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Land Reform, Trust and Natural Resource Management in Africa

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To Zimbabwe, that she may find her wings and fly!
In particular to four great Zimbabweans whose love sets me free:
Douglas, Joyce, Thulisile, and Thobekile Zikhali.

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Abstract

Four self-contained papers constitute this thesis.

Paper I investigates what impact Zimbabwe's Fast Track Land Reform Programme, launched in 2000 as part of an ongoing land reform and resettlement programme aimed at addressing a racially skewed land distribution, has had on its beneficiaries' perceptions of land tenure security and subsequent decisions to invest in soil conservation. Evidence suggests that the programme has created some tenure insecurity, which has adversely affected soil conservation investments among its beneficiaries. We find support for the contention that households invest in land-related investments to enhance security of tenure. The results underscore the need for the government of Zimbabwe to clarify and formalise land tenure arrangements within the programme.

Paper II uses data on beneficiaries of Zimbabwe's Fast Track Land Reform Programme and a control group of communal farmers to investigate programme impacts on the agricultural productivity of its beneficiaries. The results suggest that the programme's beneficiaries are more productive than farmers in communal areas. The source of this productivity differential is found to lie in differences in input usage. In addition, we find that programme beneficiaries gain a productivity advantage not only due to using more fertiliser per hectare; they also attain a higher rate of return from its use. Furthermore, differences in the use of capital assets, which are found to be a significant determinant of productivity, suggest that policies aimed at alleviating poverty would have a positive impact on agricultural productivity. We also find evidence that soil conservation, among other factors, has a significant impact on productivity.

Paper III proposes that ethnicity coupled with ethnic nepotism may reduce interpersonal generalised trust. We use the 2001 wave of the World Values Survey data for eight African countries to test this claim, and show that ethnicity and ethnic nepotism are each important in affecting generalised trust levels, and in addition their interaction has a self-reinforcing and negative effect. The results underscore the importance of institutions in controlling ethnic nepotism and thus contributing to mitigating the adverse effects of ethnicity on trust.

Paper IV focuses on the mopane worm, which is the caterpillar form of the Saturnid moth *Imbrasia belina* Westwood, a vital source of protein in southern African countries. The worms live and graze on mopane trees, which have alternative uses. Increased commercialisation of the worm has degraded its management to almost open access. This paper develops a bioeconomic model to show that for some optimal allocation of the mopane forest stock, the restrictive harvest period policy advocated by community leaders may not lead to sustainable harvesting of the mopane worm unless it is accompanied by an optimal tax. This tax should correct for (1) undervaluation of the scarcity value of the mopane stock under the restrictive harvest period policy, (2) differences in harvest costs and (3) a stock externality. Comparative static analyses indicate that the optimal tax rate is negatively related to the benefit discount rate but positively related to the number of harvesters.

Keywords: Africa, Agricultural productivity, Bioeconomic model, Dynamic analysis, Land reform, Ethnicity, Ethnic nepotism, Investments, Mopane worm, Restrictive harvest period policy, Tenure security, Trust, Zimbabwe.

JEL classification: C61, D02, D24, O12, O13, Q12, Q15, Q18, Q24, Q57, Z13.

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Isifinqo

Ngamafitshane ugwadlana lolu lubunjwe ngamaphepha angamahlandla amane amele imibono lendlela ezitshiyeneyo.

Ihlandla lakuqala lihlolisisa umphumela weFast Track Land Reform Program yeZimbabwe eyaqala ngomnyaka ka2000 njengengxenye yokuqhubeka kokubuyiselwa komhlabathi lohlelo lokuhlaliswa kakusha inzalo kazulu losapho lwabansundu eZimbabwe. Lokhu-ke kulesidingo semibono emayelana lokuphathwa, kanye lokuvikelwa komhlabathi ngengxa yaloluhlelo. Ubufakazi obukhona buveza ukuthi loluhlelo alulandlela yokuvikela labo asebenikezwe umhlabathi; lokhu sekubangele ukungaphatheki kuhle komhlabathi kulabo abasanda kwabelwa. Kulokugcizelela njalo kumibono ethi abasemakhaya benza inotho ezintweni eziphathelene lomhlabathi, kuyinjongo ehlose ukubumba isivikelo sokwabelwa umhlabathi. Imiphumela iveza ngokusobala isidingo sokuthi uHulumeni weZimbabwe acacise ngokusemthethweni uhlelo lokuvikeleka kwalaba ababelwe umhlabathi kuloluhlelo.

Ihlandla lesibili lihlolisisa imniningwane yalabo abathole umhlabathi kuhlelo lweFast Track Land Reform lweZimbabwe, lubuye lugoqele lezakhamizi zamakhaya ekuhlolisiseni umphumela wezokulima kulawomapulazi. Imiphumela ibonisa ukuthi laba abathola umhlabathi kuhlelo lolu baphumelela ukwedlula izakhamizi jikelele. Isisusa salomahluko sibangelwa yilezo zinto ezisetshenziswayo ekulimeni. Ngaphezulu kwalokhu, abalimi ababelwa umhlabathi kuhlelo lolu bathola ukusizakala hatshi ngokusebenzisa umqhuba wesilungu omnengi ngokwesilinganiso sensimu ngayinye, kodwa langenani eliphezulu ngokuwusebenzisa lowomqhuba wesilungu. Okunye njalo umahluko ubangelwa yikusetshenziswa kwemitshina yokulima ngokwehlukahlukana kwayo okwenza kuvele sobala inani lomphumela ekulimeni. Umahluko lo uyisitshengiselo sokuthi izinqumo ezihlose ukuqeda indlala lenhlupho emphakathini zingaba lomphumela omuhle kwezokulima. Kulobufakazi njalo obuthi ukunakekelwa komhlabathi, phakathi kwezinye zezinto, kungangezelela umphumela omuhle kwezokulima.

Ihlandla lesithathu libonisa ukuthi ukubandlulula ngomhlobo kubangela ukungathembani phakathi kukazulu. Ekuhlolisiseni lumbono sisebenzise isibonakaliso sika2001 esitholakala kuWorld Values Survey yamazwe ayisitshiyagalombili aseAfrica. Siphinde sabona ukuqhakatheka komhlobo, kunye lokubaluleka kobandlululo ngomhlobo ukuthi kuyimbangela yokungathembani lokungahlalisani emphakathini. Imiphumela ibalulekisa ukuqhakatheka kwezikhungo ekuvikeleni lolubandlululo olungacina lusenza kungabi lokuthembana phakathi kwemihlobo.

Ihlandla lesine lilenhloso yokukhuluma ngamacimbi, wona aqakatheke ekwakheni umzimba ngalokhu esingathi phecelezi 'proteins' ikakhulu kumazwe asezansi yeAfrica. Amacimbi atholakala ezihlahleni zaMaphane. Ukwanda kwendlela amacimbi asethengiswa ngayo kwenza indlela atholakala ngayo ingalawuleki. Lelihlandla lihlose ukubumba insikampilo yomnotho ebonisa ngokwabiwa kwezihlahla zamaMaphane, lokuthi ukugcizelelwa kwezinqumo zabaphathi bezigaba ezibika izikhathi zokugola lezanelisa ukwahlulela kokugolwa kwamacimbi uma kungelamthelo othize okhokhwayo. Umthelo lo umele ukuqondisa lokhu: (1) isinqumo esibonisa ngentengo ephansi ngesikhathi sokuwagola amacimbi lapho engasatholakali, (2) umahluko phakathi kwendleko zokuwagola, (3) kunye lendleko zamacimbi angagolwanga ukuze akhusele ikusasa yethu.

Preface

The process of writing this thesis has presented me with much more than an opportunity for professional development. It has also taken me places where I have rediscovered myself and grown personally; places where I have learnt to be patient, reach out for help, and exercise self-discipline and determination. During this process I have met people who have truly inspired, touched and illuminated my life. For that I want to sincerely acknowledge everyone who has supported me along the way.

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Finally, I thank God for helping me put it all together.

Precious Zikhali
Gothenburg, October 2008

Summary of the thesis

This thesis consists of four self-contained essays. A summary of each paper is presented below.

Paper I: Tenure Security and Investments: Micro-evidence from Zimbabwe's Fast Track Land Reform Programme

Zimbabwe launched the Fast Track Land Reform Programme (FTLRP) in 2000 as part of its ongoing land reform and resettlement programme aimed at addressing a racially skewed land distribution. The aim of the FTLRP has been to accelerate both land acquisition and redistribution, targeting at least five million hectares of land for resettlement (Zimbabwe, 2000). While, in principle, the land tenure system under the FTLRP ranges from a permit system to a 99-year lease with an option to purchase the land, the reality is that beneficiaries have been issued many different types of temporary licenses that the government intends to convert to permanent leases. This could create land tenure insecurity among the beneficiaries.

The objective of this paper is to provide micro-evidence of the impact of the FTLRP on its beneficiaries' perceived tenure security and subsequent decisions to invest in soil conservation. In so doing we employ both semi-parametric and parametric econometric methods, permitting us to: (1) explore how household characteristics predispose households for selection into the FTLRP, (2) assess the difference in perceptions of land tenure security between FTLRP beneficiaries and communal farmers and (3) explore how these differences affect investments in soil conservation. In addition, our strategy allows us to overcome the problems arising from the potential endogeneity of tenure security with soil conservation investments.

The results provide evidence that the programme has created some tenure insecurity among its beneficiaries, and this in turn has had an adverse impact on investments in soil conservation, suggesting that the programme might have failed to offer the security of tenure necessary for the long-term planning horizons of its beneficiaries. The finding demonstrates the significance of tenure security in land-related investments. In addition, consistent with Besley (1995) and Deininger and Jin (2006), our results indicate that households undertake investments in soil conservation not only to enhance productivity but also to establish and/or enhance security of land tenure. This implies that policies that seek to improve the positive

impact of tenure security on farm investments should be formulated from analyses that consider tenure security as endogenous, i.e. something households believe they can affect. The results, thus, underscore the need for the government of Zimbabwe to restore confidence and credibility in the agricultural property rights system. This, together with a commitment towards respecting property rights in general, might go a long way in enhancing perceived tenure security and hence encourage on-farm investments.

Paper II: Fast Track Land Reform and Agricultural Productivity in Zimbabwe

In Zimbabwe, where a significant proportion of the population rely on agriculture for their subsistence and there is a history of social injustice or exclusion with regards to land ownership, equity and political considerations have been the driving motives for redistributive land reforms since independence in 1980 (Deininger et al., 2004). The most recent phase of these reforms, the Fast Track Land Reform Programme (FTLRP), was launched in 2000 with the objective of accelerating both land acquisition and redistribution. In this paper we use data on programme beneficiaries and a control group of communal farmers to investigate programme impact on the agricultural productivity of its beneficiaries.

The results suggest that programme 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 programme beneficiaries gain a productivity advantage not only due to using more fertiliser per hectare, but also because they attain a higher rate of return per unit of fertiliser used. However comparing with the production statistics prior to the launch of the FTLRP suggests that while beneficiaries have not achieved the full potential (as measured by the commercial farm production prior to the onset of the FTLRP), they seem to have been able to mitigate the output reductions accompanying the FTLRP better than communal farmers. As already mentioned, our analysis indicates that FTLRP beneficiaries have a clear advantage when it comes to fertiliser use, and given that this use is sustained by subsidies from the government, it is possible that the associated costs compromises the overall success of the programme. Thus, our

analysis suggests that caution is called for in using the result on the productivity advantage of the beneficiaries as an indicator of the overall success of the FTLRP.

Our findings indicate that fertilisers could play a significant role in bringing about high and sustained increased crop yields in Africa. We also find evidence that encouraging soil conservation would lead to a win-win situation where farmers realise increased production and at the same time reduce soil degradation. Furthermore, differences in the use of capital assets, which are found to be a significant determinant of productivity, suggest that alleviating poverty would have a positive impact on agricultural productivity.

Paper III: Does Ethnicity Matter for Trust? Evidence from Africa

Generalised interpersonal trust plays an important role in shaping economic and social outcomes; it eases exchange without a need for a strict means of enforcement and thus reduces transaction costs (Zak and Knack, 2001), promotes investment efficiency and is the foundation of cognitive social capital, which has been argued to be important in a country's institutional and economic development (Knack and Keefer, 1997). In ethnically diverse societies, however, generalised interpersonal trust appears to be low compared to in homogenous societies. This argument gains particular relevance in African countries as they have among the highest levels of ethnic diversity in the world. Ethnic nepotism – a form of extended nepotism that capitalises on the divisions of people into separate ethnic groups based on for example race, nationality, language, tribe, religion or caste – is one of the most important causes of tensioned ethnic relationships. Its prevalence may create an environment marred by suspicion among individuals, which in turn may reduce generalised trust levels.

In this paper we use World Values Surveys data for eight African countries to examine whether ethnicity, defined as associating oneself with a certain ethnic group as opposed to the society as a whole, and ethnic nepotism affect generalised interpersonal trust. Our contribution to the social trust literature can be seen from at least two perspectives. First, while country-level ethnic diversity data is used in most of the previous studies, we use an attitudinal definition and measurement of ethnicity at the individual level. Hence, we can identify the association between ethnicity and generalised trust at the individual level. Second, we use country-level data on ethnic

nepotism. This is particularly important given our focus on African countries where politics is run mainly along ethnic lines and hence ethnic nepotism could be more of a norm than an exception. We argue that while ethnicity lowers trust levels, ethnicity per se may not affect interpersonal trust in situations where ethnic nepotism is not a problem. We therefore posit that ethnicity coupled with ethnic nepotism could reduce generalised interpersonal trust.

Our results show that ethnicity attenuates trust levels. In addition, we find that the presence of ethnic nepotism may propagate the adverse effects of ethnicity on trust levels. The implication of our findings is that policy interventions that reduce the extent of ethnic nepotism could be an important instrument in minimising the adverse effects of ethnicity on trust.

Paper IV: Can the restrictive harvest period policy conserve mopane worms in southern Africa? A bioeconomic modelling approach

Edible insects and caterpillars constitute one of the cheapest sources of animal protein in most African countries. Most of them contain more protein, fat and carbohydrates than equal amounts of beef and fish, and a higher energy value than soybeans, maize, beef, fish, lentils and other beans (Illgner and Nel, 2000). One of the most nutritious, commonly eaten and economically important caterpillars in southern Africa is the edible larvae or caterpillar of the Saturnid moth *Imbrasia belina* Westwood, colloquially referred to as the 'mopane worm'. It grazes primarily on the leaves of *Colophospermum mopane* or the mopane tree.

Overexploitation and in some cases disappearance of the worms have been reported (Illgner and Nel, 2000). This can be attributed to minimal barriers to entry into the collection and trade of the worm, an increasing incidence of poverty in southern African countries, and the threat to mopane trees due to deforestation of the mopane woodlands. Moreover, the institutional capacities to govern forest resources in most southern African countries are weak (Campbell *et al.*, 2001). The only existing policy instrument informally employed by some traditional leaders, is embargos on harvesting the worm during certain periods (Toms and Thagwana, 2005). This, on its own, has proved insufficient as overexploitation continues to be of major concern, prompting the need to look into alternative policies.

In this paper we draw on Reed (1979) and Clark (1990) to develop a bioeconomic model that investigates whether, for some predetermined mopane forest allocation,

restricting the harvesting season to a predetermined harvest period, as currently advocated, will result in sustainable harvesting of the worms. Our results show that some optimal tax that corrects for (1) undervaluation of the scarcity value of the mopane stock under the restrictive harvest period policy, (2) differences in harvest costs and (3) a stock externality must accompany the restrictive harvest period policy. The optimal tax is negatively related to the benefit discount rate but positively related to the number of harvesters. The fact that some communities have managed to restrict harvesting to certain time periods and at the same time impose a fee on harvesters (FAO, 2007) shows that the hybrid instrument we propose might be feasible in southern Africa.

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Paper I

**Tenure Security and Investments:
Micro-evidence from Zimbabwe's Fast Track Land Reform
Programme**

Precious Zikhali¹

Abstract

The government of Zimbabwe launched the Fast Track Land Reform Programme (FTLRP) in 2000 as part of its ongoing land reform and resettlement programme aimed at addressing a racially skewed land distribution. Its goal has been to accelerate both land acquisition and redistribution, targeting at least five million hectares of land for resettlement. This paper investigates the impact of the FTLRP on its beneficiaries' perceptions of land tenure security, and how these subsequently impacted soil conservation investments. Evidence suggests that the programme created some tenure insecurity, which adversely affected soil conservation investments among its beneficiaries. We find support for the contention that households invest in land-related investments to enhance security of tenure. The results underscore the need for the government of Zimbabwe to clarify and formalise land tenure arrangements within the programme.

Key words: Land reform, Tenure security, Investments, Zimbabwe.

JEL Classification: O12, O13, Q15, Q24.

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1. Introduction

In an attempt to address a racially skewed land distribution, Zimbabwe has, since independence in 1980, pursued a land reform and resettlement programme premised on land acquisition and redistribution. The most recent phase of this programme, the Fast Track Land Reform Programme (FTLRP), on which this analysis is based, was officially launched in July 2000 with a goal to attain extensive, compulsory land acquisition and redistribution, targeting at least five million hectares of land for resettlement (Zimbabwe, 2000). While, in principle, the land tenure system under the FTLRP ranges from a permit system to a 99-year lease with an option to purchase the land, the reality is that the FTLRP beneficiaries have been issued many different types of temporary licenses that the government intends to convert, in time, to permanent leases. This has been argued to be a source of tenure insecurity among the beneficiaries (Munyuki-Hungwe and Matondi, 2006).

Macro-evidence indicates that the FTLRP had been accompanied by a 30% drop in agricultural production by 2004 (Richardson, 2004). Given that land-related investments such as soil conservation investments have been found to enhance productivity in Zimbabwe (Zikhali, 2008), it can be argued that the rapid decline in production is partly due to low levels of land-related investments conditioned by the reform process.² Moreover, a survey in 2003 concluded that about one-quarter of all land in Zimbabwe is severely eroded (Richardson, 2004), implying that comparatively large benefits could be derived from land-related investments. Thus, using Zimbabwe as a case study makes an interesting contribution to the existing literature that assesses empirically the link between tenure security and investment incentives in the context of land reforms.

Economic theory postulates three links between land tenure security and agricultural investment incentives:³ The first is what Besley (1995) refers to as a ‘security argument’, which captures the direct and positive link between tenure security and investment incentives. The logic is that insecure tenure leads to market imperfections and increases the risk associated with farming through the threat of dispossession. The second link is referred to as a ‘collateral-based view’ due to its premise that when land

² Of course there are other explanations as well, such as the loss of economic scale and replacement of experienced farmers with less experienced ones who are more geared towards subsistence production.

³ See Besley (1995) for a comprehensive summary.

tenure is secure and thus easier to collateralise, it can reduce the price of capital and subsequently increase the value of investments. The third and final link is referred to as a 'gains-from-trade perspective' and is based on the fact that secure land rights increase investment incentives by lowering transaction costs if land is to be either rented out or sold, thereby expanding trading opportunities and the ability to take advantage of gains from trade. Tenure security is more important when one considers medium- to long-term investments; hence the justification of investigating the impact of tenure security on long-term investments such as tree planting and construction of soil conservation structures (Besley, 1995; Hayes et al., 1997; Holden and Yohannes, 2002).

The main econometric challenge in most studies analysing the link between tenure security and investments arises from the fact that most African countries have a causality problem where land rights may depend on past investments and vice versa (Besley, 1995; Brasselle et al., 2002). Consistent with this, tree planting has been identified as a way of establishing and/or enhancing tenure security (Besley, 1995; Sjaastad and Bromley, 1997). This endogeneity of tenure security with investments could partly explain the mixed results found in the existing literature on the empirical analysis of the link between land tenure and investments.⁴ For instance Besley (1995), Holden and Yohannes (2002), and Ayalew et al. (2005) underscore the significance of tenure security in promoting land-related investments while Gavian and Fafchamps (1996) found little impact of property rights on land-related investments. This paper employs an estimation methodology that allows for the possible endogeneity of land tenure security and investment decisions.

Few studies have explored the link between tenure security and land-related investments in Zimbabwe, especially within a land reform framework. Fortmann (1998) suggested that lack of tenure security discourages female farmers from making long-term, ecologically beneficial investments on their land. With regards to the impact of land reforms in Zimbabwe, Moor (1996) found that perceived tenure security in the form of land titling and registration had a significant and positive effect on long-term on-farm investments among beneficiaries of pre-2000 land reform programmes.

No study, as can best be determined, has conducted an empirical analysis of the impact of Zimbabwe's FTLRP on tenure security and land-related investments. Hence, we set out to do this by investigating the impact of Zimbabwe's FTLRP on its

⁴ See Brasselle et al. (2002) for a survey of empirical studies on land tenure and investments in Africa.

beneficiaries' perceptions of tenure security and subsequently investments in soil conservation. We pursue an estimation strategy that employs both semi-parametric and parametric econometric methods, permitting us to (1) explore how household characteristics condition households for selection into the FTLRP, (2) assess the differences in perceptions of land tenure security between beneficiaries of the FTLRP and communal farmers and (3) explore how these differences, if any, affect investments in soil conservation. In addition, our strategy allows us to overcome the problems arising from the potential endogeneity of perceived tenure security with soil conservation investments. Specifically, it makes it possible for us to deal with the causality problem between security and investment by using modes of acquiring land as instruments for perceived tenure security, with acquisition through the FTLRP being one of them. Using data from Mashonaland Central province in Zimbabwe, the results provide evidence that the programme has created some tenure insecurity among its beneficiaries, which has impacted investments in soil conservation adversely. Endogeneity of perceived tenure security is confirmed, suggesting that households invest to establish and/or enhance security of land tenure.

The credibility of this analysis could be questioned in light of the current economic crisis in Zimbabwe (especially the hyperinflationary environment). However, since the analysis is based on quantities and not prices, this problem is minimised. In particular, the fact that the analysis focuses on soil conservation, which is labour-intensive and has family labour as the default labour available to the household, implies that liquidity or financial constraints that could be associated with the economic crisis might not be a limiting factor in soil conservation investments. This increases the chances of isolating the effect of the FTLRP on soil conservation investments. Thus, we believe the analysis gives a fairly reasonable reflection of the direction of the FTLRP's impact on perceived tenure security and soil conservation investments.

The following section gives a brief background on the FTLRP. Section 3 presents the underlying conceptual framework, while our econometric framework and estimation strategy are discussed in Section 4. Section 5 discusses the data used in the empirical estimation and the results. Section 6 concludes the paper with policy implications.

2. Fast Track Land Reform in Zimbabwe

Zimbabwe inherited a racially skewed agricultural land-ownership pattern at independence in 1980. White large-scale commercial farmers – 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).⁵ Consequently, the Zimbabwean government adopted a land reform and resettlement programme aimed at land acquisition and redistribution. The primary, long-standing objectives of this programme have been to for example (1) address the imbalances in land access while alleviating population pressure in communal areas, (2) improve the base for productive agriculture in the smallholder farming sector, (3) improve the living standards of the majority of the population, and (4) bring idle or under-utilised land into full production (Kinsey, 1999). Indigenous Africans constitute 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. These rights can, in principle, be passed on as an inheritance along the lines of primogeniture, following the death of the original owner.

The land reform and resettlement programme can be classified into two broad phases, the first of which began in 1980 with the primary objectives of addressing inequitable land ownership, insecurity of tenure, and unsustainable and sub-optimal land use (Moyo, 2006). Given its policy of national reconciliation as well as the restrictive Lancaster House Constitution,⁶ the government pursued a land resettlement programme based on a willing-seller/willing-buyer approach. However, in 1997 the government of Zimbabwe initiated a process of radical land reform based on extensive, compulsory land acquisition and redistribution that targeted at least 5 million hectares of land for resettlement (Moyo, 2004). This heralded the start of the second phase of the programme. The FTLRP, on which this 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 and resettlement, to accelerate

⁵ It is also worth noting that commercial farms were crucial for employment and total agricultural production, as well as export earnings. For example, in the 1990s, commercial farms accounted for 68% of gross agricultural output and 40% of export earnings (Addison and Laakson, 2003).

⁶ The Lancaster House Constitution obligated the government to acquire land on a willing-seller/willing-buyer basis during the first 10 years of independence.

the planning and demarcation of the acquired land and placement of settlers, and to provide basic infrastructure and farmer support services (Zimbabwe, 2000; Moyo, 2006). The programme has two models: Model A1 is intended to decongest communal areas and generally help land-constrained subsistence farmers. It is based on the existing communal-area organisation, where peasants produce mainly for subsistence with small surpluses for the market in good seasons. Model A2, on the other hand, is a commercial settlement scheme for small-, medium- and large-scale farming based on the concept of full-cost recovery from the beneficiary, and is intended to create a cadre of black commercial farmers. This is, in principle, targeted at any Zimbabwean who can prove their farming experience and/or resource availability (Zimbabwe, 2000). The bulk of the programme centres 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 settlers have been issued many different types of temporary licenses. Moreover, the duration of contract under the lease is relative despite it stating that the lease is for 99 years, and its conditions for subletting are not clear (Moyo, 2004). Munyuki-Hungwe and Matondi (2006) claim this to be a source of tenure insecurity among FTLRP beneficiaries. This paper attempts to assess empirically how the FTLRP has affected perceived tenure security among farming communities, and then goes a step further by analysing how these perceptions have affected land-related investments. We base the analysis on a sample of communal farmers as well as farmers who have benefited from the FTLRP under Model A1. Communal farmers acquire land either through inheritance, allocation by a traditional leader, buying or renting.

3. The conceptual framework

The conceptual framework models households' perceptions of tenure security and investments in soil conservation, conditioned by the FTLRP. The theoretical literature on the link between land tenure security and farm investments suggests that tenure security affects investments especially when considering medium- to long-term investments such as tree planting and soil conservation (Besley, 1995; Sjaastad and Bromley, 1997). Accordingly, we model investments in soil conservation as:

$$I = I(S, \Lambda, P) , \quad (1)$$

where I is the level of soil conservation investments, measured as the total parcel area under soil conservation structures constructed in the last five years, normalised by the total parcel size. A parcel is defined as a contiguous piece of land on which one or more different crops can be cultivated. S is an indicator of perceived tenure security and Λ is a vector that captures households' socioeconomic characteristics, e.g. gender, age, education of household head, household composition, access to agricultural extension workers, social capital indicators and involvement in off-farm activities. P is a vector of parcel characteristics and these include size, subjective measures of steepness, soil depth and fertility of parcel as well as the initial endowment of soil conservation structures.⁷ Our choice of variables is informed by previous studies that analyse determinants of investments in soil conservation (see for example Shiferaw and Holden, 1998; Deininger and Jin, 2006).

Consistent with theoretical postulations, the study hypothesises that $\frac{\partial I}{\partial S} > 0$. Furthermore, in many African countries, long-term investments are a means of attaining and/or enhancing tenure security (Besley, 1995; Sjaastad and Bromley, 1997), implying that households with physical long-term investments such as soil conservation structures on their plots might feel more tenure secure. This is supported by the fact that about 58% of the households in the sample believe land investments reduce the probability of losing land through evictions or expropriation, for example. Accordingly, our empirical strategy corrects for the possibility of this kind of endogeneity, thereby minimising the upward-biased inferences on the impact of perceived tenure security on investment decisions.

Given the background of the FTLRP in Zimbabwe, we postulate that perceived tenure security has indeed been affected by the programme. This implies:

$$S = S(R) , \quad (2)$$

where R is a dummy indicating whether or not a household got the parcel through the FTLRP. We maximise the information at hand by including dummies that capture

⁷ Ideally the level of investment will be a function of the difference between a household's desired stock of soil conservation structures and the current stock. However, data limitations made it unworkable to model this.

different modes of acquiring the parcel (i.e. whether the parcel was bought, inherited, allocated to the household by a traditional leader or acquired via the FTLRP). We hypothesise that farmers feel less tenure secure about parcels received via the FTLRP.

4. The econometric framework and estimation strategy

Equation (1) implies the estimation of equation (3) below for investment levels:

$$I = \alpha_0 + \alpha_1 S + \alpha_2 \Lambda + \alpha_3 P + \nu , \quad (3)$$

where $\alpha_0, \alpha_1, \alpha_2$ and α_3 are parameters or vectors of parameters to be estimated, and ν is the error term. It is assumed that the error term is independently, identically and normally distributed with zero mean (Wooldridge, 2002). To ensure robustness, both semi-parametric and parametric approaches are employed to estimate equation (3). Specifically, we start by using a semi-parametric method, the Propensity Score Matching (PSM) method. This is followed by an estimation of two-stage Probit and Tobit models with endogenous regressors, i.e. Instrumental Variable Probit (IV-Probit) and Instrumental Variable Tobit (IV-Tobit), both parametric methods. A detailed discussion of the estimation strategy follows below.

4.1. The Propensity Score Matching method

The idea underlying the PSM is that one group of people participates in a programme while another group does not, and the objective is to assess the effectiveness of the programme (or treatment) by comparing the average outcomes. Given observational rather than experimental data, there is non-random selection into the programme. Thus, a matching process based on observed characteristics is used to compare participants and non-participants. Here, we use the PSM method to address the problem that FTLRP beneficiaries might not form a randomly selected sub-group of all farmers in the sample. If so, there is a risk that the non-random selection process may lead to differences between FTLRP beneficiaries and communal farmers that can be mistaken for effects of the FTLRP. The PSM method is a semi-parametric method used to estimate the average treatment effect of a binary treatment on a continuous scalar outcome (Rosenbaum and Rubin, 1983). We take FTLRP as the treatment variable, while investments in soil conservation and perceived tenure security are the outcomes of interest. The group that

has benefited from the reform is the treatment group, while those in the communal areas form the control group.

In order to estimate the average treatment effect of the FTLRP on soil conservation investments in the resettlement areas, we would ideally want to estimate the following:

$$ATT = E[I_1 | R = 1] - E[I_0 | R = 1] , \quad (4)$$

where ATT is the average effect of the treatment on the treated households or parcels, $I_0 | R = 1$ is the level of soil conservation investments that would have been observed had the parcel *not* been acquired through the FTLRP, while $I_1 | R = 1$ is the level of investments actually observed in the land reform sub-sample. The challenge is that $I_0 | R = 1$ cannot be observed, necessitating the creation of a counterfactual of what can be observed by matching treatment and control groups.

Given that matching on covariates is not always practical, particularly with many covariates, propensity scores ($p(X)$) – the conditional probabilities of being in the land reform group conditional on X – are used to reduce this dimensionality problem. Here X is the set of covariates that influence selection into the FTLRP. The model matches treated units to control units with similar values of X . The equation to be estimated then becomes:

$$ATT = E[I_1 | R = 1, p(X)] - E[I_0 | R = 0, p(X)] . \quad (5)$$

The PSM relies on the key assumption that conditional on X , the outcomes must be independent of the targeting dummy R (the conditional independence assumption, or CIA). While the CIA cannot be directly tested since PSM uses non-experimental data, we make use of the ‘Rosenbaum bounds’ (Rosenbaum, 2002) to investigate how strong the effect of unobservable characteristics has to be to in order to change the treatment outcomes. This sensitivity analysis makes use of the odds ratio of participating in the FTLRP between two matched households. Let the probability of participation by an household i be:

$$p(X) = p[R = 1 | X] = F(\theta X + \gamma\omega) , \quad (6)$$

where ω is the unobserved variable and γ is its effect on selection into the FTLRP. If there is no hidden bias, γ will be zero and the chances of selection into FTLRP will be

the same for matched households. It will, however, be different in the presence of a hidden bias. The odds ratio for selection into the FTLRP is given by $\exp[\gamma(\omega_i - \omega_j)]$ for matched households i and j . If the ratio departs from the value of 1, it is due to hidden bias, i.e. because $\omega_i \neq \omega_j$ or $\gamma \neq 0$. Sensitivity analysis evaluates how much the effect of the FTLRP is changed by changing the values of γ and $(\omega_i - \omega_j)$, i.e. examining the bounds on $1/\exp(\gamma)$ and $\exp(\gamma)$.

The matching process used here uses the kernel matching method which matches a treated unit to all control units weighted in proportion to the closeness between the treated and the control unit. We also estimate equation (5) for perceived tenure security instead of I , to investigate how the FTLRP has affected households' perceptions of tenure security.⁸

4.2. Instrumental Variable models

As the next section describes, not all surveyed parcels experienced soil conservation investments in the last five years. Hence, we need econometric models that correct for this censoring of the dependent variable, since the use of Ordinary Least Squares (OLS) on the whole sample will give inconsistent estimates (Wooldridge, 2002). Accordingly, a censored regression model is used to estimate equation (3). Specifically we estimate a two-stage Tobit model with endogenous regressors. The Tobit model, originally developed by Tobin (1958), is defined by equations (7) and (8) below:

$$I = \begin{cases} I^* & \text{if } I^* > 0 \\ 0 & \text{otherwise} \end{cases} , \quad (7)$$

$$I^* = \alpha_0 + \alpha_1 S + \alpha_2 \Lambda + \alpha_3 P + v = \varphi Z + v , \quad (8)$$

where I^* is a latent variable that is observed only when $I > 0$. The Tobit model assumes that the error term in equation (8) is independently, identically and normally distributed with zero mean and constant variance (Wooldridge, 2002). S is the potentially endogenous perceived tenure security variable and $Z = [S, \Lambda, P]$, $\varphi' = [\alpha_0', \alpha_1', \alpha_2', \alpha_3']$. A test proposed by Smith and Blundell (1986) is used to test the exogeneity of perceived tenure security. The test works in the same way as a Hausman test for OLS regression whereby in the first stage the endogenous variable is estimated

⁸ More details on this method can be found in Becker and Ichino (2002). The estimation here uses the STATA 10's `psmatch2` routine developed by Leuven and Sianesi (2003).

with OLS over a set of instruments and exogenous variables of the Tobit model and then in the second stage the residuals from the first stage are included as an additional explanatory variable in equation (8). The null hypothesis here is that the residuals have no explanatory power. Failure to reject the null implies that the standard Tobit model is appropriate, while rejection suggests the need to use an alternative model.

Efficient estimation of φ' for endogenous S

To estimate the parameters in φ' in case of a rejection of exogeneity of perceived tenure security, we use an estimator proposed by Amemiya (1978, 1979) and shown by Newey (1987) to be efficient. The method applies the generalised least squares in the relationship between the Tobit model's structural parameters, φ , given by equation (8) and its reduced-form parameters:

$$I^* = \mu_0 + \mu_1 \hat{S} + \mu_2 \Lambda + \mu_3 P + \eta \quad , \quad (9)$$

where \hat{S} is a residual from the first stage regression of perceived tenure security on a set of instruments and exogenous variables; $\mu_0, \mu_1, \mu_2, \mu_3$ are parameters to be estimated; and η is an error term. The exogeneity test is performed using Baum's (1999) procedure while $\mu_0, \mu_1, \mu_2, \mu_3$ are estimated using Harkness' (2000) procedure in STATA. Following the preceding discussion, the mode of acquisition of the parcel (i.e. whether the parcel was bought, inherited, allocated to the household by a traditional leader, or acquired through the FTLRP) is used as an instrument for perceived tenure security. The IV-Tobit model is estimated using the two-stage procedure in STATA 10. We also estimate an IV-Probit model to examine factors affecting the decision to invest in soil conservation. Estimating both IV-Probit and IV-Tobit models allows for the possibility that the decision to invest and the intensity of investments 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.

5. The data, empirical results and discussion

5.1. The data

The primary aim of the empirical analysis is to test the hypotheses that the FTLRP has been accompanied by tenure insecurity and subsequently an adverse impact on soil conservation investments among its beneficiaries. It is based on primary data collected from Mazowe District, one of the seven districts in the Mashonaland Central province in Zimbabwe. Mazowe District lies in Natural Regions 2 and 3 and is divided into 29 wards.⁹

The data was 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). It is in resettlement areas that we find beneficiaries of the FTLRP. The questionnaire asked detailed questions about the households' perceptions of tenure security, investments made in the last five years, parcel and socioeconomic characteristics.

Descriptive statistics

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, and these reveal significant differences. Around 27% of the surveyed parcels were acquired through the FTLRP, 27% were inherited, 32% allocated to the household by a traditional leader, 6% rented and 7% bought. The data reveals thin land rental and sales markets.

The data includes three indicators of perceptions of parcel-level tenure security: (1) the perceived right to bequeath the parcel, (2) the perceived ease of renting out the parcel and (3) the perceived ease of using the parcel as collateral against a financial loan. These are all dummy variables with a value of one if the answer is in the affirmative, and zero otherwise. To utilise all the information gathered without losing too many degrees of freedom, we use Principal Components Analysis (PCA) to construct an overall indicator of tenure security: *Tenure security*. PCA is used here to

⁹ On the basis of its climatic pattern, altitude and soil type, the country is classified into five agro-ecological regions with agricultural potential declining from Region 1 to Region 5.

statistically weigh the three indicators in order to calculate an aggregate index of perceived tenure security (Jolliffe, 1986). Generally, the communal group exhibits higher levels of perceived tenure security than the FTLRP group.

This study focuses on a specific type of soil conservation structures – contour ridges. The decision to focus on contour ridges was guided not only by availability of data but also by their popularity as soil conservation technology in the study area. Initially, similar to the experiences in Kenya and Niger, the construction of contour ridges in Zimbabwe was promoted by projects and government bodies. Contour ridges are earthen ridges which continue to be widely used in southern Africa as a means of controlling soil erosion (Critchley et al., 1992). Just over 29% of the surveyed parcels had soil conservation investments in the last five years. The average area of contour ridges investments is 79.5 square metres per hectare, with significantly more investments undertaken in communal relative to resettlement areas. This is in spite of the fact that communal farmers have higher contour ridges endowments than FTLRP farmers. These descriptive statistics are in line with the hypotheses that the FTLRP has been accompanied by tenure insecurity and a reduction in soil conservation investments among its beneficiaries.

We also 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*; 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). In all PCA constructions we retained components with an eigenvalue greater than one.

Table 1: Descriptive statistics of parcel level variables

Variable	Description	Communal (n=431)	FTLRP (n=161)	t-tests	Pooled (N=592)
<i>Mode of acquisition</i>					
FTLRP	Acquired the parcel under the FTLRP (1=yes, 0=no)				0.27
Inherited	Inherited the parcel (1=yes, 0=no). The reference mode of acquisition variable	0.38			0.28
Allocation	Allocated the parcel by a traditional leader (1=yes, 0=no)	0.44			0.32
Bought	Bought the parcel (1=yes, 0=no)	0.09			0.07
Rented	Renting the parcel (1=yes, 0=no)	0.09			0.06
<i>Tenure security indicators</i>					
Bequeath	Can easily bequeath the parcel (1=yes, 0=no)	0.80	0.57	***	0.74
Rent	Can easily rent out the parcel (1=yes, 0=no)	0.26	0.22		0.25
Collateral	Can easily use the parcel as collateral (1=yes, 0=no)	0.37	0.22	***	0.33
Tenure security	Aggregate indicator of tenure security from Principal Components Analysis	0.79	0.56	***	0.72
<i>Soil conservation investments</i>					
Investment decision	Decision to construct contour ridges on the parcel in the last 5 years (1=yes, 0=no)	0.28	0.33		0.29
Investment level	Total length of contour ridges constructed in the last 5 years, in square metres per ha	91.05	48.63	***	79.51
Soil conservation endowment	Total length of contour ridges constructed more than 5 years ago, in square metres per ha	217.02	125.71	***	192.19
<i>Parcel characteristics</i>					
Parcel size	Size of the parcel, in hectares	3.56	6.38	***	4.33
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
Flat	Light slope (1=yes, 0=no). The reference slope variable	0.44	0.17	***	0.37
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
High Fertility	High fertile (1=yes, 0=no)	0.14	0.06	***	0.12
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

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)
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
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
Livestock2000	Livestock holdings in the year 2000 (in Tropical Livestock Units)	2.84	1.99	**	2.49
Communal farmer2000	Household head a communal farmer before FTLRP (1=yes, 0=no). The reference occupation of household head before FTLRP	0.96	0.40	***	0.72
Farm worker2000	Household head farm worker before FTLRP (1=yes, 0=no)	0.01	0.09	***	0.05
Non-farmer2000	Household head engaged in non-farming before FTLRP (1=yes, 0=no)	0.03	0.51	***	0.23
Extension	Whether the household has access to an extension worker (1=yes, 0=no)	0.72	0.89	***	0.79
Farming Certificate	Household has at least one member 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
Small-Scale	Number of household members involved in small-scale artisanship	1.05	0.60	***	0.86
Natural Resource	Number of household members involved in natural resource utilisation	1.18	0.62	***	0.95
Employment	Number of household members in employment	0.53	0.35	***	0.45
Trade	Number of household members involved in trade e.g. buying and reselling of goods	0.49	0.14	***	0.35
Off-farm	Principal components scores on involvement in small-scale artisanship, natural resource utilization and cross-border trade	1.67	0.86	***	1.33
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 on access 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
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 neighbours	1.08	0.91	**	1.01
Makope	Chief Makope (1=chief Makope). The reference chieftainship variable	0.30	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%.

5.2. Results from the Propensity Score Matching method

As the foregoing discussion on the econometric strategy we pursue shows, the use of the PSM method allows us an opportunity to explore how the households' characteristics predispose them for selection into the FTLRP as well as how the programme has impacted their perceived tenure security and investments in soil conservation.

We begin by investigating how the households' characteristics predispose them for selection into the programme. We do this by estimating a probit model of selection into the FTLRP on households' socioeconomic characteristics. A particular challenge given the cross-sectional nature of our data is obtaining variables that capture the situation before the start of the FTLRP. Fortunately the questionnaire had questions on livestock holdings and occupation of the household head in the year 2000. We also include education of household head, number of male and female adults, number of children, whether the household has at least one household member with a farming qualification, access to remittances and media, as well as involvement in off-farm activities. There could be concerns that the last five variables might have changed between the start of the programme and the time the data was collected. To deal with this problem, two probit models are estimated: the first includes only those variables that existed for sure at the beginning of the FTLRP, while the second model also includes variables that might have changed over the years. The ensuing discussion of the results is based on the second model, which we consider the full model.

Another concern could be the controversy regarding the selection process under the FTLRP. This might imply that we may not have been able to control for some factors such as political inclination, which has been argued to have played a role in the selection process. However, we believe that by focusing on Model A1 beneficiaries, who are fairly comparable to communal farmers, we minimise the bias especially given that the controversy surrounding the allocation of land under the FTLRP is more of a concern when it comes to commercial settlement under Model A2.

Table 3 below reports the probit results of participation, or the likelihood of being selected into the FTLRP.

Table 3: Probit estimates for selection into the FTLRP

Variable	Restricted Model		Full Model	
	Coefficient	Robust Std. Error	Coefficient	Robust Std. Error
Male	0.13	0.19	-0.24	0.24
Age in year 2000	-0.02***	0.01	-0.02**	0.01
Education	0.02	0.03	0.01	0.03
Male adults	0.03	0.04	0.15***	0.04
Female adults	-0.01	0.03	0.01	0.04
Livestock in year 2000	-0.01	0.03	-0.04	0.03
Farm worker2000	1.69***	0.38	2.12***	0.39
Non-farmer2000	2.21***	0.23	2.67***	0.32
Children			0.04	0.05
Farming certificate			0.17	0.22
Remittances			-0.85***	0.21
Off-farm			-0.64***	0.12
Media			0.76***	0.16
Constant	-0.30	-0.40	0.14	-0.48
Observations		383		383
Log-likelihood		-172.55		-129.12
Overall correct predictions (%)		81		85

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

The broad objectives of the FTLRP's Model A1 scheme are to for example decongest overcrowded communal areas, alleviate poverty within rural communities by giving them enough land for agricultural land use, and promote sustainable land use. This implies that selection into the FTLRP should favour poor households. Although the coefficient for livestock holdings is negative, it is insignificant. With livestock holdings as a proxy for wealth in this study, our results thus do not point to a systematic attempt by the government to prioritise poor households as beneficiaries of the programme.

Furthermore, the decongestion objective implies that we would expect priority to be given to communal households when it comes to selection into the FTLRP. However, contradictory to the programme's goal of decongesting communal areas, the results indicate that households in which the household head was either a commercial farm worker or engaged in non-farm activities prior to the commencement of the FTLRP were more likely to have benefited from the programme than households in which the household head was a communal farmer. While we would expect commercial farm workers to have had an advantage in taking over commercial farms given that they were already in the system, caution is called for in interpreting this finding since the data is not able to reveal whether they had any land of their own prior to the reform. The

positive effect of having a household head who was engaged in non-farm activities before the programme could be indicative of corrupt tendencies that could frustrate the programme's decongestion goal. Again there is need for caution in interpreting this finding as it is possible that those engaged in non-farm activities prior to the FTLRP were forced to do so due to landlessness.

The FTLRP's Model A1 scheme is intended to reach out to households whose livelihoods are based mainly on agriculture. Accordingly, the negative impact of involvement in off-farm activities may be evidence of some screening within the FTLRP in favour of people who depend mainly on farming for a living. This is also true for the negative coefficient for remittances. The results might also reflect the fact that households involved in off-farm activities are less likely to apply for land under the FTLRP.

Our findings suggest that efforts to increase women's access to land within the FTLRP may have been ineffective, in line with concerns posed by Goebel (2005); the more male adults in a household, the more likely it is to benefit from the FTLRP. Customarily in Zimbabwe, rights to land have been reserved for men and, thus, the more men a household has, the greater the comparative advantage with regards to land access. In addition we find that the FTLRP has tended to favour younger household heads. The significance of access to media indicates that media plays a significant role in providing detailed information on programme eligibility and the application process.

The reform has two complementary selection processes: selection of beneficiaries and selection or identification of farms or parcels to be redistributed. Both beneficiary and parcel characteristics affect observed productivity. Consequently, the propensity scores used in the matching process are based on a probit model that includes both households' socioeconomic characteristics and parcel characteristics (not reported here). These parcel characteristics include steepness of parcel, soil depth and fertility indicators and whether the parcel had soil conservation structures at the start of the programme. We also control for whether the parcel is in an area with access to extension services, distance from parcel to nearest trading town, and regional dummies. Sensitivity analysis is then used to examine how robust the treatment effects are to unobservables.

The estimated propensity scores are used to generate samples of matched FTLRP and communal areas groups using the kernel matching method. First, the results are used to calculate the impact of the programme on perceptions of tenure security. Second, as when estimating equation (3), we calculate the direct impact of the programme on the

intensity of soil conservation investments. PSM results are presented in Table 4 below. Only observations within common support are used, i.e. observations for which matches were found. ATT is the average treatment effect on the treated. The standard errors for the ATT are calculated using bootstrapping with 200 replications.

Table 4: Perceived tenure security and investment levels estimated by PSM

	Tenure Security	Investment Levels
FTLRP	0.52	54.80
Communal	0.78	83.01
Difference, ATT	-0.26**	-28.22
(Std. Error)	(0.13)	(50.38)
<i>Total number of observations</i>		
FTLRP	161	161
Communal	431	431
<i>Number of observations within common support</i>		
FTLRP	73	73
Communal	431	431

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

The results indicate that, based on household characteristics of the FTLRP beneficiaries and on parcel characteristics, a randomly chosen farmer among the programme beneficiaries perceives tenure security to be weaker by a score of about 0.26, compared to if s/he were a communal farmer. However, although the ATT for investment levels is negative, the results do not reveal a significant direct effect of the FTLRP on soil conservation investments. This does not, however, lead to the conclusion that the FTLRP has not had an impact on soil conservation investments; it could suggest that the programme has impacted soil conservation behaviour via its impact on households' perceived parcel-level tenure security. In the following section we use parametric methods to investigate this possibility.

Assessing the quality of the matching process

The PSM method conditions only on the propensity score. This necessitates the need to check whether the matching procedure is able to balance the distribution of the covariates in both the FTLRP and the communal areas groups. If differences persist even after matching, then matching on the propensity score was not totally successful. We thus perform balancing tests that examine the standardised bias for all covariates

used in the matching process. The standardised bias is defined as the difference between the sample means in the FTLRP and the matched control group subsamples as a percentage of the square root of the average of the sample variances in both groups. We also use two-sample *t*-tests to investigate the significance of the differences in the covariate means for the two groups. We do this only for perceived tenure security for which the treatment effect is significant. The results are reported in Table 5.

Table 5: Balancing tests for all matching covariates

Variable	Mean		Standardised Bias		T-test
	FTLRP	Communal	% bias	% reduction in bias	p-values
<i>Socioeconomic characteristics</i>					
Male	0.77	0.7	15.3	18.2	0.36
Age	40.84	37.57	22.6	44.8	0.11
Education	8.33	9.24	-27.2	14	0.13
Male adults	1.82	1.86	-2.3	76.9	0.86
Female adults	2.36	1.86	19.6	-43.8	0.11
Children	2.71	3.01	-16.3	-294.8	0.30
Livestock	2.57	3.04	-14.4	61	0.39
Farming certificate	0.19	0.11	20.2	-75.3	0.14
Remittances	0.25	0.23	3.3	92.5	0.83
Off-farm	1.12	1.23	-10.9	86.2	0.41
Media	0.92	0.91	1.1	98.1	0.95
Extension	0.88	0.83	12.6	65.3	0.43
Social capital	0.88	0.96	-10.2	65.9	0.55
Farm worker2000	0.03	0.004	10.5	69.4	0.26
Non-farmer2000	0.19	0.14	14	89.1	0.40
<i>Parcel characteristics</i>					
Size	6.70	8.18	-40.2	47.6	0.11
Size squared	74.17	99.13	-16.1	14.3	0.53
Steep slope	0.14	0.07	22	-310.3	0.18
Moderate slope	0.69	0.77	-17.9	71.1	0.25
Deep soils	0.25	0.20	11.3	-1109.1	0.47
Moderately deep soils	0.66	0.75	-18.5	61	0.24
High fertility	0.06	0.03	8.4	69.5	0.46
Moderate fertility	0.48	0.59	-23.1	-426	0.17
Soil conservation endowment	138.55	168.9	-12.6	66.8	0.33
Chiweshe	0.26	0.33	-15.6	80.3	0.38
Negomo	0.56	0.49	14.4	58.7	0.39

As the results indicate, the reduction in the standardised bias is substantially reduced after matching. Moreover, the test of the null hypothesis of *no* significant differences after matching cannot be rejected at 10% for any of the variables. This suggests that the propensity score is balanced for each covariate between the two subsamples.

Sensitivity analysis

Given that the PSM method we use is based on observable characteristics, it could be the case that there are unobservable characteristics affecting assignment into the FTLRP and the outcome variable simultaneously, i.e. there could be a hidden bias to which matching estimators are not robust. As discussed earlier, we address this problem by using the bounding approach proposed by Rosenbaum (2002) with the help of an add-on provided by DiPrete and Gangl (2004), which allows us to test sensitivity for continuous-outcome variables. Using the Rosenbaum bounds, by selecting a number of values of the odds that matched pairs may differ in their probability of treatment due to differences in unobservables (i.e. $\exp(\gamma)$ values), we can tell at what point the treatment effect becomes insignificant. Table 6 presents the results of this analysis.

Table 6: Rosenbaum bounds

$\exp(\gamma)$ values	Upper bound significance level	Lower bound significance level	Upper bound Hodges- Lehman point estimate	Lower bound Hodges- Lehman point estimate	Upper bound confidence interval	Lower bound confidence interval
1	0.000	0.0001	-0.30	-0.30	-0.43	-0.16
1.5	2.7e-08	0.008	-0.40	-0.20	-0.53	-0.04
2	1.1e-11	0.07	-0.46	-0.12	-0.60	0.06
2.25	2.1e-13	0.14	-0.49	-0.09	-0.63	0.1
3	0	0.43	-0.56	-0.01	-0.70	0.19

The results reported in Table 6 suggest that the unobserved effect would have to increase the odds of benefiting from the FTLRP by at least 100% before it would change the conclusion that the FTLRP leads to a 0.262 reduction in the perceived tenure security score. Using the Hodges-Lehman point estimates, the results indicate that at $\exp(\gamma) = 2$, the estimated treatment effect may be as high as 0.458 or as low as 0.12, and the upper bound estimated treatment effect is significant at 10%. While there is no definitive answer to what constitutes a small or large odds ratio, an odds ratio of 2 implies that the postulated unobservable effects would have to be considerably large to cast doubt on the treatment results.

5.3. Results from the Instrumental Variable estimations

This section presents the results from the Instrumental Variable estimation of the FTLRP's impact on perceived tenure security and subsequently on households' investments in soil conservation. Instrumental variable estimations are employed to deal with the causality problem between tenure security and investment decisions. Perceived tenure security is assumed to be endogenous, i.e. tenure security may depend on soil conservation investments and vice versa. The modes of acquisition are used as instruments for perceived tenure security, with acquisition via the FTLRP as one of them. Table 7 reports the results from (1) the first stage OLS estimation of perceived tenure security; (2) the second stage IV-Probit estimation of the households' decision to invest in soil conservation; and (3) the second stage IV-Tobit estimation of the intensity of investments.

The main finding is that perceived tenure security is endogenous both in the decision to invest and in the intensity of the investments. However, it has a positive and significant impact only on the intensity of investments while it has no significant effect on the decision to undertake investments. We also perform a Wald test of exogeneity of perceived tenure security and find it to be rejected at 10% and 5% levels of significance in the IV-Probit and IV-Tobit estimations, respectively, justifying the use of IV-Probit and IV-Tobit instead of the standard Probit and Tobit estimators. This suggests that households invest in land-related investments to enhance security of tenure, consistent with Besley (1995) and Deininger and Jin (2006). Hence it is implied that tenure security should be understood as something that farmers believe they can affect and that is not exogenously given, emphasising the need to understand the determinants of perceived tenure security instead of focusing solely on its consequences. Our findings indicate that the impact of improved tenure security on farm investments can be enhanced by coordinating policies that aim at improving property rights systems with complementary policies that support well-functioning capital and asset markets. Such policies would allow households to focus primarily on productivity-enhancing investments.

We investigate the validity of the instruments using the Amemiya-Lee-Newey test of over-identifying restrictions (Baum et al., 2006). The test fails to reject the null hypothesis of validity of dummies for different modes of acquiring the parcel as instruments for perceived tenure security, making their use as instruments acceptable.

Table 7: Two-stage Least Squares Probit and Tobit models with endogenous regressors

Variable	First Stage: Tenure Security		Probit: Decision to Invest		Tobit: Investment Levels	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
<i>Mode of acquisition and tenure security</i>						
Tenure Security			0.51	0.36	286.92**	129.55
FTLRP	-0.38***	0.07				
Allocation	0.003	0.05				
Bought	-0.06	0.08				
Rented	-0.62***	0.08				
<i>Socioeconomic characteristics</i>						
Male	0.02	0.05	0.23	0.16	104.72*	58.18
Age	-0.001	0.001	0.004	0.01	1.65	1.61
Education	0.01	0.01	0.01	0.02	-3.13	8.08
Male adults	-0.02*	0.01	0.02	0.04	-2.10	16.10
Female adults	0.02*	0.01	0.01	0.03	2.37	9.28
Children	-0.03***	0.01	-0.01	0.04	5.44	13.57
Livestock	-0.0002	0.01	0.03	0.02	8.05	6.04
Farming certificate	0.13***	0.04	0.03	0.15	-27.13	53.47
Remittances	-0.06	0.04	-0.16	0.13	-47.71	47.43
Off-farm	-0.01	0.02	-0.04	0.06	-11.52	21.30
Media	-0.07**	0.03	-0.01	0.11	7.15	40.43
Extension	0.12**	0.05	0.02	0.16	15.06	58.94
Social capital	0.06**	0.03	0.02	0.09	-8.82	31.58
Farm worker2000	0.07	0.10	0.39	0.32	129.55	111.06
Non-farmer2000	0.10	0.06	-0.24	0.19	-97.92	69.05
Chiweshe	-0.05	0.06	-0.50**	0.20	-172.03**	73.99
Negomo	-0.07	0.05	-0.24	0.16	-83.12	57.62
<i>Parcel characteristics</i>						
Parcel size	0.02**	0.01	0.22***	0.05	45.17***	17.19
Parcel size squared	-0.001**	0.0003	-0.01***	0.003	-2.14**	0.96
Steep slope	0.09	0.06	0.24	0.21	66.83	77.39
Moderate slope	-0.05	0.04	0.46***	0.15	171.19***	52.31
Deep soils	0.11*	0.06	-0.68***	0.19	-241.41***	69.97
Moderately deep soils	0.08	0.05	-0.30*	0.17	-94.98	59.66
High fertility	0.05	0.06	0.14	0.20	35.16	70.10
Moderate fertility	-0.02	0.04	0.07	0.13	27.13	46.74
Soil conservation endowment	-0.00004	0.0001	-0.0003	0.0003	-0.23**	0.11
Constant	0.72***	0.13	-1.79***	0.53	-571.80***	194.96
Observations		592		592		592
Uncensored Observations						174
R-squared		0.22				
Model Wald Chi2 (27)				70.42		51.47
Exogeneity test (p-value)				0.086		0.016
Amemiya-Lee-Newey Over-identification test (p-value)				0.684		0.725

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

Fast Track Land Reform and tenure security

The results reveal a highly significant and negative impact of the FTLRP on perceptions of tenure security, consistent with the *a priori* hypothesis. This could be due to the fact that the FTLRP has been carried out at an accelerated pace which has overridden legal procedures, thereby raising tenure insecurity among its beneficiaries. Moreover, since the introduction of the FTLRP, the government's policy and stated aims in relation to redistribution and land occupations have repeatedly changed, further fuelling tenure insecurity. In addition, the use of different laws, inauguration of different administrations, and institution of different policies – creating multiple tenure systems – has spawned grounds for conflict which has further contributed to tenure insecurity (Munyuki-Hungwe and Matondi, 2006). Farmers also feel less secure about parcels they rent compared to parcels acquired through inheritance. This reflects the uncertainty of tenure that apparently accompanies rented parcels. These results are worrisome, as tenure insecurity might have adverse implications on planning horizons and consequently agricultural productivity.

In Zimbabwe, as in most patriarchal societies in Africa where limited resources makes society prioritise the education of men rather than women, men are more connected to the wider events of the country, hence more informed and thus more concerned with the general instability in the agricultural and political scenes. The finding that perceived tenure security declines with the number of male adults in a household indicates that this apparently translates into lower perceived tenure security. Conversely, the more female household members a household has, the higher the levels of perceived tenure security. The labour constraints imposed by an extra child in the household are reflected by the finding that the more children a household has, the lower the perceived tenure security. Having many children is demanding in terms of labour hours spent child rearing, which obviously implies less time spent monitoring parcels.

Given that one of the criteria the government uses in selecting people for resettlement within the FTLRP is farming experience or knowledge, we would expect households with at least one household member with a farming qualification to feel more secure. So, the results here are as expected. Access to media is associated with lower levels of tenure security. This could reflect the fact that access to media makes the household more aware of the manner of the reform process and the ongoing debates on the

government's ever-changing policies that might make households uncertain about their security of tenure.

Access to extension workers improves perceived tenure security. A possible explanation for this result is that extension workers in Zimbabwe are sometimes seen as an institution that not only disseminates information to farmers but also helps resolve agriculture-related disputes if the need arises. Hence, the presence of agricultural extension workers could in principle make households feel more protected and thus more tenure secure. Social capital strengthens tenure security. Having more community ties assures the household of support from neighbours in case there is a need to defend land rights. Thus, a household with strong ties with the neighbours generally feels more secure.

Interestingly, equity considerations might make households feel that excessive or large parcels relative to others make them a likely target of acquisition of land for redistribution. This is supported by the finding that perceived tenure security increases with size but only up to a certain threshold; i.e. parcel size is concavely associated with perceived tenure security. However, since the threshold is around 21 hectares and 99% of all parcels are below this size, we can argue that perceived tenure security increases with parcel size. This together with the finding that tenure security increases with soil depth, one of the indicators of good parcel quality, implies that having high quality parcels could also be confounded with other qualities that capture the unobserved relative social power of the household. Socially powerful households obtain higher quality parcels and naturally have higher perceived tenure security than less socially powerful households.

Fast Track Land Reform and the decision to invest in soil conservation

The results reveal no significant impact of perceived tenure security on the likelihood to invest in soil conservation technology.

The significance of regional dummies points to the importance of location-specific determinants or deterrents of adoption of soil conservation technology. In particular, the results suggest that households under the chieftainship of Chiweshe are less likely to have invested in soil conservation than households under Chief Makope.

As expected, households are more likely to build contour ridges on larger parcels, consistent with Holden and Yohannes (2002) and Hayes et al. (1997). Contour ridges compete for space with regular crops; thus, the bigger the parcel the easier it is for the household to have contours and still have some space left for regular crops. However, the marginal effect declines with size. Steepness of a parcel affects the decision to construct conservation structures positively, with moderately steep parcels being more likely to have investments compared to those with a low slope, consistent with Gebremedhin and Swinton (2003). Soil depth impacts the likelihood of investing negatively. This is intuitive given that one main objective of soil conservation structures is to conserve soils, which is of less concern when soils are perceived to be deep.

Fast Track Land Reform and the intensity of soil conservation investments

The objective of the empirical analysis has been to investigate whether the FTLRP has had, via its impact on perceived tenure security among its beneficiaries, any impact on soil conservation investments. We find evidence that perceived tenure security has had a positive impact on the intensity of investments among its beneficiaries, consistent with Besley (1995) and Holden and Yohannes (2002) who found a positive and significant role of tenure security in promoting land-related investments. This, together with the first stage results which suggest that FTLRP program beneficiaries feel less tenure secure than communal farmers who inherited their parcels, lends support to the *a priori* hypothesis that the FTLRP impacts soil conservation investments negatively via its negative impact on perceived tenure security. This adverse effect could partly explain the decline in agricultural production following the launch of the programme.

Our results help shed light on the implications of gender on soil conservation investments. In particular, we find that male-headed households undertake more investments than female-headed households, consistent with Holden and Yohannes (2002). Construction of contour ridges requires manual labour and having a male household head makes it easier for households to commit to such projects. It is also relatively easier for male heads to organise more male labour to help with construction of contours. This implies that policies that seek to encourage investments in soil conservation should be gender-sensitive.

With regards to parcel characteristics, we find, consistent with Gebremedhin and Swinton (2003), a convex association between parcel size and investment levels. This could be indicative of possible diminishing marginal returns to contour ridges. The result also suggests that households with smaller parcels might be more likely to practice agricultural intensification and, therefore, construct more contour ridges to increase agricultural productivity. Households tend to invest more on moderately steep parcels compared to those with a low slope. This is intuitive since steeper slopes are more prone to erosion. In the same vein, parcels with deep soils indicate that soil erosion is of less concern, and subsequently less soil conservation structures are needed on them than on parcels with shallow soils. Intensity of investments decreases with level of initial endowments of conservation structures, reflecting possibly declining marginal returns to contour ridges.

The significance of regional dummies points to the importance of location-specific determinants of investments, with households under the chieftainship of Chiweshe investing less than households under Chief Makope.

In sum, the results suggest that parcel characteristics, along with perceived parcel-level tenure security, are more important than socioeconomic characteristics in determining both the decision to invest as well as the intensity of the investments.

6. Conclusions and policy implications

This paper seeks to contribute to the literature that assesses empirically the impact of land reforms. It does this by providing micro-evidence of the impact of the most recent phase of Zimbabwe's land reform programme, the Fast Track Land Reform Programme (FTLRP), on its beneficiaries' perceived tenure security and subsequent decisions to invest in soil conservation. In so doing we employ both semi-parametric and parametric econometric methods, permitting us to: (1) explore how household characteristics predispose households for selection into the FTLRP, (2) assess the difference in perceptions of land tenure security between beneficiaries of the FTLRP and communal farmers and (3) explore how these differences affect investments in soil conservation. In addition, our strategy allows us to overcome the problems arising from the potential endogeneity of perceived tenure security with soil conservation investments.

The results provide evidence that the programme has created some tenure insecurity among its beneficiaries, and this in turn has had an adverse impact on investments in soil conservation. The analysis suggests that the programme might have failed to offer security of tenure necessary for the long-term planning horizons of its beneficiaries. The results, thus, underscore the need for the government of Zimbabwe to restore confidence and credibility in the agricultural property rights system. As a start, the government is recommended to clarify and formalise tenure arrangements within the FTLRP. This, together with a commitment towards respecting property rights in general, might go a long way in enhancing perceived tenure security and encouraging on-farm investments.

In addition, our results indicate that households undertake investments in soil conservation not only to enhance productivity but also to establish and/or enhance security of land tenure. This implies that policies that seek to improve the positive impact of tenure security on farm investments should be formulated from analyses that consider tenure security as endogenous. Furthermore, as Antle et al. (2003) argue, such policies should be accompanied by complementary policies such as improved legal institutions and other policies needed to support well-functioning capital and asset markets. This would allow households to focus primarily on productivity-enhancing investments. This further reinforces the need for the government of Zimbabwe to prioritise the formulation and implementation of policies that clarify and formalise tenure arrangements within the FTLRP.

It is important to emphasise that formalisation of tenure arrangements without a commitment to respect property rights in general or without policies that guarantee the government's preparedness to respect tenure arrangements, will amount to what Bromley (2000, p.2) likens to 'governments issuing counterfeit currency', i.e. tenure arrangements are meaningless without the full support of the issuing entity – the government. Furthermore, for tenure arrangements to affect outcomes such as on-farm investments effectively, they should be connected to wider policies that for example increase access to credit.

Future research investigating whether soil conservation technology enhances productivity in the study area is needed, as this plays an important role in investments decisions. Furthermore, the positive impact of perceived tenure security on soil conservation investments suggests that there are still policy gains to be made from revisiting the issue of land tenure security and investments in Africa.

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Paper II

Fast Track Land Reform and Agricultural Productivity in Zimbabwe

Precious Zikhali¹

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

$$Yield_j = f(R_j, X_j) , \quad (1)$$

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:

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

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:

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

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)
<i>Mode of acquisition</i>					
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
<i>Production</i>					
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
<i>Inputs</i>					
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
<i>Parcel characteristics</i>					
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%.

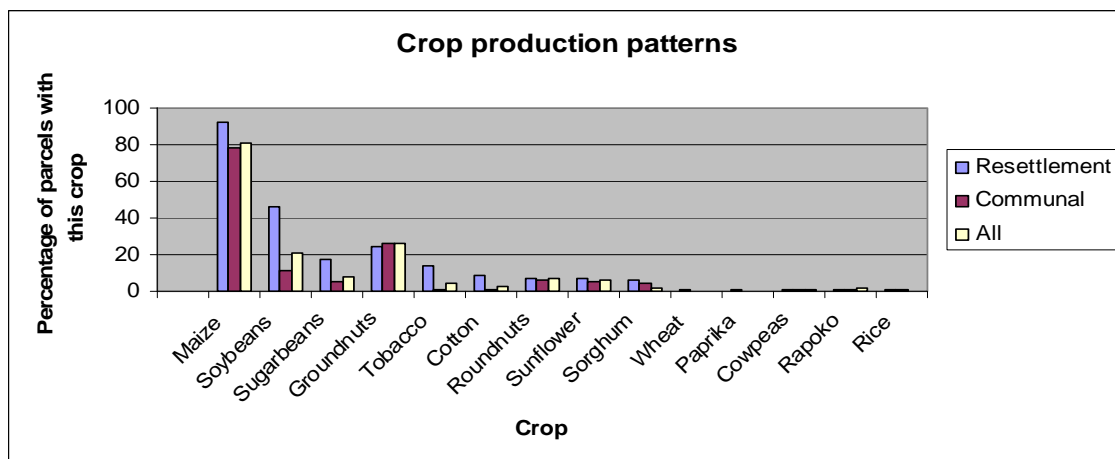
Table 2: Descriptive statistics of household level variables

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 20000ZMW\$ (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
Makepe	Chief Makepe (1=Chief Makepe). 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

Variable	OLS (1)		OLS (2)		2SLS (3)	
	Coeff.	Robust Std. Error	Coeff.	Robust Std. Error	Coeff.	Std. Error
<i>Mode of acquisition</i>						
FTLRP	1.47***	0.16	0.35	0.62	-0.10	0.73
<i>Inputs</i>						
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
<i>Inputs interacted with FTLRP</i>						
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
<i>Exogenous parcel characteristics</i>						
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:

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

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

Variable	Probit: <i>Fertiliser decision</i>		Tobit: <i>Fertiliser</i>	
	Coeff.	Robust Std. Error	Coeff.	Robust Std. Error
<i>Mode of acquisition</i>				
FTLRP	0.64**	0.27	1.39***	0.31
<i>Socioeconomic characteristics</i>				
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
<i>Parcel characteristics</i>				
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 Revolution⁷ 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

⁷Green 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-win 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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Paper III

Does Ethnicity Matter for Trust? Evidence from Africa

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This paper proposes that ethnicity coupled with ethnic nepotism may reduce interpersonal generalised trust. We use the 2001 wave of the World Values Survey data for eight African countries to test this claim, and show that while ethnicity and ethnic nepotism are each important in affecting generalised trust levels, their interaction has a self-reinforcing and negative effect on trust levels. The results underscore the importance of institutions in controlling ethnic nepotism and thus partly in mitigating the adverse effects of ethnicity on trust.

JEL classification: D02, Z13

1. Introduction

Generalised interpersonal trust plays an important role in shaping economic and social outcomes. Generalised trust is a reflection of the 'bond that people share across a society and across economic and ethnic groups, religions, and races' (Rothstein and Uslaner, 2005, p. 45). It eases exchange without a need for a strict means of enforcement and thus reduces transaction costs (Zak and Knack, 2001), promotes investment efficiency and is the foundation of cognitive social capital which has been argued to be important in a country's institutional and economic development (Knack and Keefer, 1997). In particular, Zak and Knack (2001) and Knack and

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Keefer (1997) show that a one-standard deviation increase in the trust index raises economic growth by more than one-half of a standard deviation. Reid and Salmen (2000) find that trust is a key determinant of the success of agricultural extension in Mali. Another case study by Fafchamps and Minten (2001) suggests that cognitive social capital, in the form of trust emanating from personal contacts, increases incomes of agricultural traders and their families.

In ethnically diverse societies, however, generalised interpersonal trust appears to be low compared with in homogenous societies. Using data from US localities, Alesina and LaFerrara (2000) find that racially diverse communities experience lower levels of trust than homogenous ones, which reduces the efficiency of public service delivery. This is further echoed by Lassen (2003), who shows that ethnic diversity decreases tax compliance by reducing trust levels, and thus frustrates public sector performance. According to Zak and Knack (2001), the main argument for this inverse relationship between interpersonal trust and social distance is that when people share the same ethnic background, their social distance is reduced and thus trust is strengthened. This argument gains particular relevance in African countries as they have among the highest levels of ethnic diversity in the world. Collier (1998) shows empirically that high ethnic diversity lowers the level of trust, although his measure of ethnic fractionalisation is only marginally significant.

Long before ethnic diversity was introduced into the economics discipline, Marcson (1945) noted that ethnic diversity leads to antipathy between unlike groups. He argued that antipathy is socially conditioned. Unlike groups may coexist either in harmony or conflict depending on the initial social stimuli specific to the groups as opposed to individual experiences. This suggests that the group to which an individual belongs influences his/her identity formation and hence his/her trust behaviour.

Furthermore, when people associate themselves with a certain group, ethnic or non-ethnic, and limit their interaction within that particular group, they may develop particularised trust for that group. Particularised trust implies 'deeper ties to a closer circle such as family members, friends, and others with similar background' (Bahry *et al.*, 2005). Interestingly, such behaviour can have a negative bearing on generalised trust; the overall levels of

trust in society decline as trust becomes particularised, i.e., limited within a specific group. This is what is referred to as a 'similarity argument' in the social trust literature. People develop trust among themselves on the basis of their similarity.

It is important to note that a high level of particularised trust may not necessarily lead to low levels of generalised trust, as it is possible to have high particularised and generalised trust simultaneously (Bahry *et al.*, 2005). Given tension- and domination-free relationships among different ethnic groups, trust among different ethnic group members could flourish, suggesting the presence of both high particularised and generalised trust levels. On the other hand, tensioned ethnic relationships discourage generalised trust in favour of particularised trust. Ethnic nepotism is one of the most important causes of tensioned ethnic relationships; its prevalence may create an environment marred by suspicion among individuals, which in turn may reduce generalised trust levels.

Ethnic nepotism is a form of extended nepotism that capitalises on the divisions of people into separate ethnic groups based on race, nationality, language, tribe, religion or caste. Evolutionary theories of inclusive fitness and kin selection postulate that members of an ethnic group favour their group members over non-members because they are more related to their group members than to outsiders (Vanhanen, 1999; Silverman and Case, 2001). This disposition to favour kin over non-kin becomes important especially when people or groups of people have to compete for scarce resources.

Ethnicity, defined as associating oneself with a certain ethnic group as opposed to the society as a whole, and ethnic nepotism may reduce generalised trust levels. However, it is important to recognise the bi-directional relationship between the two. For instance, ethnicity may lead to ethnic nepotism when people organise themselves along ethnic lines and compete with others to get more resources. It is also possible that ethnic nepotism fuels ethnicity as disadvantaged or discriminated ethnic group members associate themselves more with their ethnic groups. Ethnicity and ethnic nepotism may, thus, be self-reinforcing. This makes it difficult to identify whether the effect on trust is due to ethnicity or ethnic nepotism alone or to both.

Ethnic nepotism could also lead to other forms of nepotisms such as corruption, political injustice and rising income inequality.

You (2005) uses these as 'fairness' indicators in explaining social trust, using data from the World Values Survey (WVS). His results suggest that these factors significantly reduce social trust. In addition, Rothstein and Uslaner (2005) show that economic equality and equality of opportunities are important foundations for building social trust. Ethnic nepotism is a potent force in eroding these foundations and therefore in eroding generalised trust.

Using WVS data for eight African countries, this paper examines whether ethnicity and ethnic nepotism affect generalised interpersonal trust. Our contribution to the social trust literature could be seen from at least two perspectives. First, while country-level ethnic diversity data are used in most of the previous studies, we use an attitudinal definition and measurement of ethnicity at the individual level. Hence, we can identify the association between ethnicity and generalised trust at the individual level. Second, we use country-level data on ethnic nepotism. This is particularly important given our focus on African countries where politics is run mainly along ethnic lines and hence ethnic nepotism could be more of a norm than an exception.

We argue that ethnicity lowers trust levels in the sense that the more people identify themselves with a subset of a society instead of with the society as a whole,¹ the lower the generalised trust levels in that particular society. However, we recognise that ethnicity *per se* may not have an impact on interpersonal trust in situations where ethnic nepotism is not a problem. We therefore posit that ethnicity coupled with ethnic nepotism could reduce generalised interpersonal trust.

Our results show that ethnicity constitutes a potent force in attenuating trust levels. Our results also show that the presence of ethnic nepotism may propagate the adverse effects of ethnicity on trust levels. The implication of our findings is that policy interventions that reduce the extent of ethnic nepotism could be an important instrument in minimising the adverse effects of ethnicity on trust. As such, the implication of our finding is consistent with an argument raised by Johnson (2005) where constitutional and fundamental organisational reforms are pointed out as viable long-term solutions in managing the undesirable outcomes of ethnicity.

¹ In this case, an ethnic group could be tribal or racial depending on the most natural and convenient definition in that particular country. And the whole society is represented by country in our analysis.

The following section briefly describes the data and provides some descriptive statistics. The estimation framework and results are discussed in Section 3. Section 4 concludes the paper.

2. Data and Descriptive Statistics

This paper uses attitudinal measures of trust and ethnicity for eight African countries from the 2001 wave of the WVS. The existing literature in the case of Africa uses indices of ethnic heterogeneity, measured nationally to capture ethnicity while the trust levels are captured at the individual level (see, for example, Collier, 1998). In contrast, this paper attempts to analyse how ethnic inclinations at the personal level affect trust levels, also at the personal level. This is important, as ethnicity and ethnic heterogeneity are different concepts; i.e., ethnically homogenous countries could show high ethnicity and vice versa. For instance, in our sample of countries, Egypt and Tanzania present these patterns. While Egypt is relatively ethnically homogenous, it scores the highest in terms of our ethnicity indicator. On the other hand, though Tanzania is highly ethnically fractionalised, it has one of the lowest proportions of respondents identifying themselves with a certain ethnic group compared with the country as a whole.

The concept of ethnic group and thus ethnic identity is such that there can be many ways to specify ethnic groups in a country (Fearon, 2003). Ethnic identity is not exclusively racial, cultural, religious or even political. Instead, it is best understood as a dynamic, constantly evolving property of both individual identity and group organisation. While ethnicity can be viewed as a product of actions undertaken by ethnic groups as they shape and reshape their self-definition and culture, it is also framed by external social, economic and political processes and actors as they shape and reshape ethnic categories and definitions (Nagel, 1994). In this paper we define ethnicity at the personal level as a case where an individual identifies him/herself with a subset of a society instead of the society as a whole. Helliwell (1996) and Bahry *et al.* (2005) use similar ways of defining ethnicity in studying the cases of the USA and Canada, and Russia, respectively.

In the WVS, respondents were asked whether they identified themselves primarily as nationals and secondarily as members of some ethnic groups. For example, respondents in South Africa

could choose between identifying themselves as 'Zulu (a local tribe there) before being South African' or as a 'South African first'. We argue that an individual who best describes him/herself as a Zulu (or any of the other tribes or ethnic groups) before being South African has an ethnic orientation, and we construct a dummy variable to capture this. Our measure of ethnicity can best be interpreted as ethnic identity. It captures how individuals describe and hopefully feel about themselves. In this sense, our measure of ethnicity is close to what Fearon and Laitin (2000) refer to as a social category that an individual either takes a special pride in or views as a more-or-less unchangeable and socially consequential characteristic.

The use of the WVS trust questions is not without scrutiny, however. One problem is the difficulty in interpreting the responses. Variations in responses may arise because of 'differences in beliefs about the trustworthiness of a common set of people; differences in interpretation of who comprises "most people"; differences in interpretation of what it means to be able to trust someone; or differences in the ability to elicit trustworthy behavior from other people' (Glaeser *et al.*, 2000, p. 815). The second problem is the warm glow effect; i.e., respondents may respond positively to the trust questions while their actual behaviours indicate something different (Alesina and La Ferrara, 2000). This may lead to an upward bias in measuring trust. However, this does not seem to be a problem in our sample, as only about 20% of the respondents responded affirmatively. In addition, measurement errors in our trust variable may not bias our results, assuming that the errors are not correlated with the explanatory variables. Under this scenario, measurement errors may lead to the loss of efficiency without biasing the estimates.

Glaeser *et al.* (2000) raise another problem in the use of the WVS trust question. In their experimental study, they found that positive responses for the trust attitude questions are correlated more with being trustworthy than with a trusting behaviour. This points to the divergence between a trusting attitude and behaviour. They conclude that such questions are more suitable to capture the overall trustworthiness in a society than to predict an individual's level of trust. As such, the WVS trust questions may only show trust attitudes, which may be different from trust behaviour. However, the overall trustworthiness in the society could affect

trusting behaviour, i.e., when fewer people are trustworthy, fewer people would be trusting (Hardin, 1992, cited in Knack and Keefer, 1997). Nevertheless, the WVS is the best available data on trust in the context of African countries. We thus proceed using the attitudinal measure of trust as the best indicator of trust behaviour.

2.1. Descriptive Statistics

African countries are the most fragmented societies in the world, especially when using the concept of Ethno-Linguistic Fractionalization (ELF), which measures the probability that two randomly selected individuals in a given country will not belong to the same ethno-linguistic group (Easterly and Levine, 1997). The sample contains both Egypt, one of the least fractionalised countries in Africa with an ELF of 0.04, and Tanzania, the most fractionalised with an ELF of 0.93. At the same time, we have countries with moderate ELF indices (about 0.5): Zimbabwe with 0.54, South Africa with 0.49 and Morocco with 0.53. All the countries in the sample have ethnic minorities as captured by ELF indices greater than zero for all eight countries. Just over half the countries in the sample have English as the official language (Nigeria, Tanzania, Uganda, South Africa and Zimbabwe), while the rest use Arabic. Similarly, just over half of the countries have a predominantly Muslim population (Algeria, Morocco, Egypt, Tanzania and Nigeria), while the rest have predominantly Christian populations. In terms of race, just over half are predominantly black African (Nigeria, South Africa, Uganda, Tanzania and Zimbabwe), while the rest are Arab nations. Table 1 presents descriptive statistics of all the variables used in the ensuing econometric analysis.

Almost half of the respondents are male and about 44% are Muslim. The overall picture is that attitudinal trust levels are low in Africa, with more than half of the countries having less than 20% of the respondents believing that most people can be trusted. However, 72% identify themselves with an ethnic group before the nation as a whole, revealing high levels of ethnicity or ethnic identity as we define it here.

Figure 1 gives an overview of the relationship between the trust and ethnicity variables across the eight countries. The overall picture is that attitudinal trust levels are low in Africa, with more

Table 1: *Descriptive Statistics*

Variables	Description	Mean	Standard deviation
Dependent variable			
Trust	Generalised trust (1 = if respondent thinks most people can be trusted, else = 0)	0.2036	0.4027
Socio-economic			
Ethnicity	Ethnic identity (1 = if respondent identifies herself with an ethnic group first, else = 0)	0.7267	0.4457
Married	Marital status of the respondent (1 = married, else = 0)	0.0325	0.1773
Education	Years of formal education	3.5544	2.211
Age	Age of respondent	35.2536	13.8899
Sex	Sex of respondent (1 = male, 0 = female)	0.4917	0.4999
Protestant	Whether the respondent is a protestant or not (1 = if protestant, else = 0)	0.2342	0.4235
Orthodox	Whether the respondent is orthodox or not (1 = if orthodox, else = 0)	0.0345	0.1824
Catholic	Whether the respondent is Catholic or not (1 = if Catholic, else = 0)	0.0767	0.2661
Evangelist	Whether the respondent is evangelist or not (1 = if evangelist, else = 0)	0.0335	0.18
Muslim	Whether the respondent is Muslim or not (1 = if Muslim, else = 0)	0.4425	0.4967
No religion	Whether the respondent belongs to no religious denomination or not (1 = no religious denomination, else = 0). Used as a reference group here.	0.0248	0.1554
Low class	Lower income class (1 = if lower income class, else = 0).	0.3616	0.4805
Middle class	Middle income class (1 = if middle income class, else = 0). Used as a reference group here.	0.3026	0.4594

Upper class	Upper income class (1 = if upper income class, else = 0)	0.3358	0.4723
Language at home	Whether the respondent speaks the country's common language at home (1 = yes, 0 = no)	0.6514	0.4765
Town size	Size of the town the respondent lives in (in terms of population)	2.9616	1.6096
Fractionalisation Indices ^a			
Ethnic fractionalisation	Ethnic fractionalisation	0.5588	0.2584
Linguistic fractionalisation	Linguistic fractionalisation	0.5723	0.3321
Nepotism indicators			
Interest	Whether the respondent feels that the country is being 'run by a few big interests' or 'run for all people' (1 = run by a few big interest, 0 = otherwise)	0.6799222	0.466525
Ethnic nepotism ^b	Score of the prevalence of ethnic institutional conflict	35.8753	29.3246

^aAlesina, *et al* (2003).

^bVanhanen (1999).

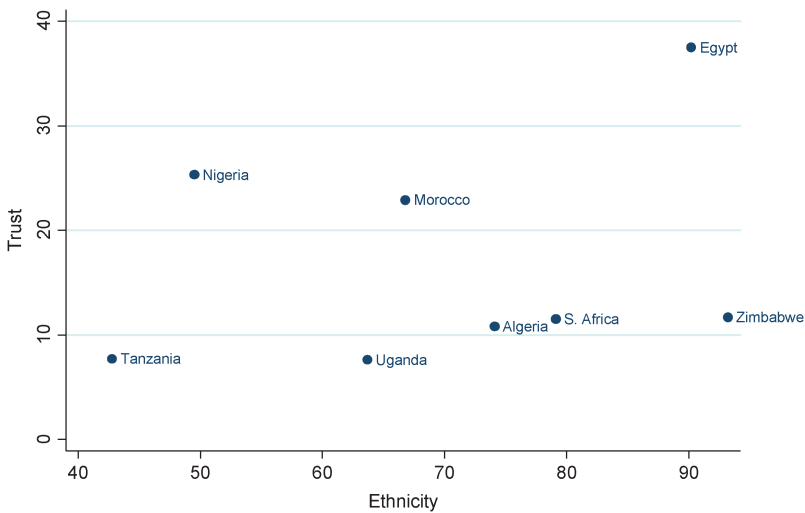


Figure 1: *Trust and Ethnicity*

than half of the countries having less than 20% of the respondents believing most people can be trusted. Egypt has the highest percentage, while Uganda has the lowest. An interesting observation is that the predominantly Muslim countries Algeria, Egypt, Morocco and Nigeria have higher trust levels compared with the predominantly Christian countries Uganda, South Africa and Zimbabwe.

Table 2 shows each country's interpersonal trust level and perception of ethnic identity (ethnicity), as well as an objective measure of the country's level of ethnic fractionalisation. The measure of ethnic fractionalisation is from Alesina *et al.* (2003).

Ethnicity is of strongest concern in Zimbabwe, where about 93% of the respondents identify themselves first with an ethnic group and then with the country, while Tanzania, at 43%, shows the least concern about ethnic affiliations. Egypt, on the other hand, presents an interesting case: it has considerably strong concerns for ethnicity yet the highest level of trust. At a glimpse, this could suggest that the role of ethnicity in explaining trust is insignificant. This observation can also be arrived at when we consider the case of Tanzania, which has the least concern for ethnicity but the lowest trust levels.

The puzzle presented by Egypt and Tanzania could indicate the presence of other mechanisms influencing the impact of ethnicity

Table 2: *Trust, Ethnicity and Ethnic Fractionalisation*

Country	Trust	Ethnicity	Ethnic fractionalisation
Egypt	37.5	90.2	0.18
Nigeria	25.3	49.5	0.85
Morocco	22.9	66.8	0.48
Zimbabwe	11.7	93.2	0.39
South Africa	11.5	79.1	0.75
Algeria	10.8	74.1	0.34
Tanzania	7.7	42.8	0.74
Uganda	7.6	63.7	0.93

on trust. We argue that institutions are one such mechanism, and we single out the presence of ethnic nepotism in particular. Thus, in the case of Egypt, it is possible that ethnic nepotism (presence or absence of it) may affect the relationship between trust and ethnicity. In Section 3, we attempt to address this issue by controlling for the presence (or absence) of ethnic nepotism as proxied by Vanhanen’s (1999) measure of institutional ethnic conflict.

As a precursor to our empirical analysis, Figure 2 presents the Lowess estimates of trust and institutional ethnic conflict where the latter variable is used as an indicator of ethnic nepotism.

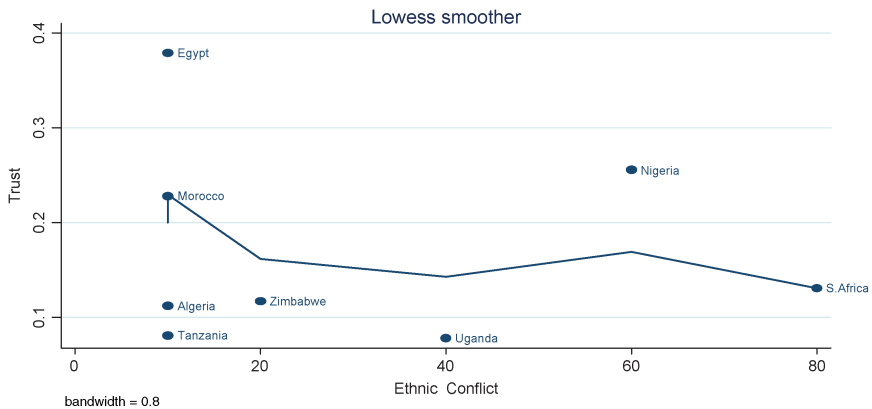


Figure 2: *Trust and Institutional Ethnic Conflict*

Though the number of observations is too small to give a robust interpretation of the Lowess estimates, the figure shows an inverse relationship between trust and ethnic nepotism. In countries where ethnic nepotism is prevalent as measured by the institutionalised ethnic conflict (e.g., South Africa), the trust levels appear to be lower.

Table 2 reveals another interesting pattern. The low-trusting countries Tanzania, Uganda and South Africa are highly ethnically fractionalised, while the relatively ethnically homogenous countries Egypt and Morocco are among the most trusting. However, Nigeria and Algeria are anomalies for this classification, as the former is highly ethnically fractionalised and has the second most trusting respondents, while the latter is among the least ethnically fractionalised but has one of the lowest proportions of trusting respondents.

We used a non-parametric smoothing method to further explore this relationship using the data at the individual level. The result of the Lowess smoothing is shown in Figure 3. The result suggests an inverse relationship between trust and ethnicity. It is important to note that the relationship between ethnicity and trust may not be as simple as the figure suggests. In particular, for example, the country's degree of ethnic fractionalisation and the presence of

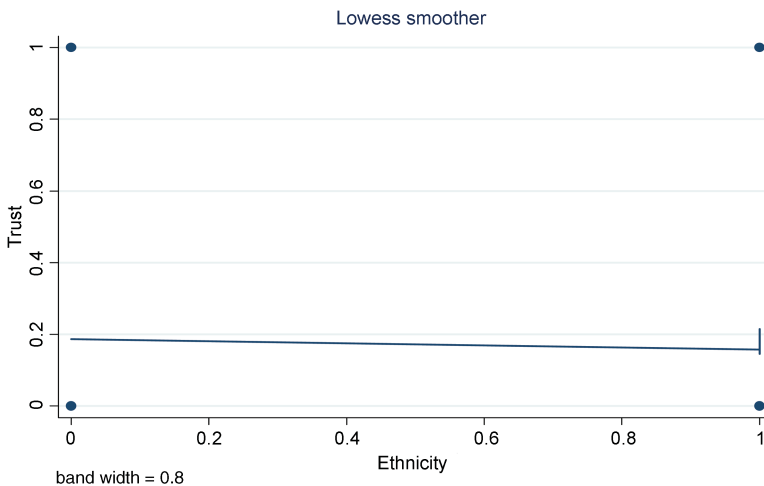


Figure 3: Lowess Estimate of Trust and Ethnicity

ethnic nepotism need to be controlled for, as these factors may shape the relationship between ethnic identity and trust. We explore this relationship further in the ensuing analysis.

In the following section, we undertake a multivariate analysis to better understand the links among trust, ethnicity and ethnic nepotism.

3. Econometric Evidences

In this section, we set up an empirical model to test the hypothesis that attitudinal levels of trust decline with high levels of ethnicity.

3.1. The Empirical Model

We estimate the following empirical model:

$$\text{TRUST}_i = \beta_0 + \beta_1 \text{Ethnicity}_i + \sum_{j=2}^n \beta_{ji} X + \varepsilon_i.$$

Our dependent variable is TRUST, a dummy to capture the respondent's view on whether most people can be trusted. As discussed earlier, this is a measure of generalised interpersonal trust and is based on the standard question of whether most people can be trusted or 'you cannot be too careful' in dealing with people. 'Ethnicity' is a dummy variable showing the respondent's ethnic inclination. X is a vector of variables comprising socio-economic characteristics, experiences of the respondent, country-level fractionalisation indices, as well as indicators of the presence of ethnic nepotism. A detailed description of the variables is given in Table 1.

In our estimation, we proceed step-by-step to examine the impacts of ethnicity and ethnic nepotism. First we introduce an ethnicity indicator to see how ethnicity affects trust. Controlling for social and demographical characteristics, the coefficient of ethnicity is expected to be negative and significant if the similarity argument holds.

Then we raise the question of whether people's perceptions about the existence of nepotism of any form matter for trust. To address this question, we use a variable that captures whether the respondent feels that the country is 'run by a few big interests' or 'run for all people'. We argue that when a respondent feels that a

few big interests are running the country, it is an indication of the presence of some form of nepotism—ethnic or non-ethnic.

Finally, to address the issue of ethnic nepotism directly we use Vanhanen's (1999) measure of institutionalised ethnic conflict. This measure, which ranges from 0 to 100, is constructed on the basis of the relative significance of ethnic parties and organisations,² ethnic inequalities in governmental institutions and the level of customary ethnic discrimination (see Appendix 1 for a detailed description of this variable). A higher value of this measure may show all or one of the following characteristics: ethnically organised parties are important, a high prevalence of ethnic inequality in government institutions and finally a higher degree of customary ethnic discrimination. These characteristics are also observable in societies marred by ethnic nepotism.

3.2. Results

3.2.1. Ethnicity and trust

Exploring the link between ethnicity and trust yields the results reported in Table 3. The results presented in Table 3 support our hypothesis that a person who predominantly identifies him/herself with some ethnic group is less likely to think that most people can be trusted at a personal level. The results remain the same even after controlling for linguistic and ethnic fractionalisation at the country level. This suggests that ethnicity does matter for generalised trust, which is consistent with the findings both by Bahry *et al.* (2005), who report a negative relationship between ethnicity and trust in Russia, and by Helliwell (1996) for the USA and Canada.

3.2.2. Ethnic nepotism and trust

In Table 4,³ we focus on the effects of ethnic nepotism on trust. In column 2, we introduce the 'interest' dummy variable, which captures people's perceptions about whether the country is 'run by a few big interests' or 'run for all people'. Interestingly, the

² When political parties are organised along ethnic lines, they tend to favour their ethnic groups once they are in power. The existence of many such organisations could, thus, create an environment conducive to ethnic nepotism.

³ We do not report all the coefficients on the individual controls, as their effects remain stable.

Table 3: Trust and Ethnicity: Probit Coefficients

Dependent variable: trust	2	3	4	5
Ethnicity	-0.061 (0.083)*	-0.086 (0.033)**	-0.151 (0.000)***	-0.143 (0.000)***
Marital status	-0.028; -0.75	-0.015 0.89	-0.05 -(0.064)*	-0.054 (0.056)*
Education	-0.035 (0.000)***	-0.095 (0.003)***	-0.111 (0.000)**	-0.11 (0.001)***
Education squared		0.007 (0.042)**	0.011 (0.020)**	0.011 (0.024)**
Age	0.002 (0.057)*	-0.014 (0.012)**	0.015 (0.000)***	-0.014 (0.000)***
Age squared		0.0002 (0.003)***	0.0002 (0.000)***	0.0002 (0.000)***
Sex	-0.004; -0.892	-0.023; -0.481	-0.008; -0.757	-0.006; -0.83
Size of town	-0.025 (0.013)**	-0.026 (0.024)**	-0.025; -0.109	-0.032 (0.059)*
Protestant		-0.131 (0.063)*	0.141; -0.459	0.164; -0.413
Orthodox		-0.406 (0.004)***	-0.164; -0.119	-0.096; -0.6411
Catholic		-0.064; -0.538	-0.154 (0.018)**	-0.143 (0.023)**
Evangelist		-0.173; 0.112	-0.093; -0.367	-0.092; -0.379
Muslim		-0.118; -0.181	0.312 (0.071)*	0.424 (0.007)***
Low class		0.087 (0.041)**	0.13; -0.124	0.13; -0.118
Upper class		0.058; -0.16	0.007; -0.886	0.004; -0.929
Language at home		-0.089; -0.497		
Linguistic fractionalisation			-0.542 (0.000)***	
Ethnic fractionalisation				
Constant	-1.236 (0.000)***	-0.041; -0.842	-0.026; -0.925	-0.531 (0.007)***
Observations	10,640	7,787	8,599	8,599
Country specific effects	Yes	Yes	Yes	Yes

Robust *p*-values in parentheses.

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

Table 4: Trust and Ethnicity Nepotism: Probit Coefficients

Dependent variable: trust			
	2	3	4
Ethnicity	-0.04; -0.33	-0.082; -0.112	0.064; -0.288
Interest (nepotism)	-0.251 (0.000)***		
Ethnic nepotism		-0.007 (0.004)***	-0.005 (0.077)*
Ethnicity*ethnic nepotism			-0.003 (0.012)**
Constant	-0.356 (0.035)**	0.101; -0.759	-0.002; -0.994
Observations	7,338	7,787	7,787
Country-specific effects	Yes	Yes	Yes

Robust p -values in parentheses.

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

significance of our 'ethnicity' variable has vanished, while the 'interest' variable is highly significant and negative. In terms of marginal effects, nepotism seems to have a higher impact than ethnicity, suggesting that nepotism is a stronger determinant of trust than ethnicity is.

Columns 3 and 4 of Table 4 introduce our measure of ethnic nepotism. Both estimation results indicate that the presence of ethnic nepotism reduces generalised interpersonal trust. The third column shows ethnicity to be insignificant at the 10% level of significance, though negative, while the coefficient of ethnic nepotism is significant and negative. The implication of this result is consistent with the results in column 2, which indicate that nepotism, in this case ethnic nepotism, is stronger than ethnicity in explaining trust. In column 4, we interacted the ethnic nepotism and ethnic variables to test the hypothesis that ethnicity *per se* might not have an impact on generalised interpersonal trust unless it is accompanied by ethnic nepotism, i.e., ethnicity coupled with ethnic nepotism may reduce trust.

The non-linearities and complexities associated with using interaction terms in a probit model imply that we cannot directly interpret the coefficients of the interaction term in column 4 of Table 4.

Table 5: *Marginal Effects of Ethnicity*

Ethnic nepotism	Ethnicity	Interaction
10	0.00043 (0.977)	-0.0007 (0.039)**
20	-0.0079 (0.522)	-0.0006 (0.038)**
30	-0.0159 (0.12)	-0.0006 (0.041)**
40	-0.0235 (0.01)***	-0.0005 (0.05)**
50	-0.0308 (0.001)***	-0.0005 (0.06)*
60	-0.0378 (0.000)***	-0.0005 (0.092)*
70	-0.0444 (0.000)***	0.0004 (0.13)
80	-0.0507 (0.001)***	-0.0004 (0.18)

Probability values are in parentheses.

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

To calculate the correct marginal effects, we use a method proposed by Norton *et al.* (2004), which entails computing the cross-derivative or cross-difference to derive the interaction effect. The results strongly support our hypothesis. In particular, the probit estimation with the interaction allows us to explore different channels through which ethnicity and ethnic nepotism work to affect trust levels. We evaluate the marginal effects at different values of ethnic nepotism and report the results in Table 5.

The marginal effect of ethnicity is significant only for higher levels of ethnic nepotism, suggesting that ethnicity by itself does not have a significant impact on trust levels unless it is accompanied by high levels of ethnic nepotism. Besides, our interaction variable is negative and significant for most levels of ethnic nepotism (from 10 to 60) and insignificant at the very high levels. This may be because of the possibility that individuals in societies with high levels of ethnic nepotism are more likely to be ethnically charged. In such cases, it is difficult to identify the effects of ethnicity and ethnic nepotism separately. Also, the interaction model shows that the probability of trust is a declining function of ethnic nepotism as shown in Figure 4.

The results underscore the importance of not only the direct effect of ethnic nepotism on trust but also its importance in shaping the effect of ethnicity on trust. Addressing the problems

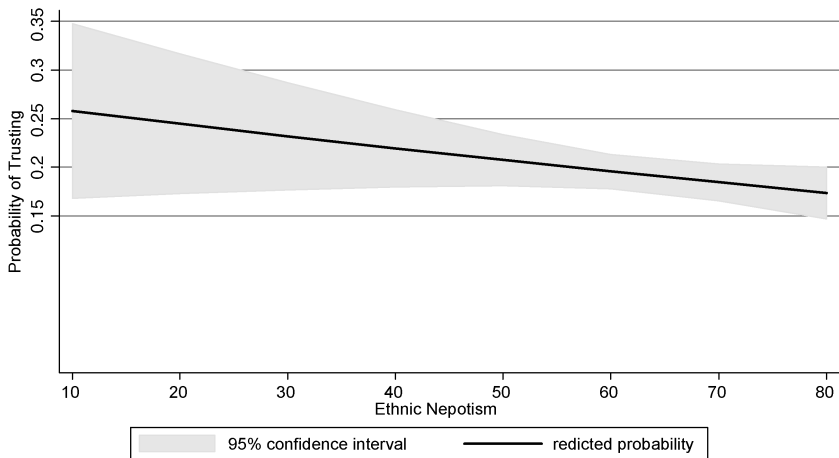


Figure 4: *Trust and Ethnic Nepotism*

of ethnic nepotism would thus be an important channel in promoting the levels of interpersonal trust in society.

3.2.3. Other correlates of trust

To capture individual characteristics and experiences, we include variables such as age, gender, education, size of the town the individual lives in, whether the individual's language is also the country's dominant language, income (formulated as a categorical variable with three different self-reported income groups, i.e., lower, middle and upper income classes), as well as the individual's religious inclinations (grouped into Protestant, Orthodox, Catholic, Evangelist, Muslim and no religion/Atheist, following the sample characteristics).

In all estimation results in Table 3, education is highly significant and the relationship between education and trust shows a robust U-shape, as both education and its square remain statistically significant at the 1% level. This implies that people with lower levels of education are less trusting, while people with higher levels of education are more trusting. Evidence from other research is in sharp contrast with our results. Schechter (2007) finds that higher educated people in rural areas of Uruguay spent less money in a trust game, suggesting that they are less trusting. Bellemare and

Kroger (2003) on the other hand use a random sample from the Dutch population and find that the correlation between education and trust follows an inverted U-shape. Our result, on the other hand, suggests that higher levels of education could possibly encourage cooperative behaviour, which builds trust. This result is important and hopeful, as it implies that the negative effect of ethnicity on trust can be mitigated through instruments such as education, which can be affected by policy.

A U-shaped relationship is also observed between age and trust. This is in contrast with Sutter and Kocher (2003), who, using an experimental trust game, find that trust in anonymous partners increases almost linearly from early childhood to early adulthood but then stays almost constant. However, we find that older people tend to be more trusting and that the age effect is convex.

Income is another possible correlate of trust. However, the expected impact of an individual's income on generalised trust is ambiguous. Following the argument that trust develops among similar people or groups of people, people in the lower and middle-income groups are more trusting, as they constitute the majority in many societies. For people in these groups, the phrase 'most people' in the trust questionnaires refers to people in their own groups. Hence, for people in the rich income group, the same phrase refers to people outside their own group. Given that trust develops among similar groups of people, the rich are then expected to be less trusting, while people in the lower and middle-income groups are more trusting. On the other hand, with ethnic nepotism, people in the discriminated and disadvantaged group are less trusting of others since they have experienced unfair rules and practices. As such people are concentrated in the lower income group, it is also possible that this group may be less trusting (You, 2005). At any rate, our results point to the first explanation; people in the lowest income group in Africa are more trusting, in line with the similarity argument.

Religion has a significant impact on trust. In all estimations, we explore the relationship between trust and specific religious affiliation at the individual level. Notwithstanding the variation in results across our different specifications mainly due to sample differences, the overall conclusion seems to be that Muslims are more trusting, and Catholic and Orthodox are less trusting compared with Atheists or people who claim they do not follow a religion.

We use the size of the town an individual lives in (in terms of population) as a proxy for the effect of population density. Our result confirms the hypothesis that residents in big cities are less trusting. Collier (1998) also finds a significant (though quadratic) relationship between population density and trust.

In ethnically diverse countries, communication between people belonging to different ethnic groups might be difficult due to the inability to speak the same language, which is likely to affect interpersonal trust negatively. We control for this by introducing a dummy equal to 1 if the respondent is able to speak the most commonly used language and zero otherwise.⁴ Then we use the Alesina *et al.* (2003) linguistics fractionalisation index, which shows the probability that two randomly selected individuals from the population speak different languages. The results show that the language dummy variable is insignificant,⁵ while our latter indicator, linguistic fractionalisation, is significant and negative. However, as linguistic fractionalisation is highly correlated with ethnic fractionalisation, the result may be driven by factors other than linguistic fractionalisation.

Personal traumas such as divorce do not affect trust, consistent with Alesina and LaFerrara (2000). Similarly, gender has no significant effect on trust, i.e., there are no significantly different patterns of trust between men and women. On the other hand, marital status appears to be significant and negative, suggesting that married people are less trusting.

Following Alesina and LaFerrara (2000), we tested the robustness of our results by removing the influential observations using the DFbeta method. Our results remained stable.

4. Conclusions

This paper has shown that while ethnicity and ethnic nepotism are each important in determining generalised interpersonal trust levels in Africa, their interaction has a self-reinforcing and negative

⁴ We recognise the measurement errors arising from the fact that the respondent may speak the most commonly used language but reside in a locality where that language is not widely spoken. In addition, it is difficult to say which language is the most commonly used in the case of South Africa and Nigeria, where two or three languages are equally common.

⁵ This result may be due to the poor measurement of the language variable as discussed in footnote 4.

effect on trust levels. That is, the presence of ethnic nepotism worsens the negative effect of ethnicity on interpersonal trust. In particular, our results suggest that ethnicity by itself may not affect trust significantly in situations where the degree of ethnic nepotism is low. Furthermore, we found that the other factors with strong effects on trust are education, age, income, religious affiliation and population density.

The implication of our findings is that policy interventions that reduce the extent of ethnic nepotism could be an important instrument in minimising the adverse effects of ethnicity on trust. This is consistent with an argument raised by Johnson (2005) where constitutional and fundamental organisational reforms are pointed out as viable long-term solutions in managing the undesirable outcomes of ethnicity.

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Appendix 1. The scale of institutional conflict

- 0 = No significant ethnic organisations; no significant ethnic inequality in political representation
- 5 = The share of ethnic parties comprises less than 10% of the votes cast in parliamentary or presidential elections; some other ethnic organisations; minor ethnic inequalities in political representation; some small ethnic groups are discriminated
- 10 = The share of ethnic parties 10–14%; some prominent ethnic organisations; clear ethnic inequalities in political institutions; ethnic discrimination
- 20 = The share of ethnic parties 15–29%; significant ethnic organisation; significant ethnic inequality in political institutions; serious forms of ethnic discrimination
- 40 = The share of ethnic parties 30–49%; ethnic organisations cover a significant part of the population; ethnic interest conflicts characterise social life; conspicuous ethnic inequality in governmental institutions; large ethnic groups are discriminated
- 60 = The share of ethnic parties 50–69%; most interest organisations are ethnic ones; ethnic interest conflict more important than other types of interest conflict; striking ethnic inequality in governmental institutions
- 80 = The share of ethnic parties 70–89%; nearly all interest organisations are ethnically based; ethnic interest conflict or inequality in governmental institutions dominate national politics
- 100 = The share of ethnic parties 90–100%; all significant interest organisations are ethnic by nature; practically all interest conflict between groups takes place along ethnic lines
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Source: Vanhanen (1999, p. 61; Table 1).

Paper IV

Can the restrictive harvest period policy conserve mopane worms in southern Africa? A bioeconomic modelling approach

(Forthcoming: *Environment and Development Economics*)

Wisdom Akpalu¹, Edwin Muchapondwa², and Precious Zikhali³

Abstract

The mopane worm, which is the caterpillar form of the Saturnid moth *Imbrasia belina* Westwood is, like other edible insects and caterpillars, a vital source of protein in southern African countries. The worms live and graze on mopane trees, which have alternative uses. With increasing commercialisation of the worm, its management, which was hitherto organized as a common property resource, has degraded to almost open access. This paper uses a bioeconomic modelling approach to show that for some optimal allocation of the mopane forest stock, the restrictive harvest period policy advocated by community leaders may not lead to sustainable harvesting of the worm.

Keywords: Bioeconomic Model, Dynamic Analysis, Mopane Worm, Restrictive harvest period policy.

JEL Classification: Q15, Q18, Q57, C61.

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1. Introduction

Edible insects and caterpillars constitute one of the cheapest sources of animal protein in most African countries (Chavunduka, 1975; Defoliart, 1995; Banjo *et al.*, 2006). Most of them contain more protein, fat and carbohydrates than equal amounts of beef and fish, and a higher energy value than soybeans, maize, beef, fish, lentils and other beans (Illgner and Nel, 2000; Banjo *et al.*, 2006). In some African countries, children are fed flour made from dried caterpillars to curb malnutrition, while pregnant and nursing women as well as people who are anaemic are encouraged to eat caterpillars because of their high protein, calcium and iron content (Moruakgomo, 1996, cited in Illgner and Nel, 2000). Owing to the nutritional properties of caterpillars, South African entomologist Rob Toms (Toms *et al.*, 2003) recommended that HIV-positive people eat caterpillars to boost their nutritional levels.

One of the most nutritious, commonly eaten and economically important caterpillars in southern Africa is the edible larvae or caterpillar of the Saturniid moth *Imbrasia belina* Westwood, colloquially referred to as the ‘mopane worm’. It grazes primarily on the leaves of *Colophospermum mopane* or the mopane tree (Chavunduka, 1975; Mlambo *et al.*, 2005), a dominant tree species in mopane woodlands, which are mainly confined to several parts of southern Africa including Angola, Botswana, Malawi, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe (Mapaure, 1994). Besides hosting mopane worms, mopane woodlands provide fuelwood, construction materials, fibre, medicines, resin, tannins as well as browse for livestock and wildlife (Mlambo *et al.*, 2005). It has been argued that the mopane tree is used for these purposes not because it is the dominant tree species but rather because it is simply highly preferred for many of its uses (Musvoto *et al.*, 2007). For example, mopane trees have been cited as one of the most preferred species not only for fuelwood but also for construction poles, putting it at risk of being cut down for these purposes. Research has shown that collection of branches and trunks for fuelwood and construction purposes has led to extensive harvesting of mopane trees (Illgner and Nel, 2000). Moreover, although mopane trees grow on land that has relatively low natural potential for agriculture, high population growth on limited land coupled with hard economic conditions accentuated by adverse climatic conditions such as drought might increase incentives to rural communities not only to accelerate harvesting of mopane worms but in some cases to clear mopane woodlands for agricultural expansion (Chipika and Kowero, 2000). It has been noted that smallholder farmers continue to grow crops such

as sorghum, millet and maize on these marginal rainfall areas (Stack *et al.*, 2003). However, since farmers do not generally consider the mopane land as the preferred option for cropping, our analysis is based on the potential threat to the mopane forest stock from other alternative uses such as fuelwood.

Estimates show that the processed mopane worm (dried and ready for consumption) contains 60.70% crude protein, 16.70% crude fat and 10.72% minerals on a dry matter basis (Headings and Rahnema, 2002). It also contains high levels of lysine, tryptopan and methionine (Dreyer, 1968, cited in Illgner and Nel, 2000) and three times the protein content of beef per unit weight, and has the advantage that it can be stored for many months (Menzel and D'Aluisio, 1998, cited in Illgner and Nel, 2000). Consequently, it is listed in the 'Big Twelve African Insects' by entomologists (Toms *et al.*, 2003), highlighting its importance in the region.

With minimal barriers to entry into both the collection and trade of the worm, coupled with an increasing incidence of poverty in southern African countries where the worms are found, overexploitation is currently increasing while selective harvesting is decreasing (Hobane, 1995). This, together with the threat to mopane trees due to deforestation of the mopane woodlands for fuelwood, construction poles or in some extreme cases agricultural expansion, has led to the disappearance of the worms from parts of Botswana and South Africa (Illgner and Nel, 2000). Moreover, the institutional capacities to govern forest resources, which to a large extent are communally owned⁴ in most African countries, are very weak owing to the social, economic and ecological challenges associated with implementing and improving institutions to manage common property resources, and woodland resources in particular, in Africa (Campbell *et al.*, 2001; Campbell *et al.*, 2003). These challenges have led to a drive towards a policy of devolution of responsibility of and control over natural resources from government agencies to resource users, i.e. Community Based Natural Resource Management (CBNRM) (Ostrom, 1990). With the poor heavily dependent on the collection and marketing of the worm, policies towards its sustainable management will contribute to the alleviation of poverty and increase food security, especially among the rural poor.

⁴ In addition to being a communal resource, mopane trees in for example Zimbabwe are also found around homesteads, in communal grazing areas, on large-scale commercial farms and on state farms, while in Botswana much of the mopane areas are located in tribal areas where customary law allows anyone to harvest (Stack *et al.*, 2003).

The only existing policy instrument, which is informally employed by some traditional leaders, is embargos on harvesting the worm during certain periods (Toms and Thagwana, 2005). This, on its own, has proved insufficient as overexploitation continues to be of major concern, prompting the need to look into alternative policies. An example of communities that have implemented the restrictive harvest period policy is the Uukwaluudhi Conservancy in Namibia (FAO, 2007). In this conservancy traditional leaders insist on villagers harvesting mature worms during a pre-specified harvest period only (FAO, 2007), with each harvester paying a fee to the community leaders in order to harvest the worms.

In this paper, we present a two-stage bioeconomic model to explore the effectiveness of the aforementioned policy instrument (i.e. restrictions on harvesting the worms during certain periods). First we present a benchmark case where the social planner's mopane forest stock management problem is modelled (where some optimal quantity/biomass of the mopane forest stock can be harvested periodically for e.g. fuelwood, construction poles and mine props, and the standing forest serves as a host plant for the mopane worm). Second, given the optimal stock obtained from the first stage, an expression for a possible Pigouvian tax that guarantees sustainable harvesting under a restrictive harvest period policy is derived. Furthermore, we explore the comparative static analyses of an increased social discount rate and an increased number of exploiters on the tax. The result, which is unambiguous, shows that some optimal tax must accompany the restrictive harvest period policy if the number of resource exploiters is very large. The tax rate is negatively related to the benefit discount rate but positively related to the number of harvesters. To the best of our knowledge, no bioeconomic model has been developed to help us understand the implications of this existing management regime (i.e. the restricted harvest period policy) on the sustainability of harvesting of the worm.

In the next section we present a brief description of the life cycle and the method of harvesting and processing of the worm. Section 3 introduces the social planner's problem from which the optimal forest stock allocation decision is derived. Section 4 models the restrictive harvest period management regime, taking the optimal mopane forest stock allocation derived in Section 3 as given. Section 5 derives the expression for the optimal tax and explores the conditions under which this tax could be zero. In addition, we undertake comparative static analyses for some policy-relevant variables. Discussions and conclusions are presented in Section 6.

2. The life cycle, harvesting and marketing of the worm

The mopane worm is actually the caterpillar of the Saturnid moth *Imbrasia belina* Westwood. The adult moths lay single clusters of 50 to 200 eggs over a two month period and the larval stage lasts for approximately 6 weeks during which the caterpillars undergo a 4000-fold increase in body mass (Gullan and Cranston, 1994). The worm completes five larval stages in its life cycle before pupation. During the first three stages, the caterpillars strictly aggregate in numbers of between 20 and 200 and forage together. Then they immediately disperse to become solitary (Toms *et al.*, 2003). Although mature larvae are preferred to younger ones, harvesting is indiscriminate of age and size. Thus, the population of worms that are not harvested in one period determines the intensity of the outbreak in the next period. At the end of the larval stage, the fifth instar caterpillars that survive harvesting burrow underground where they undergo a period of diapause. After some six to seven months they reach the adult stage, which is crucial as this is the stage at which they mate and lay eggs marking the beginning of an outbreak of the worms. In general, the species is bivoltine with the first generation emerging from pupation in November to January and the second in March to May; it is univoltine only in more arid areas (Toms *et al.*, 2003).⁵

Traditionally, mopane worms are collected, prepared and consumed by rural communities within the range of the mopane woodlands. The bulk of the harvesting and processing of the worms is done by women and children. A survey in Botswana indicated that 95 percent of harvesters are poor rural women, of which 73 percent live within 50 kilometers of the harvesting areas (Illgner and Nel, 2000). Approximately 40 percent of the estimated £57m annual harvest of the mopane worms in South Africa goes to producers who are primarily poor rural women (Styles, 1994, cited in Stack *et al.*, 2003). The most common and basic method of collection is to manually pick the worms from the ground and trees. After the larvae are collected, the undigested material in the gut is removed by either squeezing them between the thumb and fingers or by using a bottle as a roller to squeeze out the contents. While younger larvae have relatively large amounts of gut content, fully-grown larvae have less; instead their bodies are filled with a yellow nutritive material that is liked by consumers. After removing the gut content, the larvae are charcoal roasted or boiled and then dried to preserve them (Kozanayi and Frost, 2002).

⁵ See Ghazoul *et al.* (2006) for a comprehensive summary of the life cycle of the worm.

On the demand side, owing partly to the economic misfortunes faced by rural communities, the mopane worms have become a vital trading commodity in southern Africa. Unemployed men close to urban areas are becoming increasingly involved in the collection of the worms and are in most cases contracted by local traders (Kozanayi and Frost, 2002). The women are generally engaged in the sale (including barter) of the commodity in small volumes while men tend to be engaged mainly in the more lucrative long-distance and large-volume trade which is sometimes of cross-border nature (Kozanayi and Frost, 2002).

Also on the demand side, the on-going urbanisation has made people migrate from rural areas taking their eating habits with them to urban areas. In addition, increasing poverty in urban areas has created a demand for low-cost protein such as the mopane worm (Stack *et al.*, 2003). Supermarkets have over the years become the main retail outlets for pre-packed and labelled mopane worms supplied by wholesale food packaging companies such as Quality Foods and Jasbro in Zimbabwe (Kozanayi and Frost, 2002). Research indicates that about 16000 tonnes of mopane worms were traded on the South African commercial market in 1982, some of which were traded as animal feed (Dreyer and Wehmeyer, 1982, cited in Illgner and Nel, 2000). A sizeable amount of trade occurs at bus terminals, roadside markets and beer halls where the worms are sold as snacks.

3. The mopane worm model: the social planner's problem

This section presents the social planner's mopane forest stock management problem. Suppose that a single rational decision maker manages the mopane forest or woodland and has to decide on the biomass of the forest stock to be harvested in each period (for e.g. fuelwood or construction poles) and, conversely, on the standing stock to be conserved for hosting the mopane worms. Thus, the social planner will choose an allocation that maximises overall benefits from these two activities. This is tantamount to the domestication of the worm, a possible policy that some researchers have advocated and for which there have been some projects to test its feasibility (Ghazoul, 2006). Suppose that the stock evolution equation for worm biomass is

$$\frac{dx}{dt} = \dot{x} = \gamma x \left(1 - \frac{x}{k}\right) - h, \quad (1)$$

which can be written as

$$\dot{x} = g(x, k) - h, \quad (1')$$

where $g(x, k) = \gamma x(1 - \frac{x}{k})$; x is the stock/biomass of the mopane worm; h is the total harvest (biomass in kilograms) of the worm and the intrinsic growth rate of the worm is given by γ . Note that since in reality all sizes of the worm are harvested, the biomass model is preferred to an age-structured model. As indicated in the preceding section, the worm goes through different stages as part of its life cycle eventually transforming into a moth that can migrate, meaning that different behavioural equations could be specified for each stage. However, due to the biological and mathematical complexities involved in characterising the problem, the logistic function is assumed for simplicity. Similarly, since there is no existing information on the migratory pattern of the worm, it is assumed for simplicity that there is no cross-community migration of the worms. Thus, our model could be considered restrictive in these ways. Nevertheless, this simple specification provides a benchmark upon which some extensions can be made. The woodland's carrying capacity is captured by k , which is the stock of the mopane trees that are set aside to host the mopane worms. Following Ben-Shahar (1996), suppose that the mopane forest stock grows over time so that the equation of motion defining this process is

$$\frac{dk}{dt} = \dot{k} = w(k) - v, \quad (2)$$

where v is the harvest or biomass cleared for e.g. fuelwood, and the change in the forest stock is assumed to be a function of the existing forest stock, i.e. $w(k)$. Consequently, while the carrying capacity could grow, say, logistically, harvesting dampens the growth rate.

As mentioned, the objective of the social planner is to maximise the net benefits from both mopane worm production and the harvest of mopane trees for e.g. fuelwood and construction poles, while considering the effects of harvesting the worms on worm stock dynamics as well as the effects of clearing the forests on mopane forest stock dynamics. Assuming that the net benefits from fuelwood or construction pole production can be collapsed into a net benefit function $B(v)$, the social planner's problem can be set out as follows:

$$Max_{\{h, v\}} \int_0^{\infty} [ph + B(v) - c(x)h] e^{-\delta t} dt \quad (3)$$

subject to equations (1') and (2), with $x \geq 0$, $h \geq 0$, $B_v > 0$, $B_{vv} \leq 0$ and $x(0) = x_0$.

Here p is the competitive market price per kilogram of the worm and $c(x) = \frac{c}{\sigma x}$ is the cost per unit harvest of the worm (c is cost per unit effort and σ is the catchability coefficient of the worm, which is normalised to one). The current value Hamiltonian associated with this problem is:

$$H(h, l, \lambda, x, v, \varepsilon) = ph + B(v) - c(x)h + \lambda(g(x, k) - h) + \varepsilon(w(k) - v). \quad (4)$$

The Pontryagin maximum principle is given by:

$$\frac{\partial H}{\partial h} = p - c(x) - \lambda \begin{pmatrix} > \\ = \\ < \end{pmatrix} 0, \Rightarrow \begin{pmatrix} h = h_{\max} & \text{if } x > x^{**} \\ h = h^* & \text{if } x = x^{**} \\ h = h_{\min} & \text{if } x < x^{**} \end{pmatrix}, \quad (5)$$

$$\frac{\partial H}{\partial v} = B_v - \varepsilon = 0 \Rightarrow B_v = \varepsilon, \quad (6)$$

where x^{**} and h^* are the optimum stock and harvest of the worm respectively. From equation (5), the maximum principle indicates that in an intertemporal equilibrium, the marginal profit from harvesting the mopane worm, $(p - c(x))$, should reflect or equate the scarcity value of the stock of mopane, λ . Note that if $p - c(x) < \lambda$, then the level of stock is less than what is optimally desired (i.e. $x < x^{**}$), and it is hence more valuable to preserve the worm and harvest will therefore be at its minimum (i.e. $h = h_{\min}$). On the other hand, if $p - c(x) > \lambda$, then the worm is less valuable to preserve and harvest will be at its possible maximum. Equation (6) states that the marginal benefit from using a unit of the mopane forest biomass for an alternative use (e.g. for fuelwood), B_v , should equate or reflect the scarcity value of using the mopane forest for this alternative use, ε . Here B_v denotes the first derivative of B with respect to v .⁶ The costate equations associated with the two stocks are as follows:

$$\dot{\lambda} - \delta\lambda = -\frac{\partial H}{\partial x} = c_x h - \lambda g_x, \quad (7)$$

$$\dot{\varepsilon} - \delta\varepsilon = -\frac{\partial H}{\partial k} = -(\lambda g_k + \varepsilon w_k). \quad (8)$$

⁶ Subscripts are henceforth used to denote derivatives.

Thus, in a dynamic equilibrium, the returns from harvesting the resource today on the margin, $\delta\lambda$, should be offset by the capital gains from postponing that additional harvest, $\dot{\lambda}$, plus the stock effect, $(\lambda g_x - c_x h)$. Similarly, the returns from using the mopane trees today for fuelwood, $\delta\varepsilon$, must compensate for the capital gains from postponing using it, $\dot{\varepsilon}$, plus the stock effect, $(\lambda g_k + \varepsilon w_k)$. Since we are interested in sustainable harvesting of the worm, which is a renewable resource, we explore the steady state conditions. In steady state, the following conditions hold: $\dot{\lambda} = \dot{x} = \dot{\varepsilon} = 0$. From the costate and the stock dynamics equations, the optimum shadow values of the stock of mopane worms and the forest stock are

$$\lambda^* = \frac{c_x h}{(g_x - \delta)}, \quad (9)$$

$$\varepsilon^* = \lambda^* \frac{g_k}{(\delta - w_k)}. \quad (10)$$

Equation (9) stipulates that in steady state, the marginal value from additional stock of the worm (λ^*) is some adjusted discounted value of the stock effect of the worm ($c_x h / (g_x - \delta)$). From equation (10), the marginal value of an additional unit of the forest stock (ε^*) is the product of the marginal benefit from additional stock of the worm and some adjusted discounted value of the forest stock effect ($\lambda^* g_k / (\delta - w_k)$). Note that the relative shadow prices will depend on $g_k / (\delta - w_k)$ and if the marginal gain from increasing the size of the forest stock is high, say $g_k / (\delta - w_k) > 1$, then the shadow price of the forest stock will exceed that of the worm.

The optimal values of k (and $x, h, v, \lambda, \varepsilon$) can be obtained by solving equations (5) to (10), and using $h^* = g(x^*, k^*)$ and $v^* = w(k^*)$ we can solve for $k^* = k(p, c, \delta, \gamma)$.⁷ At this stage the social planner decides on the optimal harvest of the mopane forest stock to be allowed in each period. Consequently, the social planner also decides on the optimal mopane worm harvest. However, if the worms are harvested under open access, the worms will have no capitalised value (i.e. $\lambda = 0$) and will

⁷ By assuming a logistic biomass growth function of the worm and the carrying capacity, we have a unique solution of the optimal harvest and stock of forest allocated for hosting the worms.

therefore not be harvested sustainably. Hence, open access creates incentives for accelerated rates of exploitation. Thus, the current rate of open access exploitation of the mopane worms in many southern African communities poses a serious threat to the worm stock. Sustainability of the mopane worm requires policies that restrain the rate of exploitation.

4. The restrictive harvest period policy model

This section analyses the stock and harvest dynamics under the restrictive harvest period regime, in accordance with the prevailing management policy. A restrictive harvest period management regime is defined as a regime in which the harvest of the worm is limited to an instantaneous harvest period (i.e. harvest reduces escapement but does not affect the growth of the biomass), a situation that mimics the practice of some traditional leaders who allow harvesting during certain periods only (Toms and Thagwana, 2005). As in the previous case, we assume that harvesters are price takers, thereby assuming a competitive restrictive harvest period management regime. Thus, it is assumed that the social planner or community leader allocates an optimal stock of the mopane woodland to mopane worm production (as per the preceding section). Given this allocation, he/she imposes a restrictive harvest period policy.

Drawing from the escapement model of Reed (1979) and Clark (1990), we specify the stock dynamics of the restrictive or instantaneous harvest as

$$\frac{dx}{dt} = \dot{x} = \gamma z \left(1 - \frac{z}{k^*}\right) - h, \quad (11)$$

which can be presented as

$$\dot{x} = \Lambda(z, k^*) - h, \quad (11')$$

where $z = x - h$ is escapement (i.e. the biomass of worm that escapes capture at each point in time), $\Lambda(z, k^*) = \gamma z \left(1 - \frac{z}{k^*}\right)$, $h = \sum_{i=1}^n h_i = h_i + h_{-i}$ is the total harvest of the worm,

and n is the total number of harvesters.⁸ Note that since the social planner predetermines the optimum forest stock k^* , each harvester i will have the following optimisation programme:

$$\text{Max}_{\{h_i\}} \int_0^{\infty} [ph_i - \zeta(x, h_i + h_{-i})] e^{-\delta t} dt, \quad (12)$$

where $\zeta(x, h) = \zeta(x, h_i + h_{-i}) = \int_{x-h}^x \zeta(z) dz = \int_{x-h}^x \left(\frac{c}{z} \right) dz = c \ln \left(\frac{x}{x-h} \right)$. Equation (12) is maximised subject to equation (11). The current value Hamiltonian associated with this problem for the i^{th} harvester is:

$$H^I = ph_i - \zeta(x, h_i + h_{-i}) + \mu_i (\Lambda(z, k^*) - h). \quad (13)$$

Assuming symmetric harvests of the worm so that $h = nh_i$, the maximum principle equation and the costate equation are defined by equations (14) and (15) below, respectively:

$$\frac{\partial H^I}{\partial h_i} = 0 \Rightarrow p - n\zeta_h + \mu_i (n\Lambda_z z_h - n) = 0 \quad \Rightarrow p - n\zeta_h = \mu_i n(1 + \Lambda_z), \quad (14)$$

$$\dot{\mu}_i - \delta\mu_i = -\frac{\partial H^I}{\partial x} \Rightarrow \dot{\mu}_i - \delta\mu_i = \zeta_x - \mu_i \Lambda_z. \quad (15)$$

The interpretation of the maximum principle remains the same; in an intertemporal equilibrium, the marginal profit obtained from harvesting the worm, $(p - n\zeta_h)$, must reflect the scarcity value of the stock of the worm, $\mu_i n(1 + \Lambda_z)$. Clearly, the terms for the marginal profit and the shadow value under the restrictive harvest policy are different from those in equation (5). Furthermore, from the costate equation (i.e. equation 15), the returns on investment from harvesting an additional unit of the worm, $\delta\mu_i$, should be equal to capital gains, $\dot{\mu}_i$, plus some stock effect given by $(\zeta_x - \mu_i \Lambda_z)$. It is also clear that this dynamic equilibrium condition is different from that in equation (7), implying that harvest levels under the restrictive harvest period policy may not be

⁸ Note that the discrete time representation of the model is $x_{t+1} = z_t \left(1 + \gamma - \frac{\gamma z_t}{k^*} \right)$. This implies that the biomass in the next period is the escapement plus the growth of the escaped biomass. By letting $x_{t+1} - x_t \approx \dot{x}$, in continuous time, this equation is rewritten as equation (11).

optimal, making it imperative to consider complementary policies. In the next section we propose a hybrid instrument that combines the restrictive harvest period policy with a Pigouvian tax.

5. The economic policy instrument (tax)

In this section we derive an expression for an optimal ad valorem tax and then explore the conditions under which the tax may not be necessary (i.e. conditions under which the tax is zero). We then derive comparative static analyses for some policy relevant variables. Consequently, some relevant propositions are derived. As mentioned earlier, the increased commercialisation of the worm implies that it has a market value, which makes it relatively easy to impose an ad valorem tax on harvest. Notably, communities such as the Uukwaluudhi Conservancy in Namibia provide a good example of the feasibility of some form of tax on mopane worms. In this community each harvester must pay a fee to get written permission from the Uukwaluudhi Traditional Authority or from other relevant authorities and people are allowed to harvest only within a restricted period (FAO, 2007). This lends support to the kind of hybrid policy instrument we are proposing, i.e. the restrictive harvest period policy accompanied by a Pigouvian tax on harvest.

Proposition 1: *The optimal tax is defined by the expression*

$$t^* = \frac{n\zeta_x(\Lambda_z + 1)}{(\Lambda_z - \delta)} - \frac{c_x h}{(g_x - \delta)} + (n\zeta_h - c(x)).$$

Proof. By subtracting $c(x) + \lambda$ from both sides of equation (14) and rearranging the terms, the maximum principle can be written as:

$$p - c(x) - \lambda = \omega\Lambda_z + (n\zeta_h - c(x)) + (\omega - \lambda), \quad (16)$$

where $\omega = n\mu_t$. Comparing equations (5) and (16) and following Akpalu and Parks (2007), we derive the expression in equation (17) for the tax rate:

$$t = \omega\Lambda_z + (n\zeta_h - c(x)) + (\omega - \lambda). \quad (17)$$

In steady state, $\dot{\mu}_i, \dot{n} = \dot{\omega} = \dot{\lambda} = 0$ implying that $\omega = \frac{n\zeta_x}{(\Lambda_z - \delta)}$. Also, from equation (7)

we know that $\lambda = \frac{c_x h}{(g_x - \delta)}$. Substituting these values into the tax expression gives

$$t^* = \frac{n\zeta_x(\Lambda_z + 1)}{(\Lambda_z - \delta)} - \frac{c_x h}{(g_x - \delta)} + (n\zeta_h - c(x)). \blacksquare$$

This tax corrects for undervaluation of the scarcity value of the mopane stock under the restrictive harvest period policy, differences in harvest costs and some stock externality. While there could be legitimate concerns regarding the feasibility of implementing a tax in relatively non-monetised economies such as those in rural Africa, it can be argued that since the resource has become very much commercialised, imposing a tax is not unrealistic. Moreover, the quantity equivalent of the ad valorem tax that could apply to individuals who harvest for subsistence consumption is simply $\alpha = t^*/p$.⁹ Nevertheless, other challenges including the risk of misuse of the funds by corrupt community leaders as well as costs associated with monitoring harvesters might still have to be overcome.

The existence of zero optimal tax

It may not be necessary to impose any tax on harvest (i.e. $t^* = 0$) if the stock level in the absence of the tax coincides with what is optimally desired (i.e. if a restrictive harvest period policy leads to optimal resource stocks and harvest levels), yet this is indeed a *rare* condition. From the tax expression it is straightforward to see that there exist replicate dynamics between the level of stock and number of harvesters, all other things being equal. In this section we tabulate such equilibrium relationships for different numbers of resource users, assuming the aforementioned specific functional forms. Note that no tax implies

$$t^* = \frac{n\zeta_x(\Lambda_z + 1)}{(\Lambda_z - \delta)} - \frac{c_x h}{(g_x - \delta)} - (c(x) - n\zeta_h) = 0. \quad (18)$$

Using the parameter values $\gamma = 0.1$, $\delta = 0.03$, $c = 1000$, $h = 100$ and $k^* = k(\bullet) = 100$ (assumed for convenience), Table 1 presents simple simulated results of the relationship between harvest, the number of harvesters and the optimum level of stock.

⁹ This expression is obtained by equating the revenue after the ad valorem tax (i.e. $(p - t)h$) and that of the quantity tax $((1 - \alpha)ph)$ and solving for the quantity tax (i. e. α).

Table 1: The equilibrium relationships between harvest and stock for different numbers of harvesters

Tax (t^*)	Number of harvesters (n)	Optimal stock (x^*)
0	5	50
0	10	45
0	100	36

The table shows that, in general, an increase in the number of harvesters might lead to overexploitation of the worms in the absence of any tax on harvest. Consequently, the tax should be imposed if, all other things being equal, the number of harvesters is sufficiently large.

Characterising the optimal tax

Proposition 2: *The optimal tax must increase if the number of worm harvesters increases, all other things being equal.*

Proof. The proof of this proposition requires taking comparative statics of the optimal tax with respect to the number of harvesters and characterising the results to show that the derivative is positive. From equation (17), we have:

$$\frac{\partial t^*}{\partial n} = \frac{-n\zeta_x \Lambda_{zn} (\delta + 1)}{(\Lambda_z - \delta)^2} + \frac{\zeta_x (\Lambda_z + 1)}{(\Lambda_z - \delta)} + \frac{-c_x h_i}{(g_x - \delta)} + \zeta_h + n\zeta_{hm} > 0. \quad (19)$$

Note that $-\zeta_x \Lambda_{zn} > 0$, $-c_x > 0$, $n\zeta_{hm} > 0$ and $\frac{\zeta_x (\Lambda_z + 1)}{(\Lambda_z - \delta)} > 0$. Therefore, $\frac{\partial t^*}{\partial n} > 0$ if it

can be shown that $\zeta_x (\Lambda_z + 1) > -\zeta_h (\Lambda_z - \delta)$. Since $\delta > 0$, we will have $\frac{\partial t^*}{\partial n} > 0$ if

$\zeta_x > -\zeta_h$. But we know from the specific functional forms that $\zeta_x = c \left(\frac{1}{x} - \frac{1}{x-h} \right)$ and

$\zeta_h = \frac{c}{x-h}$. It follows that $\zeta_x > -\zeta_h \Rightarrow \frac{c}{x} > 0$, which is as given. Thus, as the number of

worm exploiters increases, the tax rate must increase to ensure sustainable harvesting of the worm. ■

Proposition 3: *The optimal tax t^* must decrease if the benefit discount rate increases, all other things being equal.*

Proof. The proof of this proposition requires taking the first derivative of the optimal tax with respect to the discount rate and characterising the results to show that the derivative is negative. Thus, from equation (17) we have:

$$\frac{\partial t^*}{\partial \delta} = \frac{n\zeta_x(\Lambda_z + 1)}{(\Lambda_z - \delta)^2} - \frac{c_x h}{(g_x - \delta)^2}. \quad (20)$$

From equation (19), since $(g_x - \delta)^2 < (\Lambda_z - \delta)^2 \quad \forall x_i > 0$, it follows that $\frac{\partial t^*}{\partial \delta} < 0$ if $n\zeta_x(\Lambda_z + 1) > c_x h$. Using the specific functional forms of the cost functions (i.e. $c_x = -\frac{c}{x^2}$ and $\zeta_x = c\left(\frac{1}{x} - \frac{1}{x-h}\right) = -\frac{c}{x}\left(\frac{h}{x-h}\right)$, and $h = nh_i$), we have $\frac{\partial t^*}{\partial \delta} < 0$ if $x - nh_i < n^2 x$, which is true since $n \geq 1$. ■

Increasing discount rates imply increased returns on investment of proceeds from the worm. Consequently, as the discount increases, more worms must be harvested to earn higher returns on the investment of the proceeds; therefore, the tax rate will have to decrease.

6. Discussions and Conclusions

Inadequate forest resource management policies in southern Africa, like in other regions of Africa, contribute to unsustainable exploitation of mopane worms. It has already been noted that overexploitation has led to the disappearance of the worms from parts of Botswana and South Africa (Illgner and Nel, 2000). Clearly, in view of the important role of the worms in poverty alleviation and food security in the region, adequate and timely policy interventions are needed to address the problem. It is therefore not surprising that some community leaders have placed restrictions on harvesting during certain time periods in an effort to ensure sustainable harvesting of the worm.

Using a simple bioeconomic modelling approach, this paper has investigated whether, for some predetermined mopane forest allocation, restricting the harvesting season to an instant or predetermined harvest period as currently advocated will result

in sustainable harvesting of the worms. Our results show that some optimal tax that corrects for (1) undervaluation of the scarcity value of the mopane stock under the restrictive harvest period policy, (2) differences in harvest costs and (3) some stock externality must accompany the restrictive harvest period policy. The optimal tax is negatively related to the benefit discount rate but positively related to the number of harvesters.

While the fact that some communities have managed to restrict harvesting to certain time periods and at the same time impose a fee on harvesters (FAO, 2007) gives us faith that the hybrid policy instrument we propose is feasible in the analysed setting, we also acknowledge the challenges that might come with its implementation. In particular, an implementation of the policy might for example require a Community-Based Natural Resource Management (CBNRM) setting or some institutions to support common property resource (CPR) management. The rules that come with such settings might be far removed from the current institutional systems in Africa (Campbell *et al.*, 2001). For example, national policies are not conducive to CPR management in some cases; economic hardships might undermine CPR institutions; local institutions might lack legitimacy and in the case of woodland resources, returns to their management might be too low to encourage the establishment of CPR institutions (Campbell *et al.*, 2001). As noted by Campbell *et al.* (2001), these complexities need not lead to institutional vacuums since a set of customs and norms might still be in place to influence resource use. However, there are successful cases of Community-Based Forest Management (CBFM), for example in Tanzania's Duru-Haitemba Forest Reserve, where devolution has induced local communities to conserve forests (Kajembe *et al.*, 2003), although its success is derived mainly from a unique local situation in that the village is permitted by the government to own property in its own right as a corporate entity (Campbell *et al.*, 2003).

As the case of Uukwaluudhi Conservancy in Namibia shows, the increasing commercial value of the worm is expected to create incentives for introducing mechanisms to support sustainable harvesting policies. Moreover, the case also shows that the hybrid instrument we propose might be feasible in southern Africa.

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