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Performance of Smallholder Agriculture Under Limited Mechanization and the Fast Track Land Reform Program in Zimbabwe

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Abstract

The Zimbabwean government has long been committed to expansion of agricultural production through mechanization and pursued this goal under the unpopular fast track land reform program (FTLRP). The acquisition and use of tractors by arable crop farmers in communal and resettlement state land were encouraged. This research examines the performance of the program in the Bindura District. Ninety farmers were interviewed using a multistage sampling technique of structured questionnaires to collect data on demographic background, investment levels and production in terms of costs and returns. The Stochastic Frontier Model revealed the significant impact of the program on participating farmers, highlighting the significance of land and other productive factors. While overall production and productivity remain low, triggering a hyperinflationary situation due to supply constraints, practical implications for agribusinesses are foreseen.

Keywords: agricultural mechanization, fast track land reform, agricultural development, Stochastic Frontier model, technical efficiency, agribusiness management

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Introduction

When the Government of Zimbabwe launched the farm mechanization program in 2007, the goal was to support the land reform program

and improve farm productivity on newly resettled farms where output was either beginning to decline or had never looked good since the white farmers were forcibly driven off most land (FAO/WFP 2007; Mugabe 2007). Not long after the launch of the fast track land reform program (FTLRP), it became clear that the expectations had been exuberant at best as production declined dramatically and only about 30-55% of the arable land was being cultivated (Chatizwa & Khumalo 1996; Moyo 2004; FAO/WFP 2007). Although the area cultivated after the FTLRP was considerably larger than the 10-15% attained in the pre-land reform era (Scoones et al. 2010), it was grossly inadequate to reverse the downward spiral of the Zimbabwean economy that was already underway as a result of a plethora of other factors. As the FAO/WFP (2007) mission noted, such problems as shortages of tractors and draught power, fuel, and fertilizers, under-investment in infrastructure, the disincentive effects of price controls, and absenteeism of beneficiaries of the earlier land reform, were already causing serious supply bottlenecks. Theoretically, Zimbabwe's problems at that time lend themselves to the application of induced innovation interventions of which farm mechanization could be seen to be an important component, in order to contribute to increasing land and labor efficiency.

On the occasion of the 27th Anniversary of Zimbabwe's Independence, President Mugabe called attention to the creation of a Ministry of Agricultural Engineering and Mechanization to spearhead an agricultural mechanization program (Mugabe 2007). The goal was to help realize the Government's aim of raising productivity "…following the successful implementation of the Land Reform Program…" (Mugabe 2007). According to official Zimbabwean sources the main reason for the agricultural mechanization program was to replace obsolete equipment on farms while ensuring enhanced access to farm equipment for farmers considered to be inadequately served at the inception of the program. Under the program, rehabilitation of irrigation infrastructure was also an important component. The contention was that land resettlement and the provision of inputs to farmers without the support of a strong mechanization program would impact negatively on crop productivity and food security (Mugabe 2007; Muchara 2009). As farmers got land and inputs, the missing link had therefore been mechanization, which had rendered land preparation ineffective across the country (Chisoko 2007). The failure to prepare land on time because of the shortage of tractors and machinery resulted in dwindling crop yields and consequently falling agricultural productivity. For years after the Fast Track Land Reform (FTLR), the absence of an effective mechanization program was seen as the major obstacle to increasing efficiency in crop production at the individual farmer level in Zimbabwe (Made, 2006).

Before the launch of the mechanization program, the District Development Fund (DDF), a department mandated by the government to control funds donated by Non-Governmental Organizations (NGOs) for fostering rural development, provided tillage operations to the small-scale farmers who benefitted under the Fast Track Land Reform Program during 2000-2009 (designated as A1 and communal farmers) (NORAD 1984; FAO 2000; Gongera and Petts 2003). In most areas of Zimbabwe, animal draft power is used in preparation of 70% to 90% of the cropped area, tractor power for between 2**%** to 15%, and hand tillage for 5**%** to 15**%** (Chisoko 2006). Traditional Conservation Farming where farmers practice zero tillage is used in some areas. In areas where rains normally start late, the understandable anxiety of the majority of farmers to plant with the first rains often meets with frustration due to scarcity of equipment which entails long waiting times with the result that many of these farmers resort to minimum tillage practices (FAO, 2002). With the political atmosphere now largely normalized and the Government and the international community once again turning attention to crucial development concerns, it seems timely to undertake an assessment of the impact of some of the key strategies that will undoubtedly continue to play a pivotal role in the restructuring and realignment that will be required to restore growth to the Zimbabwean economy. Hence the current interests in the agricultural mechanization program.

Objectives

The main objective of this paper is to examine the performance of the agricultural mechanization program launched to reverse negative production and productivity trends that emerged in the wake of the fast track land reform program in Zimbabwe. A considerable amount of criticism has been leveled against the FTLRP and its attendant agricultural mechanization program because it was launched without proper planning and implemented in an almost arbitrary and haphazard manner. In the absence of a systematic assessment, the extent to which the operations of these programs account for the difficulties of the past few years remain unclear, hence the present investigation. This paper is an attempt to fill this gap. The first effort is to describe the key features of the fast track land reform program. Subsequently, the international experience in agricultural mechanization is highlighted. The paper then presents evidence from an empirical study to demonstrate the relative importance of agricultural mechanization, especially when introduced to jump-start a land reform program that was already fuelling serious productivity concerns.

Research Questions

The following research questions are considered:

- To what extent has agricultural mechanization been adopted and implemented to boost land productivity in the project area?
- What has been the impact of the agricultural mechanization on crop production and productivity among A1[1], A2[2] and communal farmers under the fast track land reform program in Zimbabwe?
- What are the implications of the findings for managers of firms in the food and agricultural industry?

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[1]A1 farmers are small scale farmers who benefitted under the Fast Track Land Reform Program between 2000 and 2009. Each resettled farm household was allocated between 3- 6 hectares of arable land with the rest of the land being reserved for communal grazing purposes (GOZ, 2001; UNDP, 2002; Sukume, Moyo and Matondi, 2004; Matsa, 2011; ZIMSTAT, 2011).

[2] A2 farmers are medium to large scale commercial farmers who benefitted under the Fast Track Land Reform Program between 2000 and 2009. The farm sizes are considerably larger and the farmers are mainly distinguished by their demonstration of farming experience and ability to repay cost of the farm following which a 99-year lease is granted with option to purchase (UNDP, 2002; Chiremba and Masters, 2003; ZIMSTAT, 2011).

The Fast Track Land Reform Program in Zimbabwe

Following years of bitter armed struggle triggered by intolerable levels of oppression and deprivation that revolved around access to land, peace finally came to Zimbabwe as the 1970s drew to a close. Driven by commitments made at the Lancaster House Agreement that reinforced faith in the crucial steering role of Britain, Zimbabwe launched its ambitious land resettlement program in September 1980, a mere five months after political independence was granted to this former British colony. The program was intended to redress the huge imbalance in land distribution and enhance access to land for victims of the liberation struggle and the landless, while consolidating commercial agricultural production. Kanyenze, Kondo, Chitambara and Martens (2011) have recently provided a graphical description of the extreme inequalities that preceded Zimbabwean Independence in 1980 and how much of the inequalities still remain. By the end of the 1990s, there was widespread disenchantment with the slow progress in resettling the indigenous population. At that time, in spite of nearly two decades of implementation of land reform, a mere 4,500 white farmers still controlled 28% of the land while more than a million black farmers struggled to eke out a desperate existence in largely unproductive and dry “communal areas” (Mushunje 2005). In between these two extremes, the political élites received preferential treatment in allocation of land expropriated from white owners even though much of that was promptly abandoned or mismanaged, with disastrous consequences for farm production and food prices. At the same time, Zimbabwe’s macro economy began to experience serious balance of payment problems for which a structural adjustment program was launched. As the hardships deepened, political interests capitalized upon the situation to manipulate an electoral process to seemingly obtain a popular mandate to accelerate the land transfers.

The ensuing “Fast Track” program that began in July 2000 was marked by violent invasions of white-owned farms in which war veterans and their sympathizers unleashed a wave of terror on the large-scale farm sector. Subsequently, legislation was passed to institutionalize the “fast track” process, adopting two key implementation models, namely Model A1 (to decongest communal areas by targeting the tribal areas suffering severe land constraints), and Model A2 (to promote agricultural commercialization at various scales) (Zikhali 2008; Muchara 2009). But in the view of the donor community in Zimbabwe who had privileged access to the ideas as the land invasions were just beginning, this process “had no goal, no plan, no timetable, no budget, no capacity and no transparency” (Kinsey 1999).While the FTLRP clearly led to substantial repossessions and transfers of land, it seemed to have created a number of other problems.

At one level, the FTLRP is blamed for directly leading to a 30% drop in agricultural production, a hyper-inflationary situation, and a 15% contraction of the economy that culminated in 2008 to an unemployment rate estimated to exceed 80% (Zikhali 2008). At the other level, the human rights abuses came to a head with members of opposition parties being victims of extreme persecution, beatings and murders. Not even the landmark ruling by the Southern African Development Community (SADC) Tribunal on the court challenge mounted by the Commercial Farmers Union of Zimbabwe could stop the farm seizures which continued unabated (SADC 2008). The installation of a transitional government of national unity in which the opposition party is playing a limited role has also not moderated the level of political intolerance. Targeted sanctions on the regime in Zimbabwe are still in place to force the regime’s hands. Whether or not these sanctions are worsening the political and economic crises in Zimbabwe is now being debated but a recent effort by the South African government to secure some easing-off of the sanctions has failed as Britain insists on seeing real changes first.

International Experience with Agricultural Mechanization

Several studies have been conducted on the impact of agricultural mechanization on production, productivity, cropping intensity, human labor employment as well as income generation for sustainable livelihoods of households. The faith in agricultural mechanization as a panacea to the production and productivity problems of Zimbabwe has its roots in the policy and theoretical developments of the last half a century drawing from the major conclusions of the induced innovation literature much of which was motivated by the seminal works of Ruttan and Hayami (1972 1984), Mellor (1973, 1984), Binswanger (1986), Binswanger and Von Braun (1991), Hayami and Ruttan (1995), among others. Arguing along those lines, Nweke (1978) observed that for post-Independence Ghana, tractor mechanization may have accounted for production expansion arising from bringing more land under cultivation.

The thinking then, as now, was that efficiency and tractor operations/ownership are highly correlated, with tractor efficiency increasing as farm size rises above 20 hectares (Nweke 1978). But possibly as a result of the perceived substantial displacement of labor and effective subsidization of agricultural machinery prices relative to labor (Mellor 1984), agricultural mechanization lost some popularity among academic economists who easily linked it to the growing unemployment in the wake of the introduction of the Basic Needs Strategy in many developing countries in the 1970s. Such sentiments have naturally resulted in considerable policy confusion as political élites have wavered between extremes depending on how loud and/or convincing the arguments have been. As a result, conflicting policy prescriptions have been given for the African agricultural mechanization problem by the academic, donor community and national governments but with little or no impact on productivity. The failure of many Government sponsored tractorization projects initiated in the late 1950's and early 1960's emboldened the critics who easily attributed the decline in agricultural productivity and growing unemployment as witnessed in Zimbabwe to farm mechanization (Salokhe and Oida 2003). Overall, it is safe to conclude that agricultural mechanization has had a chequered history in the African policy terrain and remains a questionable input in African agriculture particularly in the smallholder sector (FAO/UNIDO 2008).

Early literature on agricultural mechanization has defined it chiefly in terms of farm power and transportation. According to Binswanger (1986), agricultural mechanization implies the use of various power sources and improved farm tools and equipment, with a view to reducing the drudgery of farm work. Three main options were generally agreed for farm production and transportation of agricultural produce to markets, namely human power, animal power and the use of motors (Bordet and Rabezandrina 1996). Human, animal and machine power is believed to complement one another in the same household, farm or village, the choice being determined by local circumstances. Ultimately, farm mechanization aims to enhance the overall productivity and production at the lowest cost. Possibly in recognition of this fact, the use of agricultural machinery has grown progressively over the past two to three decades, with its popularity growing in land-surplus areas where it has been clearly demonstrated that one labor unit working with suitable machinery can afford to plough in excess of 10 hectares in a day (Chatizwa and Khumalo, 1996).

The contribution of agricultural mechanization has been well recognized in enhancing production together with irrigation, biological and chemical inputs, high yielding seed varieties, fertilizers, pesticides and mechanical energy. The Indian Green Revolution which is regarded as one of the greatest achievements of the 20th century (Madras 1975), is well-known for the manner in which it promoted the adoption of mechanization on a large scale for the benefit of small, medium and large sized farms. Effects of mechanization such as its impact on human labor employment in a labor abundant economy have always evoked sharp responses from the policy makers (Jafry 2000). The notion of "appropriate technology" has evolved as a compromise to ensure that adequate scope is provided for human labor to participate while equipment is phased in to respond to the need for expanded output at minimum human costs. But even the concern about equipment replacing human labor and thus increasing unemployment rates has been shown to be unfounded. For instance, it has been shown that agricultural mechanization led to overall increase in the employment of human labor (Chatizwa and Khumalo 1996). The reduction in aggregate labor used on tractor operated farms was quite low (1.3 to 12%) compared to bullock operated farms. The increase in employment of casual male labor was reported to be up to 38.55% and the mechanized small farms used 3.7 times more labor NCAER (1974). As Mellor (1984) noted, the role of farm machinery in shortening land preparation time has often made it possible for households to plant a second crop within the year, thus providing year-round employment for labor that would otherwise have been redundant for much of the time.

Of course, even before Mellor (1984), many researchers had observed that mechanization does not lead to decrease in human labor employment because with mechanization, the demand for hired labor increased while participation of family labor in crop production declined. Carney (1998) also indicated that net human labor displacement in agricultural operations was insignificant and it was more than compensated by increased demand for human labor due to multiple cropping, greater intensity of cultivation and higher yields. Furthermore the demand for non-farm labor for manufacturing, servicing, distribution, repair and maintenance as well as other complementary jobs substantially increased due to mechanization. As observed by Chatizwa and Jones (1997), farm mechanization displaced animal power from 60 to 100% but may have resulted in less time for farm work. Also mechanization has probably led to increase in the human labor employment for the on-farm and off-farm activities as a result of manufacture, repair, servicing and sales of tractors and improved farm equipment (Farrington, 1985).

Over the past half a century developing regions, with the exception of Sub-Saharan Africa, have seen labor-saving technologies being adopted at unprecedented levels (Jafry 2000). Intensification of production systems created labor bottlenecks around land preparation, harvesting and threshing operations. Alleviating these labor bottlenecks with the adoption of mechanical technologies has been linked to the enhancement of agricultural productivity and lowering of the unit cost of crop production even in the densely populated countries such as China (Bergmann 1978). Economic growth and the commercialization of agricultural systems are leading to further mechanization of agricultural systems in Asia and Latin America (Rijk 1999). Sub-Saharan Africa continues to have very low levels of mechanization and available data indicate declining rather than increasing levels of adoption, even among the countries that were the early trendsetters, such as Kenya and Zimbabwe (Binswanger 1978; FAO/UNIDO 2008). Granted that the recent macroeconomic history in many of these countries may account for the low adoption rates, but the fact remains that many of them were already under-performing even before the economic crisis of the 1980s and 1990s.

According to FAO (2000), the general trend is that agricultural production in most African countries still relies on the centuries- old hand tool technology. Whereas, everybody agrees that this has to change, the main question has been on how the change should come about. One question that has often been posed (Binswanger 1978) is: should African countries go through the evolutionary path from hand tool through animal powered to mechanically-powered agricultural mechanization as it has happened in the developed countries, or should they aim at skipping the intermediate stage of animal powered mechanization? The experience of seven African countries (Botswana, Ghana, Kenya, Nigeria, Swaziland, Tanzania and Zambia) in agricultural mechanization policy confirms that these have failed to yield positive results (FAO 2000).

Sticking to the wholly optimistic and positive view, various researchers have concluded that farm mechanization has managed to achieve enhancement of the production and productivity of different crops due to timeliness of operations, better quality of operations and precision in the application of the inputs. Madras (1975) found that the productivity increase on tractor owning and hiring farms ranged between 4.1 and 54.8 %. The % increase was comparatively low on non-mechanized farms as compared to tractor-owning farms due to higher level of inputs and better control on timeliness of operations. These productivity increases were attributed to higher doses of fertilizer, irrigation and mechanization (Bina 1983). Several studies have indicated that there was significant increase in cropping intensity due to the use of tractors and irrigation as a consequence of mechanization. The increase in cropping intensity has been reported to be 165, 156 and 149 %, respectively for tractor-owning, tractor using and bullock operated farms respectively (NCAER 1980). Similar results have been reported in other studies which concluded that as a consequence of mechanization, cropping intensity increased significantly. Furthermore, irrigation and mechanical power helped the farmers in raising the cropping intensity of their farms (Patil & Sirohi 1987). Singh (2001a and 2001b) concluded that cropping intensity was mainly dependent on annual water availability and nature of the farm power available.

Farm mechanization has been credited with the significant improvement of the economic circumstances of farming communities in which this technology has been popular. Tractor owners and users derived higher per hectare gross income compared to traditional subsistence farms (NCAER, 1980). The gross income per hectare was reported to be about 63% higher on tractor owning farms compared to the traditional farms. The average net return from a tractor owning farm on per hectare basis was reported to be 152% that of a non-tractor owning farm (Chopra, 1974).

The Model

This study applies the Stochastic Frontier Model to estimate farm level technical efficiency with particular focus on the contribution of the agricultural mechanization program towards the attainment of the goals of the fast track land reform program of the Government of Zimbabwe. The model is based on the Cobb-Douglas model in which capital represents various forms of non-labor inputs, including mechanical power. While there are many other factors affecting economic performance and technical efficiency, the flexibility of the Cobb-Douglas model makes it a very convenient for modeling technical efficiency. The formal model is generalized as:

(1) $Q = AL^{\alpha} K^{b}$

Where:

Q is output,

A, α, b are constants, and

L and K are labor and capital, respectively.

Capital can be interchanged with labor without affecting output. Or

(2) $P(L,K) = bL^{\alpha} K^{b}$

Where:

P = total production (the monetary value of all the produce or goods produced in a year)
L = labor input (the total number of person-hours worked in a year)
K = capital input (the monetary worth of all machinery, equipment, and buildings)
b = total factor productivity

The terms α and *b* are the output elasticities of labor and capital, respectively. These values are constants determined by available technology. Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production, ceteris paribus.

Applying the foregoing relationships to the case under consideration, the stochastic frontier production function can be specified as:

(3) $Y_i = f\left(L_{it}, K_{it}, X_{it}; A; e_i\right)$

where Y_i is the output by farmer *i*, and L_{it}, and K_{it} are Labor and Capital inputs as defined in equation (2) above, X_{it} represents a range of other factors deployed by the farmer, including locational and seasonal dummies, while *A* is a vector of parameters, and e_i is the disturbance term. The Stochastic Frontier Analysis (SFA) assumes that the disturbance term consists of two components, a stochastic error component *V* which is assumed to be symmetric, depicts the random variation of the production function from one farm to the other, and may be due to such factors as measurement error and factors that the farmer cannot control. On the other hand, the second error component, *U*, represents the technical inefficiency relative to the optimum.
Defined in logarithmic form, the stochastic frontier production function in this case can be expressed as:

(4) $\ln\left(Y_{it}\right) = \beta_0 + \beta_1 \ln(L_{it}) + \beta_2 \ln\left(K_{it}\right) + ... + \beta_n \ln\left(X_{it}\right) + V_{it} - U_{it}$

Where the subscripts *i* and *t* refer to the *i-th* farmer and *t-th* observation, respectively, and Ln is the natural logarithm

Y represents the total value of farm output in 2008 in monetary units (US$).

L, K, X are the inputs of labor, capital, and others, respectively. Labor and equipment use were inserted in the model as a dummy where 1= mechanical power used and 0=no mechanical power used (meaning operations were labor-based). The *X's* represented all the other factors such as age, land, fertilizer, seed, output of the two principal crops maize and soybean, livestock and irrigation that formed part of the production package.

β's are the regression coefficients or parameters to be estimated, and

$V_{it} - U_{it}$. constitute the disturbance term or errors, .

The Data

The variables collected in the field survey are presented in Table 1 and explained below.

GINC: Refers to total gross household income in 2008. Gross value of annual farm production from crops and livestock. It is hypothesized that low values signify lack of machinery, finance and access to vital resources.

AGE: this variable measures the actual age of the household head in years. Younger farmers are expected to be more mechanically constrained than older farmers who are perceived to have acquired enough wealth to access these resources. Therefore, it is hypothesized that age of household head and machinery access are positively correlated. This is supported by an observation by Mushunje, Belete and Fraser (2003) that older farmers are likely to have more resources at their disposal.

LAND: This variable refers to the size of farm land in hectares. Increase in land size may enhance production if the land is effectively utilized. At the same time, land may be available but not being effectively utilized. Effective utilization will entail application of appropriate farm practices that will lead to higher physical output than otherwise would be the case. In the absence of more direct means of assessing effectiveness, this can only be inferred from the results. Intuitively, one can expect higher output if there is effective utilization of available land, and lower output otherwise. It is also reasonable to expect that the more physical output a farmer produces, the more surplus is marketed, and hence higher gross farm income.

FERT**:** A number of studies have established that fertilizer usage is positively related to productivity (Reardon *et al.,* 1996; Xu, Guan, Jayne and Black, 2009). Conversely, a farm unit that is too constrained to afford adequate amounts of fertilizer will most probably experience lower productivity which will translate to lower physical output.

SEED: this variable refers to farm inputs such as hybrid seeds, pesticides and chemicals. It is hypothesized that farmers with inadequate inputs are less likely to achieve higher levels of production leading to lack the purchasing power for machinery and equipment.

TOTPRDMZ: Physical production of maize in kg. It is hypothesized that the total physical output of maize is positively associated with the gross farm income and explains differences in income between farming households. The physical production of maize will also be related to the area cultivated which will equally be a function of the availability of mechanical power required to bring more land under cultivation that would otherwise be the case.

TOTPRDSB: Physical production of soybean in kg. It is hypothesized that the total physical output of soybean is positively associated with the gross farm income and explains differences in income between farming households. The physical production of soybean will also be related to the area cultivated which will equally be a function of the availability of mechanical power required to bring more land under cultivation than would otherwise be the case. As a leguminous crop, it is obviously a high value crop with high potential contribution to household earning from farming.

LVSTK: Whether or not farmer kept livestock. Livestock farming is important in many parts of Mashonaland Central Province of Zimbabwe although as much as 50% of the population live in the so-called "high potential zone" where crop production is important. Livestock is kept principally for draught power, milk, meat and marginally as a source of income. There is no doubt that livestock plays a positive economic role in Zimbabwe and it is hypothesized that a positive relationship will exist between livestock ownership and gross farm income for farming households.

MECH: Whether farmer used equipment and machinery. This is calibrated as a dummy as shown in Table 1. Despite the agricultural mechanization program being described as "…the largest in the whole of Africa", not all farmers have access as would be expected. The hypothesized relationship between use of machinery and gross income is a positive one and it is expected that farmers using equipment would bring more land under cultivation and potentially realize larger revenues that those who did not.

Table 1. Definition and units of measurements of key variables modeled

Dependent Variable	**Definition**	**Value**	**Hypothesized Relationships**
GINC	Gross Farm Income	Continuous	
Independent Variables	Definition	Value	
GENDER	Gender of the household head	A dummy variable coded 1 if male and 0 otherwise.	+/-
AGE	Age of the household head in years	Actual age in years	+/-
TOTPRDMZ	Physical production of maize in kg	Continuous	+
TOTPRDSB	Physical production of soybean in kg	Continuous	+
FERT	Expenditure on fertilizer in US$	Continuous	+
SEED	Expenditure on seeds in US$	Continuous	+
LVSTK	Whether farmer kept livestock	A Dummy variable = 1 if the farmer kept livestock; 0 otherwise	+
MECH	Whether farmer used equipment and machinery	A dummy variable coded 1 if farmer used equipment and machinery and 0 otherwise	+
LAND	Area cultivated by farmer in hectares	Continuous	+
IRR	Use of Irrigation for farming	Coded 1 if the farmer uses irrigation, and 0 otherwise	+

Source: Field study. 2009.

IRR: Use of Irrigation for farming was calibrated as a dummy. Part of the agricultural mechanization program is the development of irrigation facilities and rehabilitation/maintenance of existing ones. Water availability has always been a challenge especially in the regions 3-5 of the province. It is hypothesized that farmers using irrigation with have higher gross farm income than those who do not use irrigation for crop production.

Data Collection Methods

The study was undertaken in the Mashonaland Central Province of Zimbabwe within the Bindura District which is one of the seven districts of the province. These districts are well-known for their large areas of good crop land, especially in the districts of Mazowe, Bindura and Guruve. Fine grained archaelian rocks, granodiorites soils with pockets of dolerite and gneiss are predominant in the study area. The underlying geology has a marked influence on soils in the study area, which are mostly sandy fersialitic soils with inherent low fertility and low water holding capacity (Nyamapfene, 1991). Masembura and Musana communal areas are the preferred study sites because they are contiguous to the other land reform typology, namely the resettlement areas, targeted by this study. These communal areas are dominated by the Miombo woodlands, and most predominantly bush land with canopy 28–80%. Musana communal area is particularly characterized by more intensive cultivation of horticultural crops and mixed rangelands than woodlands.

Both primary and secondary data were employed. For the secondary data, consultations were held at the provincial level with officials of the Ministries of Agriculture (Arex), Lands and Resettlement, Local Government and Agricultural Engineering and Mechanization. These consultations were of immense help in accessing previous studies conducted in the study area, on related subjects, as well as gaining insights into current and prospective policy initiatives for the area and the sector as a whole. In general, data and information obtained at this stage were helpful for profiling and gaining a deeper understanding of the study area. The Voters' Roll was another source of information on the broad demographics (GoZ, 2008).For the primary data, the focus was the southern part of the district between latitudes $17^{0}\ 17'$ and $17^{0}\ 30'$ which enclosed the key communal areas of Masembura and Musana as well as some Resettlement Areas, including the Simoona Estate.

Although this is a relatively extensive area with 18 rural electoral wards and an estimated population of 108,396 (Oxfam, 2000), only 50 farms were set aside for the land reform process, with about 2300 persons identified in the voters' roll as beneficiaries (GoZ, 2008). According to the FAO (2008), a considerable degree of absenteeism among the land reform beneficiaries has been identified as one of the most serious problems affecting the effectiveness of the land reform program; many of the farmers simply disappeared after being allocated land. For the resource-poor communal farmers, the situation was complicated by their lack of access to vital production inputs which resulted in many of them abandoning the newly allocated farms (FAO, 2008). For this reason, the present study defined a narrower sampling frame comprising land reform beneficiaries who were actually confirmed by the village chief to be residing within the area at the time of the study. Within this group, the study defined another sub-group, in line with the study objectives, comprising land reform beneficiaries who were recipients of further government assistance in the form of farm machinery. As was observed in the case of the larger groups above where access difficulties were severe, this group was similarly handicapped by non-availability of the promised machinery. According to a study conducted under the auspices of the African Institute for Agrarian Studies (Moyo et al. 2009), access to animal-drawn equipment ranged from as low as 4% to a little under 49% of the beneficiaries, while access to tractors and motorized equipment could only be guaranteed for between 2.5 – 8% of the land reform beneficiaries. This group was purposively identified and sub-divided into two further sub-groups, namely farmers with cattle and ox drawn machinery and farmers with tractor drawn or powered machinery. The active farming population targeted by this study was therefore considerably less than 1000. Other studies conducted in the same area, notably Foti et al. (2007), encountered similar shortfalls in farmer population. A random sample of 30 farmers was drawn from each of the sub-groups to give 60 farmers who benefitted from land reform and received farm equipment of one type or another. A final group comprised farmers without machinery or were non beneficiaries of the mechanization program. Another random sample of 30 farmers was drawn from this group. The overall sample of 90 farmers drawn from both communal and resettlement areas of Bindura district therefore represents about 10% of the target population if the figure of 1000 active farmers confirmed by the local chiefs.

For the purpose of collecting the primary data, the study implemented a systematic and multi-pronged data collection procedure. A single-visit farmer survey based on a structured questionnaire was employed to generate demographic, production and marketing information that varied from household to household. Table 1 above presents the relevant data collected by this process. Group meetings and focus groups were also conducted to generate community-level data as well as supplement information obtained from the extension personnel and official sources in respect to broader patterns and trends that have implications for the agricultural sector in general. The group meetings and focus groups were guided by checklists and discussion points developed on the basis of initial situational surveys, literature reviews and personal experience. Special arrangements made to improve interview effectiveness and data accuracy included prior intensive training of the enumerators and the use of local guides wherever necessary. Within the communities, meetings were held with the village chiefs during which they were fully briefed about the purpose of the study and their approval obtained well in advance. At the end of the study, before the departure of the team from the district, feedback sessions were also held in the villages.

The province has one of the most productive communal lands, producing both food and cash crops. Maize is the dominant crop; however the main sources of income include cotton, tobacco, sunflower, soya bean and sugar bean production. Employment on A1 (small scale resettlement) and commercial farms is also an alternative source of livelihood. Poor households depend equally on their own crops, daily wages from casual labor, selling of sugar cane and gold panning. In general, crop production (food and cash crops), livestock rearing or a combination constitutes the primary livelihoods in the rural provinces. These livelihood options in turn define most of the secondary livelihood options – such as employment on commercial farms and game reserves.

Estimation and Results

The estimates of the maximum likelihood ratios for the parameters in the single equation reduced form proposed in equation (3) above are presented in Table 2. Table 2 presents results with respect to the extent of technical efficiency in the communal farming system under a farm mechanization regime. Looking at Table 2 specifically, it is clear that land ownership and use of mechanical power are important contributors to the gross income of smallholder farmers, without prejudice to the absolute levels of incomes eventually attained. The indication is also that purchased inputs such as seeds and fertilizer strongly influence gross income in the farming system studied. The negative coefficients for Soybean output and seed are interesting and probably reflect the competition between the main crop maize, as the principal crop, and soybean which still represented an alien crop to the majority of the black farmers, especially the resource-poor farmers operating in the communal areas. It is understandable that inadequate knowledge about the agronomic characteristics of soybean, leading to the application of sub-optimal practices for its cultivation, may account for its negative influence on the gross farm income for the communal farmers. Seed costs had risen quite sharply in the period covered by the study and were a major disincentive to small farmer development under the fast track land reform in Zimbabwe.

Table 2. Stochastic frontier maximum likelihood estimates

Ginc	Coef	Std. Err	Z	p>|z|	95% Coef. Interval	
GENDER	42.49213	56.0706	0.76	0.449	-67.40421	152.3885
AGE ACTUAL	-1.804542	2.273684	-0.79	0.427	-6.260882	2.651798
TOT PROD MZ	.1517116	.0217881	6.69	0.000***	.1090077	.1944156
TOT PROD SB	-.4569862	.0604846	-7.56	0.000***	-.5755338	-.3384386
FERT	.7127523	.2765718	2.58	0.010***	.1706815	1.254823
SEED	-15.52525	3.039578	-5.11	0.000***	-21.48271	-9.567789
LAND	347.9645	63.21514	5.50	0.000***	224.0651	471.8639
LVSTK	-68.52655	56.23232	-1.22	0.223	-178.7399	41.68677
MECH	134.5086	66.01683	2.04	0.042**	5.118034	263.8992
IRRIGATION	93.83527	73.69449	1.27	0.203	-50.60327	238.2738
-CONS	8.883757	3202.386	0.00	0.998	-6267.678	6285.446
|INSIG2V	10.81111	.1491386	72.49	0.000	10.51881	11.10342
|INSIG2U	-5.148053	105240.8	-0.00	1.000	-206273.4	206263.1
SIGMA-V	222.6399	16.6021			192.3665	257.6775
SIGMA-U	.076228	4011.15			0	
SIGMA2	49568.54	7399.489			35065.81	64071.27
LAMBDA	.0003424	4011.683			-7862.754	7862.754

Likelihood-ratio test of sigma-u=0: chibar2(01)=0.00 prob>=chibar2=1.000

Significance denoted as follows: * (10%), **(5%), and ***(1%).

But from the point of view of technical efficiency, the lower panel statistic denoting "Insig2V" and "Insig2U" yield more policy-relevant information. Based on the relationship depicted in equation (3) above, it is obvious that the estimates indicate high random errors with the high variance of the random component. Further, the "rho", calculated by the formula:

$$(5) \qquad rho = (SIGMA\_U)^2 \Big/ \left((SIGMA\_U)^2 + 1\right)$$

is almost close to zero, at 0.00577 (not different from zero). Given that the LR test actually tests the hypothesis that "rho" =0 (see Table 2 above), and "rho" gives the proportion of the total variance contributed by the variance components, it can be concluded that all the variance in the estimates come from the variables themselves and not due to error. This would suggest high degrees of inefficiencies in resource use in the smallholder system. Thus, while mechanization and land reform can potentially contribute to gross income growth, there is clear evidence of sub-optimal resource utilization which is consistent with generally-held views about the arbitrariness and poor planning that have characterized Zimbabwe's recent economic management processes. Recent evidence from other parts of Zimbabwe (Obi, 2010) has shown that without proper plan-

ning, land reform can lead to supply bottlenecks as a result of declining productivity and production. Some of the effects have already been felt in the weakening of the primary markets that serve smallholders, with negative consequences for smallholder livelihoods and welfare.
Since the functional form of the model cannot be definitively predicted by visual inspection, a multivariate Ordinary Least Squares (OLS) model was fitted and the results are presented in Table 3.

Table 3. Multivariate regression results

	Coef	Std. Err	t	p>|t|	95% conf. interval	
GINC						
GENDER	44.99384	49.0565	0.92	0.362	-52.6317	142.6194
AGE ACTUAL	-1.64166	1.011684	-1.62	0.109	-3.654974	.3716549
TOT PROD MZ	.1513992	.0227257	6.66	0.000***	.1061735	.1966248
TOT PROD SB	-.4568934	.0641437	-7.12	0.000	-.5845435	-.3292434
FERT	.7157122	.2906488	2.46	0.016**	.1373028	1.294122
SEED	-15.52149	3.223673	-4.81	0.000***	-21.9368	-9.106173
LAND	348.2635	66.93156	5.20	0.000***	215.0655	481.4616
LVSTK	-67.95647	59.15114	-1.15	0.254	-185.6709	49.7581
MECH	134.5513	70.0215	1.92	0.058*	-4.795972	273.8985
IRRIGATION	94.56949	77.5421	1.22	0.226	-59.7442	248.8832

Significance denoted as follows: * (10%), **(5%), and ***(1%).
Number of obs=90
F (10, 79)=58.33
Prob > F=0.0000
R-squared=0.8807
Adj R-squared=0.8656

Ultimately, these two models serve different purposes which need to be explained. While Table 2 presents results with respect to technical efficiency, Table 3 present insights into the determinants of technical efficiency in the Zimbabwean smallholder sector under land reform and agricultural mechanization of the type described in this paper. Furthermore, Table 3 provides the indication that the model is more or less linear and that most of the gross income earned in the smallholder sector examined are explained by the model. As indicated earlier, Table 3 presents the results of the multivariate OLS which are close enough to the frontier estimates to suggest a generally linear model. Thus, if all that was needed was to explain the causation of gross income in the farming system, a linear model of this sort would have sufficed. The model fit is also adequate, both in terms of the whole model and the individual regression coefficients. The R-Squared value of 88% which adjusted to 86% suggests a good-fit, while the F-statistic of more than 58 confirms a whole model adequacy.

Implications of Results for Agribusiness Management

The foregoing results have far-reaching and important practical implications for agribusiness management. An obvious point from the results is the glaring government failure in introducing a mechanization program at a scale that is inappropriate to the realities of the farming system. While the estimates suggest that the system was technically efficient, the sector exhibited pronounced shortfall in output which resulted in hyper-inflation. A possible reason for such a paradox was low capacity utilization. The positive contribution of farm mechanization to enhanced labor and land efficiency is not questionable, but the mechanization program must be appropriate to the situation of the farmers, including the availability of complementary inputs and a ready market for the produce as incentive to expand production. As a matter of historical fact, the situation in Zimbabwe during the period under investigation was the exact opposite of what would have been required to enhance the effectiveness of a farm mechanization program. The evidence was that the government was unable to finance broader development imperatives which resulted in an acute shortage of essential inputs, equipment and spares. Human resource constraints were also so severe that crucial agricultural support services could not be provided in a timely manner if at all. At the same time, government imposed severe restrictions on cross-border trading in the staple maize crop. The country thus found itself in a low-equilibrium trap of proportions unheard of in other than a war context. As production economics theory (initially, Nelson, 1956) makes clear, low-equilibrium traps occur where output is falling while prices and wage rates are rising in both farm and non-farm sectors, and no costless re-allocation of resources is possible. In such a situation, external intervention such as technological and institutional innovations may be necessary to bring about the desired improvements.

The foregoing results obviously present immense opportunities for the private sector. The crucial areas of input supply, logistics (particularly in haulage of inputs and produce) and extension, have traditionally featured a high degree of governmental involvement, which explains why government failure would have such a devastating effect. The participation of the private sector in these areas will go a long way towards relieving a large part of the bottlenecks that farmers were experiencing at that time. Market pricing of the farm machinery input would also contribute to more efficient deployment of this resource according to the real need. The Zimbabwean situation also presented a scenario that lent itself to the testing of alternative innovative organizational arrangements among farmers to pool resources and rationalize costs, including the consolidation of land and implementation of variants of group farming to the extent that existing norms allowed.

Conclusion

The primary aim of this paper was to carry out a limited evaluation of two key agricultural development programs implemented within the last decade in Zimbabwe, namely the fast track land reform program and the agricultural mechanization program. The intention was to examine how these programs have impacted on the smallholder sector in terms of their importance in explaining variations in earnings. Related to this was the need to ascertain the extent to which the sector has made use of the opportunity afforded for enhanced access to the vital resources of land and farm machinery. This latter aim referred to the issue of technical efficiency which was examined indirectly without any attempt to relate observed productivity to any norms since such norms will at best be only subjective. The procedure of examining technical efficiency in terms of contributions of error variance components to total variance is justified by the fact that more direct approaches would call upon data that for Zimbabwe have become highly unreliable and contestable in the wake of the considerable degree of political interference into even the most common-place and basic human processes.

The study does find that the expected positive relationships between key productive inputs and farm performance still hold for Zimbabwe. It was found that, despite considerable political interference, Zimbabwe's agricultural production is still amenable to objective economic analysis. This is important for policy since it confirms that incentive mechanisms can still be effectively manipulated to achieve real growth if attention is paid to the rational allocation principles devoid of political influence as has been the case in recent years. What seems to be lacking, as confirmed by a large number of other studies (Obi, 2010), is proper planning. Without a doubt, proper planning is non-negotiable for a land reform program to successfully deliver the benefits of equitable distribution of land and enhanced agricultural productivity. As well, a farm mechanization program requires that needs are more precisely determined in terms of the nature of equipment required for particular purposes and environments. It smacks of unbridled politicization when the senior government functionary quoted earlier boasts of Zimbabwe having the "largest farm mechanization program in the whole of Africa". There is definitely a mismatch there and an anxiety to appeal to sectional sentiments. As serious as Zimbabwe's economic crisis can be, it does not qualify to mount the largest farm mechanization program on the continent where most of the beneficiaries of the land reform program are either absent from the farms or lack the skills to utilize the resources put at their disposal. It is also unclear how Zimbabwe can afford to finance the "largest farm mechanization program in the whole of Africa".

Increased technical efficiency at the production level is also meaningless in the absence of enhanced market access. And profitable marketing is impossible in the absence of goods and services. So there is a two-way link. Anything that chokes off supply of physical output is bound to weaken primary markets serving the poor. Policies to empower small farmers by re-distributing land in order to boost food production and link them to markets must undoubtedly be sensitive to these issues. There are opportunities for private sector involvement to fill gaps in input supply, shortage of extension services, and inadequate facilities for haulage of inputs and outputs to facilitate market access in order to provide positive incentive to farmers to expand production. There is also a role for collective innovation in agriculture and agribusiness management to take advantage of all these opportunities.

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