household members older than 15 years	2.38	2.06		2.25

Children	Number of household members younger than 15 years	2.48	2.58		2.52
Livestock	Livestock holdings (in tropical livestock units)	3.43	3.32		3.39
Farming certificate	Household has at least one member with a with a farming qualification (1=yes, 0=no)	0.23	0.22		0.23
Remittances	Receipt of remittances (1=yes, 0=no)	0.41	0.25	***	0.34
Extension contact	Number of visits by an extension worker in the last agricultural season	2.63	6.11	***	4.09
Town distance	Distance to nearest trading town (in km)	50.57	15.18	***	35.70
TV	Access to TV (1=yes, 0=no)	0.30	0.57	***	0.41
Radio	Access to radio (1=yes, 0=no)	0.58	0.78	***	0.67
Newspapers	Access to newspapers (1=yes, 0=no)	0.23	0.44	***	0.32
Media	Principal components score of access to TV, radio, and newspapers	0.64	1.03	***	0.80
Cash assistance	Household has people in the village to borrow at least ZW$ 20,000 (equivalent to 1 USD at the time of the survey) from (1=yes, 0=no)	0.52	0.38	***	0.46
Oxen assistance	Household has people in the village to borrow oxen from (1=yes, 0=no)	0.60	0.52		0.57
Maize assistance	Household has people in the village to borrow 25 kg of maize from (1=yes, 0=no)	0.51	0.50		0.50
Labor assistance	Household has people in the village to ask for extra agricultural labor from (1=yes, 0=no)	0.53	0.41	**	0.48
Social capital	Principal components scores of whether or not household can get assistance from neighbors	1.08	0.91	**	1.01
Makope	Chief Makope (1=Chief Makope). *The reference chieftainship variable*	0.29	0.12	***	0.22
Chiweshe	Chief Chiweshe (1=Chief Chiweshe)	0.14	0.47	***	0.28
Negomo	Chief Negomo (1=Chief Negomo)	0.57	0.40	***	0.50

Note: * Difference significant at 10%; ** significant at 5%; *** significant at 1%.
Source: Author’s survey data, 2007.

Although the parcels are cultivated with a multi-cropping system, data revealed maize as the major crop, produced on 78 percent and 92 percent of surveyed communal and FTLRP parcels, respectively. Summary statistics indicated that the average maize output per hectare is 2,401 kg for the FTLRP parcels, 816 kg in communal areas, and 1,275 kg for the whole sample. Comparing this to the national statistics in 1999, just before the launch of the FTLRP, we realized that while the figure for the FTLRP group exceeded that of 1999 for the communal areas (1,024 kg), it fell far short of the 4,393-kg average for the commercial farming sector (Mudimu 2003). Moreover, the sample average maize output per hectare of 1,275 kg was less than the 1999 per hectare national average of 1,516 kg (Mudimu 2003)—another indicator of a decline in agricultural production following the launch of the FTLRP. Maize is Zimbabwe's staple food and as such it plays a crucial role in the country's food security situation. In post-colonial Zimbabwe, the small-holder farming sector produced around 60 percent of all maize (Andersson 2007). The fact that a few parcels in resettlement areas have higher-value crops (e.g., tobacco and soybeans) highlights the common trend in Zimbabwean agriculture after the FTLRP, i.e., production of higher-value crops have been hit harder than that of lower-value crops, which has naturally resulted in critical shortages of foreign currency.

3.2 The Empirical Results and Discussion

Table 3 below presents results from both an OLS and a 2SLS estimation of a Cobb-Douglas production function. As outlined in the preceding discussion of our econometric strategy, this was done in three steps. First, we estimated a standard Cobb-Douglas production function (results in column 1); second, we included interaction terms for being a FTLRP beneficiary with the inputs (results in column 2); and, in the final step, we used 2SLS on a model that interacted inputs with *FTLRP* to allow for possible endogeneity of fertilizer use (results reported in column 3). The dependent variable is *Yield*, i.e., the value of total agricultural output per hectare, in South African rands. All continuous variables used in the ensuing analysis, except for the variables from the PCA, are in logarithmic forms.

Interacting input levels with *FTLRP* was part of an attempt to identify the exact micro-economic mechanism through which the FTLRP impacts productivity. In particular, it helped to explore whether differences in asset productivity between beneficiaries of the FTLRP and communal farmers drive productivity differentials. Since the 2SLS estimation also included interaction terms, this implied that we had two endogenous variables, i.e., *fertilizer* and the interaction of *fertilizer* with *FTLRP*. Thus, in addition to the instruments used, we also used interactions of these instruments with *FTLRP* as instruments.

Regarding the 2SLS results, the Wu-Hausman F test confirmed the (joint) endogeneity of *fertilizer* and the interaction of *fertilizer* with *FTLRP* in agricultural production. The Anderson canonical correlation likelihood-ratio test indicated that the model was identified, while the Hansen-Sargan test supported the validity of the instruments used. The confirmation of endogeneity of fertilizer implied that the OLS estimates were inconsistent. As a result, the ensuing discussion of results is based on the 2SLS estimates, which were robust to the endogeneity of fertilizer use.

Table 3 OLS and 2SLS Estimation of Agricultural Productivity

	OLS (1)		**OLS (2)**		**2SLS (3)**	
Variable	***Coeff.***	***Robust std. error***	***Coeff.***	***Robust std. error***	***Coeff.***	***Std. error***
Mode of acquisition						
FTLRP	1.47***	0.16	0.35	0.62	-0.10	0.73
Inputs						
Fertiliser	0.18***	0.03	0.13***	0.03	0.27**	0.11
Manure	0.00	0.02	0.00	0.02	-0.01	0.02
Traction	0.06***	0.02	0.06***	0.02	0.05**	0.02
Household labor	0.48***	0.12	0.51***	0.12	0.48***	0.13
Hired labor	0.18*	0.11	0.17	0.11	0.08	0.13
Soil conservation	0.06***	0.02	0.05**	0.02	0.05*	0.03
Experience	0.17**	0.07	0.16**	0.08	0.16**	0.07
Inputs interacted with FTLRP						
Fertiliser			0.18**	0.08	0.28*	0.17
Manure			0.02	0.04	0.04	0.05
Traction			0.06	0.06	0.04	0.08
Household labor			-0.16	0.59	-0.30	0.50
Hired labor			0.29	0.30	0.34	0.27
Soil conservation			0.01	0.04	-0.00	0.05
Experience			-0.01	0.18	-0.09	0.17
Exogenous parcel characteristics						
Farm size	0.18	0.12	0.20*	0.12	0.23**	0.11
Steep slope	-0.02	0.17	-0.02	0.17	0.07	0.19
Moderate slope	-0.09	0.12	-0.05	0.12	0.02	0.12
Clay soil	0.49*	0.29	0.49*	0.29	0.52*	0.31

Clay-loam soil	-0.20	0.15	-0.17	0.15	-0.12	0.16
Sandy soil	-0.11	0.14	-0.13	0.14	-0.09	0.16
Chiweshe	-0.44***	0.16	-0.40**	0.16	-0.34**	0.17
Negomo	-0.28**	0.13	-0.26**	0.13	-0.26**	0.13
Constant	3.80***	0.39	3.91***	0.40	3.42***	0.51
Observations	515		515		515	
R-squared	0.37		0.38			
Wu-Hausman F test of endogeneity: P-value					0.023	
Andersson canonical correlation LR statistic (identification/IV relevance test): P-value					0.015	
Sargan statistic (over-identification test of all instruments): P-value					0.60	

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

3.3 The Fast Track Land Reform Program and Agricultural Productivity

The FTLRP is a redistributive land reform that entails compulsory acquisition of land, largely from commercial farmers who held the land under private tenure, whereby a freehold title was bestowed on land users with rights to sell, lease, and rent property. As indicated earlier, data limitations mean that this study did *not* investigate whether beneficiaries of the program are more or less productive than the commercial farmers who cultivated the land prior to the FTLRP. The interest was, then, to investigate whether there are any land productivity implications of the FTLRP by testing for productivity differentials between FTLRP beneficiaries and communal farmers.

Results from an OLS estimation of a Cobb-Douglas production function not only underscored the significance of conventional inputs in agricultural productivity but also confirmed the productivity advantage of FTLRP beneficiaries; i.e., beneficiaries achieved higher land productivity than communal farmers.[6] What could explain these productivity differentials?

[6] Estimation of an extended productivity function, which included a set of socio-economic characteristics in addition to parcel characteristics and input levels, also confirmed the productivity advantage of FTLRP

It could be that the land used by FTLRP farmers is potentially of significantly better quality, implying that the results depend on how well we were able to capture this. In addition, different levels of input use, as shown by the summary statistics in table 1, and different combinations of inputs may have led to different output levels.

To identify the factors that could possibly explain the differences in productivity, we employed a richer specification in columns (2) and (3) in table 3, allowing for the possibility that not only the allocation of inputs but also the returns from these inputs differed between the two groups. As discussed above, we did this by interacting inputs levels with *FTLRP*. The results indicated that the inclusion of interaction terms ensures that the FTLRP dummy becomes insignificant, highlighting the differences in both the allocation of inputs and the returns from these inputs between the two groups. In particular, the results indicated that, although fertilizer application per hectare is found to be associated with higher productivity in both groups, FTLRP beneficiaries attained a higher rate of return on fertilizer use than communal farmers. This result was robust to both the OLS and the 2SLS estimations. Specifically, column (3) in table 3 suggests that fertilizer is almost twice as productive in the FTLRP areas as it is in the communal areas.

The 2SLS results indicated that increasing fertilizer use by 1 percent led to a 27-percent productivity increase for the communal group and a 55-percent increase for FTLRP beneficiaries. It has been shown that soils in Zimbabwe inherently have poor fertility and require regular fertilizer application (FAO 2006). Moreover, given the fact that the main crop grown on most parcels is maize, this result could also be capturing the fact that, under rain-fed conditions, maize in Africa tends to be highly fertilizer responsive (Heisey and Mwangi 1997, cited in Mwangi 1997). The rest of the inputs, however, were equally productive in both areas. This result suggested that the differences in fertilizer use could be the source of the productivity advantage enjoyed by FTLRP beneficiaries.

Given the adopted log-log specification, the marginal products of each input were estimated using the parameter value for each input and the ratio of predicted output to actual input levels (see Köhlin and Amacher 2005). This meant that for a given household the marginal product of input *i* used on the *j*th parcel is as follows:

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beneficiaries, as well as the significance of inputs in determining productivity. Socio-economic and subjective parcel characteristics proved to be insignificant, thereby justifying our use of them as instruments in the 2SLS estimation.

$$MP_{ij} = \beta_{ij} \frac{\hat{Y}_{ij}}{X_{ij}} \ , \qquad (5)$$

where MP_{ij} denotes the marginal product and β_{ij} is the estimated parameter for a given input X_{ij}, while $\hat{Y}_{ij}$ is the predicted value of total output. The marginal product measures the value of total output response, in South African rands, when one input is varied and all others are held fixed. Table 4 below presents marginal products for the significant inputs from the 2SLS estimation reported in table 3 above. Table 4 also reports two-sample *t*-tests to test for the significance of the differences in marginal products between the FTLRP and the communal groups.

Table 4 Marginal Products

Input	FTLRP	Communal	*t*-tests	Pooled
Fertilizer	5.24	2.16	***	3.15
Traction	320.17	27.53	***	117.21
Household labor	522.22	146.93	***	258.18
Soil conservation	0.66	0.1	***	0.29
Experience	5.50	5.95		5.82

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

For the FTLRP group, increasing fertilizer use by one kilogram increased the value of total output by around ZAR 5 per hectare, while the increase for the communal group was only ZAR 2. The significance of the *t*-test statistic for differences in marginal products from fertilizer use indicated that FTLRP beneficiaries enjoyed, on average, a higher marginal product from fertilizer than the communal group. This is in spite of the fact that they, on average, used twice as much fertilizer as the communal group. Similarly, FTLRP beneficiaries attained higher marginal products of traction (oxen and tractors) than the communal group. These results could indicate that there are some unobserved differences in parcel characteristics between the two groups that enhance the productivity of traction and fertilizer application in the FTLRP group. One possibility is that under colonial rule commercial farmers had access to more fertile land, implying that the results hinged on how effectively our soil quality indicators were able to capture this.

Evidence indicates that the Zimbabwean government gives the FTLRP group preferential treatment when it comes to access to farm inputs. For example, the government has, through the

Grain Marketing Board (GMB, a parastatal with the monopoly in the trade of maize and wheat in Zimbabwe) has been actively involved in the provision of fertilizers and seeds to resettled farmers (Jowah 2005). During the data collection, communal farmers expressed concerns that the government has tended to channel its resources to FTLRP beneficiaries, despite constant government pledges to extend the services to communal farmers. The data indicated that when asked to identify constraints to cultivating on their land, around 54 percent of the communal farmers cited lack of fertilizer as a constraint, compared to 31 percent in the FTLRP group. This problem has been further compounded by the fact that the government in 2003 imposed price controls on agricultural inputs, including fertilizers. This, combined with reduced supply owing to shortages of the foreign currency needed to import raw materials, led to fertilizer shortages on the open market and hence a black market for inputs, in which the price of fertilizers was far above the official controlled price and well beyond the reach of poor farmers. Timing of the distribution of fertilizer has also been a concern, with fertilizers often being distributed well after peak application time (FAO 2006).

To investigate the existence of differences in intensity of fertilizer use between the two groups, we made use of both socio-economic and parcel characteristics to estimate a demand function for fertilizer per hectare. The objective was to show that FTLRP beneficiaries used more fertilizer and that, given that they attained a higher productivity from it, differences in the use of fertilizer could be driving the productivity differentials. Since not all surveyed parcels had been fertilized, we used a Tobit model to correct for this censoring of the dependent variable (Tobin 1958; Wooldridge 2002). We also estimated a probit model to examine factors affecting the decision to apply fertilizer. Estimating both probit and Tobit models allowed for the possibility that the decision to apply fertilizers and the intensity of application were determined by different factors. We chose this over a Heckman selection model due to a lack of strong theoretical arguments to guide the selection of exclusion variables able to determine the decision to invest but not the intensity of the investments. The results are reported in table 5.

Consistent with summary statistics in table 1, the results confirmed that FTLRP beneficiaries were not only more likely to use fertilizer; they also used significantly more fertilizer (and fertilizers) than the communal group. This, together with the finding presented

Table 5 Demand Functions for Fertilizer per Hectare

	Probit: Fertilizer decision		Tobit: Fertilizer	
Variable	***Coeff.***	***Robust std. error***	***Coeff.***	***Robust std. error***
Mode of acquisition				
FTLRP	0.64**	0.27	1.39***	0.31
Socioeconomic characteristics				
Male	0.10	0.18	0.41*	0.23
Age	0.38	0.26	0.29	0.34
Education	0.27**	0.13	0.31	0.20
Children	-0.46	0.31	-0.64*	0.38
Male adults	0.15	0.21	0.15	0.28
Female adults	0.34	0.25	0.39	0.31
Livestock	0.19*	0.10	0.39***	0.12
Remittances	-0.03	0.16	0.03	0.19
Town distance	0.14	0.10	0.12	0.14
Extension contact	0.02	0.09	-0.01	0.11
Media	0.21	0.14	0.46***	0.16
Social capital	0.10	0.10	0.10	0.12
Farming certificate	-0.14	0.18	-0.04	0.21
Farm size	-0.13	0.13	-0.65***	0.17
Chiweshe	0.26	0.24	-0.03	0.28
Negomo	0.08	0.18	-0.03	0.24
Parcel characteristics				
Deep soils	0.15	0.21	0.17	0.29
Moderately deep soils	0.48**	0.21	0.54**	0.26
High fertility	0.08	0.26	0.03	0.28
Moderate fertility	0.14	0.16	0.03	0.19
Steep slope	-0.58**	0.24	-0.57*	0.32
Moderate slope	-0.43**	0.18	-0.46**	0.20
Clay soil	-0.05	0.39	-0.35	0.51
Clay-loam soil	0.13	0.26	-0.23	0.25
Sandy soil	-0.05	0.26	-0.21	0.26
Constant	-1.54	1.25	2.11	1.64

Observations	525	525
Uncensored observations		454
Pseudo R-squared	0.13	0.10

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

earlier that FTLRP beneficiaries attained higher rates of return on fertilizer use than communal farmers (see table 3), suggested that the source of the productivity differentials lies in the differences in fertilizer use.

The results revealed existence of gender discrimination in access to fertilizers, with male-headed households using more fertilizers than female-headed ones. We also found evidence that resource poverty limits fertilizer use: households with more children used less fertilizer per hectare (having a lot of children arguably strains the household's resources), and the significance of livestock holdings indicated that wealthier households used more fertilizers. In addition, we found that access to information (media) played a role in farm decisions. As expected, the larger a household's farm, the less fertilizer per hectare it used on a given parcel. Parcel characteristics do play a role in farmers' use of fertilizers, with more being used on parcels perceived to be of good quality (assuming that soil depth is an indicator of good quality and that an increasing slope indicates poorer quality).

3.4 Other Determinants of Agricultural Productivity

Agriculture accounts for about 30 percent of Africa's GDP and 75 percent of total employment (World Bank 2007). Consequently, agricultural performance determines Africa's economic performance. This warrants an investigation to understand the factors constraining the performance of the sector in Africa; the present study contributes to such an understanding.

The World Development Report for 2008 shows that sub-Saharan Africa has lagged behind in agricultural performance: rapid yield gains in cereals were realized from 1960 to 2005 in all parts of the world except in sub-Saharan Africa (World Bank 2007). In addition, the report showed that this area has lagged in use of modern inputs (defined as irrigation, improved varieties of cereals, and fertilizer consumption). This could imply that expanding the use of modern inputs could help sub-Saharan Africa improve productivity. For instance, increased fertilizer use accounted for at least 20 percent of the growth in agriculture in the developing world over the last 30 years (World Bank 2007). This, together with our main finding, demonstrates the significance of fertilizers, as one of the "green revolution"[7] technologies, in bringing about high and sustained increased crop yields in sub-Saharan Africa.

Loss of soil nutrients has been identified as one of the significant constraints to agricultural productivity in sub-Saharan Africa, and low use of fertilizers is associated with declining soil fertility and increased soil degradation through mining of nutrients (Mwangi 1997). It should be emphasized that, for increased fertilizer application to create a win-win situation (i.e., resulting in both increased production and sustainability of the environment), it needs to be part of a comprehensive production system that acknowledges and deals with the threats that fertilizers pose to the environment. For example, fertilizer application could be associated with leaching of nitrogen into the groundwater and with deposits of phosphorous in surface waters through soil erosion (Larson and Frisvold 1996). Moreover, the finding that soil conservation technology enhanced productivity in the study area implied that encouraging soil conservation would also lead to a win-win situation, i.e., farmers would realize increased production and at the same time reduce soil degradation.

Poverty has been found to be a major constraint in African agriculture (World Bank, 2007). The significance of traction in determining productivity confirms this. With the number of days households took to plow being highly correlated with oxen ownership, we found evidence that oxen ownership was a limiting factor on productivity. Taking oxen ownership as an indicator of wealth, this result suggested that poor households face significant constraints in agricultural production. Thus, communal farmers could increase their output if they could only afford and have access to more oxen, tractor, and fertilizers. This suggests that policies aimed at alleviating poverty would help alleviate constraints to small-holder agricultural productivity in Africa. If developed, such policies should be targeted at alleviating rural poverty, since this is where poor small-holder farmers are confined.

Furthermore, we found that agricultural productivity is very sensitive to labor availability, particularly household labor. Household labor has been seen to significantly affect production, given that household members are the residual claimants of the output (Feder 1987). Regarding parcel characteristics, we found evidence that parcels with predominantly clay soils

[7] "Green revolution" is a term coined by the U.S. Agency for International Development (USAID) administrator William S. Gaud and refers to the breeding of improved varieties combined with the expanded use of fertilizers, other chemical inputs, and irrigation (Quifiones et al. 1997).

were marginally more productive than parcels with red soils. This shows that differences in soil properties may lead to differences in productivity.

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

Large farms are found to be more productive than smaller ones. Although there is some evidence in support of an inverse relationship between farm size and land productivity (Barrett 1994), our results, consistent with Rao and Chotigeat (1981), indicated that with multiple cropping, large farms could, in principle, be compensating for less family labor per hectare with fertilizers, traction power, and hired labor to surpass the land productivity of small farms.

The insignificance of manure use on productivity could be indicative that farmers are using poor quality manure. Findings by Mutiro and Murwira (2004) revealed that the way small-holder farmers store and apply manure has a significant impact on yields in Zimbabwe. Furthermore, as Mugwira and Mukurumbira (1984) argued, the effectiveness of manure in improving crop yield is compromised by its low nutrient content (phosphate in particular). Although communal farmers try to compensate for low use of other inputs by using significantly more manure than the FTLRP group (see TABLE 1), the insignificance of manure use shows that it fails to impact productivity.

4. Conclusions and Policy Implications

This paper seeks to provide micro-evidence on the impact of land reforms. It focuses on the most recent phase of Zimbabwe’s land reform program, the Fast Track Land Reform Program (FTLRP), launched in 2000 and aimed at accelerating both land acquisition and redistribution. We used data on FTLRP beneficiaries and a control group of communal farmers to investigate the program’s impact on the agricultural productivity of its beneficiaries. The results suggest that FTLRP beneficiaries are more productive than communal farmers. The source of this productivity differential was found to lie in differences in input usage. In addition we found that FTLRP beneficiaries gained a productivity advantage not only from the fact that they used more fertilizer per hectare, but also from attaining a higher rate of return from its use.

However, comparison with national statistics for the year 1999, just before the launch of the FTLRP, indicated that although higher than that of communal areas, the productivity of FTLRP beneficiaries fell short of the levels demonstrated by the commercial farming sector in that year; hence, the decline in total agricultural production following the launch of the FTLRP.

This suggested that while FTLRP beneficiaries have not achieved their full potential (as measured by the commercial farm production before the onset of the FTLRP), they do seem to have been able to mitigate the reductions in output per hectare accompanying the FTLRP better than communal farmers. As argued in the foregoing analysis, this was partly due to the fact that the Zimbabwean government gives the FTLRP beneficiaries preferential treatment when it comes to access to farm inputs, such as fertilizers, and they benefit particularly from more assets in terms of capital (proxied by tractor and oxen).

Moreover, the results hint at possible institutional constraints that limit agricultural productivity. In particular, the stark differences in input use between FTLRP beneficiaries and communal farmers—which happen to be driving the productivity differences between the two groups—suggested that institutions surrounding input markets might favor FTLRP beneficiaries. Thus, our analysis suggested that caution is called for in using the result on the productivity advantage of FTLRP beneficiaries as an indicator of the overall success of the FTLRP program. This is because the analysis does not account for the extra costs that the government incurs by supporting beneficiaries. As the analysis of fertilizer demand indicates, FTLRP beneficiaries have a clear advantage when it comes to fertilizer use, and given that this is sustained by subsidies from the government, it is possible that the associated costs compromise the overall success of the program. Furthermore, the sustainability of such a program is questionable, given the financial constraints faced by the government.

The analysis sheds some light on factors that enhance agricultural productivity in Africa, where weak performance of the agricultural sector is a major concern. For example, our findings indicated that fertilizer could play a significant role in bringing about high and sustained increased crop yields in Africa. However, for fertilizer application to create a win-win situation in terms of both increased production and sustainability of the environment, it needs to be part of a comprehensive production system that acknowledges and deals with the threats fertilizers pose to the environment. Moreover, the finding that soil conservation technology enhances productivity in the studied area indicated that encouraging soil conservation would also lead to a win-sin situation, where farmers realize increased production and at the same time reduce soil degradation.

Our results confirmed the constraints imposed by poverty on agricultural productivity, suggesting that policies aimed at alleviating poverty would have a positive impact on agricultural productivity in Africa. Such policies, however, need to be targeted at alleviating rural poverty, since this is where poor small-holder farmers are confined in Africa. Given the resource constraints faced by small-scale farmers, the government is recommended to uphold and improve farmers' access to its input support schemes, and this should be gender-sensitive and non-discriminatory with regard to whether or not a farmer is a program beneficiary. However, this should not be viewed as a long-term solution. In the long term, the government should instead strive to alleviate poverty and at the same time liberalize and improve the input markets.

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