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Abstract

In the year 2000 the government of Zimbabwe launched the Fast Track Land Reform Programme (FTLRP) as part of its ongoing land reform and resettlement programme, which seeks to address the racially skewed land distribution pattern inherited at independence in 1980. This paper uses data on beneficiaries of the programme and a control group of communal farmers to investigate the programme's impact on the agricultural productivity of its beneficiaries. The data reveals 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 is found to lie in differences in input usage. In addition we find that FTLRP beneficiaries gain a productivity advantage not only from the fact that they use more fertiliser per hectare, but also from attaining a higher rate of return from its use. Furthermore we find evidence that soil conservation, among other factors, has a significant impact on productivity. Our results also confirm the constraints imposed on agricultural productivity by poverty, suggesting that policies aimed at alleviating poverty would have a positive impact on agricultural productivity.

Key words: Land reform, Agricultural productivity, Zimbabwe.
JEL Classification: D24, Q12, Q15, Q18.

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1. 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 realised 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 rely on agriculture for their subsistence. In countries with a history of social injustice or exclusion with regards to 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 characterised by duality and a racially skewed land ownership pattern. A modernised commercial large-scale farming subsector existed alongside a non-mechanised, traditional small-scale subsector. It is against this background that the government of Zimbabwe has, since independence, had to pursue a land reform and resettlement programme 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) argue that redistributive land reform can improve growth. Ghatak and Roy (2007), on the other hand, found an overall negative impact of land reform on agricultural productivity in their study on India, although some state-specific effects suggest heterogeneity in the impact of land reform across states. Land reform in Korea is found to have increased agricultural production by enhancing economic incentives (Jeon and Kim, 2000). These mixed results with regards to 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 programme-specific empirical analyses of land reforms. Moreover, while most studies have focused on analysing 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 programme, the Fast Track Land Reform Programme (FTLRP). The FTLRP was launched in 2000 with the primary objective of accelerating both land acquisition and redistribution. We use data on programme 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 programme beneficiaries.

Macro-evidence indicates that the programme has been accompanied by a contraction of the economy. In particular, agricultural production has plummeted since the programme was initiated in 2000; in fact, by 2004 it had dropped by 30% (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% by 2003 (Richardson, 2004). This is of concern especially given that prior to the FTLRP the agricultural sector employed more than 70% of the labour force, and accounted for between 9% and 15% of GDP and between 20% and 33% 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 programme has undermined land equity by taking land from private ownership and transferring it to newly resettled farmers who have to 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 programme 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 programme on productivity would require making a comparison of household productivity before and after the programme. 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 programme beneficiaries and communal farmers. Similar analyses on Zimbabwe's earlier land reform programmes suggest that the programmes increased the income of the beneficiaries and reduced their income variability (Kinsey, 1999). Deininger et al. (2004) find a positive, though modest, economic return to land reform programmes prior to the FTLRP.

In the following section we provide a brief background on Zimbabwe's FTLRP. Section 3 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 4. Section 5 concludes the paper with policy implications.

2. Fast Track Land Reform in Zimbabwe

Zimbabwe inherited a thriving agro-based economy upon independence in 1980. However the agricultural sector was characterised by duality and a racially skewed land ownership pattern. The white large-scale commercial farmers, consisting of less than 1% of the population, occupied 45% of all agricultural land, of which 75% 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, with rights of usufruct being allocated to an individual (usually a male) by a chief. This imbalanced access to land necessitated the government of Zimbabwe to adopt a land reform and resettlement programme premised on land acquisition and redistribution. The main long-standing objectives of this programme have been to for example 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-utilised land into full production (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.[2] However, in 1997 the government of Zimbabwe initiated a process of radical land reform premised on extensive compulsory land

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

acquisition and redistribution (Moyo, 2004). This marked the start of the second phase of the programme. 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 programme 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 organisation 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 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 programme 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, the FTLRP beneficiaries have been issued many different types of temporary licenses that 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, the use of different sets of laws, administration and policies on multiple tenure systems has created grounds for conflicts that have impacted agricultural production adversely (Munyuki-Hungwe and Matondi, 2006).

Under the FTLRP the four main commercial field crops, which include wheat, tobacco, soybeans and sunflower, have experienced reduced area plantings and output levels due to low uptake and use of land as well as inexperience and lack of resources on the part of new farmers (Moyo, 2004). The main crops produced by smallholder farmers, which include maize, small grains, groundnuts and cotton, have also experienced output reduction despite the marginal increase in area planted. In communal areas, maize yields halved from approximately 1.3 million tonnes per hectare in 1986 to approximately 0.8 tonnes 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.

3. 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 under perfect markets can be used as collateral against financial loans. Markets in Zimbabwe, like 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 might 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 programme on productivity among its beneficiaries relative to that of communal farmers is thus ambiguous.

Our interest is 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 measure 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 specify a productivity equation for a given household as:[3]

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

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

where *Yield* is the value of total agricultural output per hectare for the *j*th parcel. 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. 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. labour 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-labour variable inputs, including the amount of chemical fertiliser and manure used per hectare; and traction power, capturing the number of days the household used oxen and/or a tractor to plough the parcel. We treat 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 include dummies for the slope of the parcel and soil type as exogenous parcel characteristics.

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

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

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).

The estimation strategy is to first use Ordinary Least Squares (OLS) to estimate a Cobb-Douglas production function that utilises the factors of production outlined above. Secondly we explore whether any differences in asset productivity exist between FTLRP and communal households by including interaction terms for being a FTLRP beneficiary with the inputs, in line with Deininger et al. (2002).

[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).

One of the problems we could have with the data concerns endogeneity of inputs; i.e. 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 is to employ an instrumental variable estimation to tackle this problem. Specifically we employ the two-stage least squares (2SLS) framework in which we start by regressing the endogenous input use on a vector of instruments and exogenous variables such that:

$$\ln X_e = \alpha_0 + \alpha_1 \ln X_n + \alpha_2 \ln X_s + \mu \ , \quad (3)$$

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 use $\hat{\mu}$, the fitted values from (3), as an explanatory variable in equation (2) such that:

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

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

We instrument for fertiliser use since the government of Zimbabwe has been actively involved in the provision of subsidised fertilisers mainly to resettled farmers (Jowah, 2005), and thus access to and subsequent intensity of fertiliser use could be correlated to unobservable characteristics that capture the underlying criteria used by the government in allocating subsidised fertilisers. The instruments we use are based on household socioeconomic and perception-based parcel characteristics. These include 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-subsidised fertilisers 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.

4. The data, empirical results and discussion

4.1. The data

Our primary objective is to test for agricultural productivity differentials between FTLRP beneficiaries and communal farmers. We base 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.

The data were collected in May 2007 for 592 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). We find the FTLRP beneficiaries in resettlement areas. The questionnaire contained detailed questions on households' production accounts, socioeconomic 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 perform two-sample *t*-tests to test for differences between the FTLRP and the communal groups.

To capitalise on the gathered information we use 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 use PCA to aggregate social capital indicators (*Cash assistance, Oxen assistance, Maize assistance* and *Labour 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.

[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.

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 (1 ZAR = 9.07 USD)	683	2405	***	1182
Maize	Maize output, in kg per hectare	816	2401	***	1275
Inputs					
Fertiliser	Fertiliser used, in kg per hectare	96	247	***	137
Fertiliser decision	Parcel received fertiliser in the last agricultural season (1=yes, 0=no)	0.78	0.92	***	0.82
Tractor days	Number of days household used tractor to plough in the last agricultural season, per hectare	0.07	1.61	***	0.49
Oxen days	Number of days household used oxen to plough 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 labour	Number of household members who worked on the parcel, per hectare	2.60	0.68	***	2.08
Hired labour	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 square meters per ha	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

*Source: Own survey data, 2007. *Difference significant at 10%; ** significant at 5%; *** significant at 1%.*

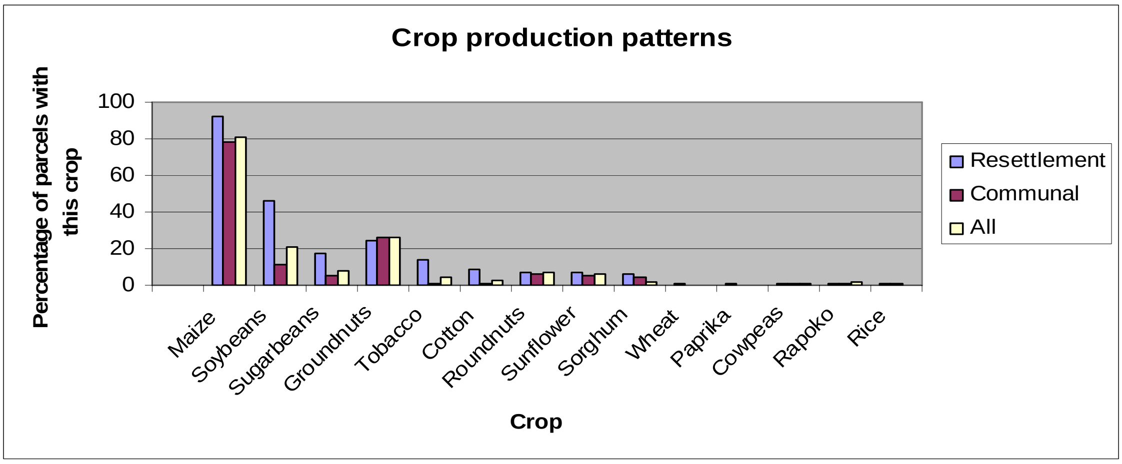
Table 2: Descriptive statistics of household level variables

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 20000ZW$ (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 25kg of maize from (1=yes, 0=no)	0.51	0.50		0.50
Labour assistance	Household has people in the village to ask for extra agricultural labour 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 neighbours	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

*Source: Own survey data, 2007. * Difference significant at 10%; ** significant at 5%; *** significant at 1%.*

Summary statistics indicate significant differences with regards to both household and parcel characteristics. Around 27% of the surveyed parcels were acquired via the FTLRP, while around 73% constitute the communal farmer group. The FTLRP subsample use significantly more fertilisers, tractors and oxen while communal farmers try to substitute by using manure and household labour intensively. Due to the fact that only 5% of communal farmers use tractors, we used oxen and tractor days to construct an overall indicator of traction days, *Traction*, using PCA. The output is more than three times higher per hectare for FTLRP, with a mean of Rand 2405 compared to Rand 683, possibly due to this group using more fertilisers, tractors and oxen, among other factors. The focus of this analysis is to explore possible factors accounting for this difference. The cropping patterns across the two groups are presented in Figure 1 below.

Figure 1: Crop production patterns



Although the parcels are a multi-cropping system, data reveals maize as the major crop, produced on 78% and 92% of surveyed communal and FTLRP parcels respectively. Summary statistics indicate that the average maize output per hectare is 2401kg for the FTLRP parcels, 816kg in communal areas and 1275kg 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 (1024kg), it falls far short of the average for the commercial farming sector (4393kg) (Mudimu, 2003). Moreover, the sample average maize output per hectare of 1275kg is less than the 1999 per hectare national average of 1516kg (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 smallholder farming sector produced around 60% 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 the lower-value crops, which has, naturally, resulted in critical shortages of foreign currency.

4.2. 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 fertiliser 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* is part of an attempt to identify the exact microeconomic mechanism through which the FTLRP impacts productivity. In particular, it helps to explore whether differences in asset productivity between beneficiaries of the FTLRP and communal farmers drive productivity differentials. Since the 2SLS estimation also includes interaction terms, this implies that we have two endogenous variables, i.e. *fertiliser* and the interaction of *fertiliser* with *FTLRP*. Thus, in addition to the instruments used we also use interactions of these instruments with *FTLRP* as instruments.

Regarding the 2SLS results, the Wu-Hausman F test confirms the (joint) endogeneity of *fertiliser* and the interaction of *fertiliser* with *FTLRP* in agricultural production. The Anderson canonical correlation likelihood-ratio test indicates that the model is identified, while the Hansen-Sargan test supports the validity of the instruments used. The confirmation of endogeneity of fertiliser implies that the OLS estimates are inconsistent. As a result, the ensuing discussion of results is based on the 2SLS estimates, which are robust to the endogeneity of fertiliser 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 labour	0.48***	0.12	0.51***	0.12	0.48***	0.13
Hired labour	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 labour			-0.16	0.59	-0.30	0.50
Hired labour			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 (overidentification test of all instruments): P-value					0.60	

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

The Fast Track Land Reform Programme 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 is bestowed on land users with rights to sell, lease and rent property. As indicated earlier, data limitations imply that this paper does *not* investigate whether beneficiaries of the programme are more or less productive than the commercial farmers who cultivated the land prior to the FTLRP. The interest is 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 underscore the significance of conventional inputs in agricultural productivity but also confirm the productivity advantage of FTLRP beneficiaries; i.e. beneficiaries achieve higher land productivity than communal farmers.[6] What could explain these productivity differentials? 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 are 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 employ 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 differ between the two groups. As discussed above, we do this by interacting inputs levels with *FTLRP*. The results indicate 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 indicate that although fertiliser application per hectare is found to be associated with higher productivity in both groups, FTLRP beneficiaries attain a higher rate of return on fertiliser use than communal farmers. This result is robust to both the OLS and the 2SLS estimations. Specifically Column (3) in Table 3 suggests that fertiliser is almost twice as productive in the FTLRP areas as it is in the

[6] Estimation of an extended productivity function which included a set of socioeconomic characteristics in addition to parcel characteristics and input levels also confirmed the productivity advantage of FTLRP beneficiaries as well as the significance of inputs in determining productivity. Socioeconomic and subjective parcel characteristics proved to be insignificant thereby justifying our use of them as instruments in the 2SLS estimation.

communal areas. The 2SLS results indicate that increasing fertiliser use by 1% leads to a 27% productivity increase for the communal group while it leads to a 55% increase for FTLRP beneficiaries. It has been shown that soils in Zimbabwe are inherently of low fertility and require regular fertiliser 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 fertiliser responsive (Heisey and Mwangi, 1997, cited in Mwangi, 1997). The rest of the inputs, however, are equally productive in both areas. This result suggests that the differences in fertiliser 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 are estimated using the parameter value for each input and the ratio of predicted output to actual input levels (see Köhlin and Amacher, 2005). This means that for a given household the marginal product of input *i* used on the *j*th parcel is as follows:

$$MP_{ij} = \beta_{ij} \frac{\hat{Y}_{ij}}{X_{ij}} \quad , \tag{5}$$

where MP_{ij} denotes the marginal product, 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
Fertiliser	5.24	2.16	***	3.15
Traction	320.17	27.53	***	117.21
Household labour	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 fertiliser use by one kilogram increases the value of total output by around 5 rands per hectare while the increase for the communal group is only 2 rands. The significance of the *t*-test statistic for differences in marginal products from fertiliser use indicates that FTLRP beneficiaries enjoy, on average, a higher marginal product from fertiliser than the communal group. This is in spite of the fact that they, on average, use twice as much fertiliser as the communal group. Similarly, FTLRP beneficiaries attain 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 fertiliser application in the FTLRP group. One possibility is that under colonial rule commercial farmers had access to more fertile land, implying that the results hinge on how effectively our soil quality indicators are 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), been actively involved in the provision of fertilisers 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 the FTLRP beneficiaries despite constant government pledges to extend the services to communal farmers. The data indicates that when asked to identify constraints to cultivating on their land, around 54% of the communal farmers cited lack of fertiliser as a constraint compared to 31% 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 fertilisers. This, combined with reduced supply owing to shortages of the foreign currency needed to import raw materials, led to fertiliser shortages on the open market and hence a black market for inputs in which the price of fertilisers was far above the official controlled price and well beyond the reach of poor farmers. Timing of the distribution of fertiliser has also been a concern, with fertilisers often being distributed well after peak application time (FAO, 2006).

To investigate the existence of differences in intensity of fertiliser use between the two groups, we make use of both socioeconomic and parcel characteristics to estimate a demand function for fertiliser per hectare. The objective is to show that FTLRP beneficiaries use more fertiliser, and given that they attain a higher productivity from it, differences in the use of fertiliser could be driving the productivity differentials.

Since not all surveyed parcels had been fertilised, we use a Tobit model to correct for this censoring of the dependent variable (Tobin, 1958; Wooldridge 2002). We also estimate a Probit model to examine factors affecting the decision to apply fertiliser. Estimating both Probit and Tobit models allows for the possibility that the decision to apply fertilisers and the intensity of application are 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.

Table 5: Demand functions for fertiliser per hectare

	Probit: *Fertiliser decision*		Tobit: *Fertiliser*	
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%.*

Consistent with summary statistics in Table 1, the results confirm that FTLRP beneficiaries are not only more likely to use fertiliser; they also use significantly more fertilisers than the communal group. This, together with the finding presented earlier that FTLRP beneficiaries attain higher rates of return on fertiliser use than communal farmers (see Table 3), suggests that the source of the productivity differentials lies in the differences in fertiliser use.

The results reveal existence of gender discrimination when it comes to access to fertilisers, with male-headed households using more fertilisers than female-headed ones. We also find evidence that resource poverty limits fertiliser use: households with more children use less fertiliser per hectare (having a lot of children arguably strains the household's resources), and the significance of livestock holdings indicates that wealthier households use more fertilisers. In addition, we find that access to media plays a role in farm decisions. As expected, the larger a household's farm the less fertiliser per hectare it uses on a given parcel. Parcel characteristics do play a role in farmers' use of fertilisers, 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).

Other determinants of agricultural productivity

Agriculture accounts for about 30% of Africa's GDP and 75% of total employment (World Bank, 2007). Consequently, agricultural performance determines Africa's economic performance. This warrants an investigation towards an understanding of the factors constraining the performance of the sector in Africa; the present 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 realised from 1960 to 2005 in all parts of the world except for in sub-Saharan Africa (World Bank, 2007). In addition, the report shows that this area has seen a lagging use of modern inputs (defined as irrigation, improved varieties of cereals and fertiliser consumption). This could imply that an expansion of the use of modern inputs could help Sub-Saharan Africa improve productivity. For instance, increased fertiliser use accounted for at least 20% 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 fertilisers, being 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 fertilisers is associated with declining soil fertility and increased soil degradation through mining of nutrients (Mwangi, 1997). It should be emphasised that for increased fertiliser 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 fertilisers in fact pose to the environment. For example, fertiliser application could be associated with leaching of nitrogen into the groundwater and with deposition of phosphorous in surface waters through soil erosion (Larson and Frisvold, 1996). Moreover, the finding that soil conservation technology enhances productivity in the study area implies that encouraging soil conservation would also lead to a win-win situation, i.e. farmers would realise 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 plough being highly correlated with oxen ownership, we find evidence that oxen ownership is a limiting factor on productivity. Taking oxen ownership as an indicator of wealth, this result suggests 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 fertilisers. 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 find that agricultural productivity is very sensitive to labour availability, particularly household labour. Household labour has been found to significantly affect production given that household members are the residual claimants of the output (Feder, 1987). Regarding parcel characteristics, we find

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

evidence that parcels with predominantly clay soils are 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 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.

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), indicate that with multiple cropping, large farms could, in principle, be compensating for less family labor per hectare with fertilisers, traction power and hired labor to surpass the land productivity of small farms.

The insignificance of manure use on productivity could be indicating that farmers are using poor quality manure. Findings by Mutiro and Murwira (2004) reveal that the way smallholder farmers store and apply manure has a significant impact on yields in Zimbabwe. Furthermore, as Mugwira and Mukurumbira (1984) argue, 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 this fails to impact productivity.

5. Conclusions and policy implications

This paper seeks to provide micro-evidence on the impact of land reforms. It does this by focusing on the most recent phase of Zimbabwe's land reform programme, the Fast Track Land Reform Programme (FTLRP), launched in 2000 and aimed at accelerating both land acquisition and redistribution. We use data on FTLRP beneficiaries and a control group of communal farmers to investigate the programme'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 is found to lie in differences in input usage. In addition we find that FTLRP beneficiaries gain a productivity advantage not only from the fact that they use more fertiliser 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, indicates that although higher than that of communal areas, the productivity of FTLRP beneficiaries falls 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 suggests 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 is 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 fertilisers, 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 – suggest that institutions surrounding input markets might favour FTLRP beneficiaries. Thus, our analysis suggests 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 programme. This is because the analysis does not account for the extra costs that the government incurs by supporting beneficiaries. As the analysis of fertiliser demand indicates, FTLRP beneficiaries have a clear advantage when it comes to fertiliser 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 programme. Furthermore, the sustainability of such a programme is questionable, given the financial constraints faced by the government.

The analysis sheds some light on factors that enhance agricultural productivity in Africa where a weak performance of the agricultural sector is of major concern. For example, our findings indicate that fertiliser could play a significant role in bringing about high and sustained increased crop yields in Africa. However, for fertiliser 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 fertilisers pose to the environment. Moreover, the finding that soil conservation technology enhances productivity in the studied area indicates that encouraging soil conservation would also lead to a win-sin situation where farmers realise increased production and at the same time reduce soil degradation.

Our results confirm 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 programme 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 liberalise and improve the input markets.

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