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Why Liberalization Alone Has Not Improved Agricultural Productivity in Zambia

The Role of Asset Ownership and Working Capital Constraints

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Policies to foster accumulation of the assets needed for agricultural production (including draft animals and implements) and to provide complementary public goods (education, credit, and good agricultural extension services) could greatly help reduce poverty and improve productivity in Zambia.

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Summary findings

Deininger and Olinto use a large panel data set from Zambia to examine factors that could explain the relatively lackluster performance of the country's agricultural sector after liberalization. Zambia's liberalization significantly opened the economy but failed to alter the structure of production or help realize efficiency gains. They reach two main conclusions.

First, not owning productive assets (in Zambia, draft animals and implements) limits improvements in agricultural productivity and household welfare. Owning oxen increases income directly, allows farmers to till their fields efficiently when rain is delayed, increases the area cultivated, and improves access to credit and fertilizer markets.

Second, the authors reject the hypothesis that the application of fertilizer is unprofitable because of high input prices. Rather, fertilizer use appears to have declined because of constraints on supplies, which government intervention exacerbated instead of alleviating. (Extending the use of fertilizer to the many producers not currently using it would be profitable, but increasing the amount applied by the few producers who now have access to it would not be.)

Policies to foster accumulation of the assets needed for agricultural production (including draft animals and implements) and to provide complementary public goods (education, credit, and good agricultural extension services) could greatly help reduce poverty and improve productivity.

This paper — a product of Rural Development, Development Research Group — is part of a larger effort in the group to analyze determinants of rural growth and market participation. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Maria Fernandez, room MC3-508, telephone 202-473-3766, fax 202-522-1151, email address mfernandez2@worldbank.org. Policy Research Working Papers are also posted on the Web at www.worldbank.org/research/workingpapers. The authors may be contacted at kdeininger@worldbank.org or polinto@worldbank.org. March 2000. (22 pages)

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1. INTRODUCTION

In the early 1990s, Zambia initiated an ambitious program of liberalization that significantly opened the economy, shifting from a highly regulated and centralized to a more market-based and liberal economic paradigm. While these changes have profoundly affected the economic environment for the agricultural sector, they have up to now failed to alter the structure of production and help realize the efficiency gains that were expected to be associated with economic liberalization. The rural economy continues to be highly dependent on maize, producers' participation in markets for input as well as output has hardly increased, credit remains out of the reach of the ordinary producer, and no appreciable change in investment can be discerned.

This paper examines whether this disappointing performance is due to the fact that reforms undermined the profitability of agricultural production or due to other factors, such as market imperfections and structural limitations at the household level. This is important for policy advice because, depending on which of these two possibilities is correct, different forms of policy intervention would be appropriate – either price measures to improve the profitability of farming or non-price policies aiming facilitating increased private sector involvement combined with better provision of public goods.

We analyze this issue using data from a two-year panel of about 5000 rural households. Panel data econometric methods allow us to overcome the biases inherent in cross sectional analysis and, from estimation of a production function plus associated demand equation for land, fertilizer, and credit, make inferences regarding the productivity of different factors. Our main results are as follows:

- Fertilizer has a significant output-increasing effect. While extending fertilizer use to the large number of producers who are currently not using this input would be highly profitable economically, increasing the amount actually *applied* by the small number of producers with access to this input is not profitable.

- Cattle ownership increases income directly, acts as an "insurance" by allowing producers to till their fields in a more timely fashion in times of delayed rain, increases area of land cultivated, and improves access to credit and fertilizer markets. This points towards the persistence of significant imperfections in markets for rural labor, credit, and draught animals, but at the same time suggests that policies to increase cattle ownership in rural areas could have high payoffs.

- We find, somewhat surprisingly, that credit has a direct productivity increasing effect – most likely through supervision that is associated with it. This notwithstanding, the main impact of credit is through increases in cultivated area and –as in the case of fertilizer– major benefits are likely to be realized by providing access to producers who do currently not have access to any credit.

- In terms of total factor productivity, female headed households are as productive as male headed households. They are, however, disadvantaged with respect to credit access and, partly as a consequence, use less land and fertilizer. This could point towards labor market imperfections or higher risk aversion on the part of these households.

- Supply of extension has a positive, though insignificant, impact on total factor productivity and no significant impact on demand for cultivated area. Improving the quality of extension and gearing it more to be in line with Zambia's relative factor endowment would thus be a necessary precondition for the expansion of such services to be justified economically.

- Once other inputs are accounted for, education does not affect productivity or the amount of area cultivated. However, education enables farmers to overcome market imperfections, as reflected in the fact that more educated farmers demand higher amounts of fertilizer and credit per hectare, tend to be more integrated into output markets.

Section two describes the sectoral background and, in this context, posits the key question to be investigated and the relationship to earlier literature. A detailed discussion of the conceptual model and estimation issues follows in section three. Section four discusses data issues and empirical results. Section five concludes by reviewing implications for policy and further research.

2. SECTOR BACKGROUND AND DATA SOURCES

Despite an abundant land resource (75 million hectares, 55% of which are suitable for agricultural production) favorable agro-climatic endowment, and low population density (a total of 9 million people out of which slightly less than 6 million live in rural areas), Zambia has long neglected its rural population and agricultural sector.

At the macro level, almost exclusive reliance on copper for exports, industrial protection, overvalued exchange rates, and unsustainable fiscal policies all contributed to a long-term decline of the productive infrastructure in a country that had, in the early 1960s, a per capita GDP higher than Korea.

These macro-economic policies were complemented by unsustainable government interventions at the sectoral level (Jansen 1991). Producer subsidies for fertilizer and maize led to the extension of maize cultivation into unsuitable areas which increased vulnerability to drought, distorted factor prices, and biased the direction of research away from high value export crops to staples with low profitability. Although Zambia does not have a strong comparative advantage in bulk commodities, more than 50% of research and extension resources were regularly devoted to maize, mainly because of price distortions introduced by government policies (World Bank, 1992). As a result, Zambia lost ground even in production of commodities (e.g. tobacco) where it had once been a leading producer in the region (Keyser 1996).

In addition, consumer subsidies posed a huge fiscal burden. Between 1971 and 1988 the average subsidy to consumers amounted to about 70% of the price of maize meal maize related subsidies accounted for almost 20% of total government spending in the 1980s (McPherson, 1995) Pan-territorial and pan-seasonal pricing, together with state monopoly trading, distorted incentives for private sector storage and helped to establish an inefficient marketing and processing structure. Credit subsidies biased investment decisions, discouraged savings mobilization, and undermined the viability of an independent financial system - real interest rates were negative throughout the 1981-93 period, with a peak of -137% in 1992 (World Bank 1992).

Following a number of aborted attempts at reform (e.g. Jansen and Ruvumo 1992; McPherson 1995), the government that took power in 1991 initiated a series of far-reaching macro-economic and sectoral reforms including the elimination of subsidies, privatization, and greater decentralization. From our perspective, two issues are of relevance. First, the reductions in maize prices together with the increases in fertilizer prices caused by the elimination of subsidies unambiguously worsened the terms of trade for the agricultural sector. Second, withdrawal of government procurement and distribution agents was supposed to open up space for the private sector to exploit profit opportunities – but this was countervailed by continued ad-hoc involvement by the public sector which greatly undermined predictability for the public sector.

Conceptual models predict that these reforms should lead to a major shift of producers out of maize (Holden, Taylor, and Hampton 1999) and emergence of a private trading sector that would realize significant welfare gains (Mwanaumo, Masters, and Preckel 1997). However, little of this has materialized, owing mainly to the fact that adjustment was associated with reductions in input use rather than changes in the quantity or mix of output. On the output side, between 1990 and 1996 Zambia's rural households continued to produce mainly for subsistence (only about 40% sold in the market, virtually unchanged from 1991), rural incomes remained backward and low (about one third urban households), and no diversification out of maize took place in response to changed price signals – the share of area planted to maize in 1996 and 1997 was higher than it had been in 1990. Changes in input prices had not only a marked effect on application of inputs; use of hybrid seed and fertilizer use was reduced by one half and one third, respectively, they were also associated with a reduction in farmers' capital stock. Partly due to a drought in 1992 from which the sector has yet to recover, the percentage of producers owning livestock decreased by almost one third (from 18% to 12%) between 1992 and 1996. It appears that policy reforms have contributed to stagnation or even regression, instead of helping Zambia's agricultural sector realize the strong regional growth linkages that have been demonstrated in the literature (Hazell and Hojjati 1995).

The question whether this disappointing performance is due to the fact that reforms undermined the profitability of agricultural production or due to other factors, such as market imperfections and structural limitations at the household level, that prevent a more vigorous supply response is of considerable policy relevance. We aim to provide and answer by focusing on two aspects. First, we are interested whether producers apply variable inputs in a profit-maximizing fashion. Second, we aim to identify structural determinants of factors demand that may underlie such inefficient allocation, if it exists. In doing so we examine variables at the household level (education, female headship, asset endowments) and in the broader market environment (extension, access to infrastructure).

While none of these issues are new, our approach improves on previous literature by using a larger sample and applying panel data econometric techniques. A number of contributions (Hatting et al. 1998, Savadogo et al. 1995, etc.) have demonstrated that farm level data can provide useful insights to examine these issues. However, these studies are characterized by small samples (122 and 150 households, respectively), a restricted set of variables (e.g. no information on household education, non-agricultural assets, or soil quality is available), and reliance on cross-sectional analysis. This limits not only the ability to generalize from the results obtained and make broader inferences but, more importantly, may also bias the results significantly. The reason is that there is likely to be a strong correlation between the large number of unobserved household and farm characteristics and input use. As, to take just one example, more educated farmers would tend to use inputs more intensively, the coefficients on observed inputs in a traditional production function will be biased upwards. Thus, the impact of purchased inputs would be overstated and cross-sectional evidence alone would appear to suggest that farmers "underuse" these inputs.

To overcome these limitations of cross-sectional analysis, we apply panel data techniques. Under the condition that farmers' unobserved characteristics are time-invariant, use of panel data techniques allows to overcome these limitations that have plagued the earlier literature and are likely to have led to an upward bias on the coefficients for purchased inputs. Instead of making it appear these inputs are more effective and farmers inefficient in not applying the optimal quantities, they allow to retrieve structural parameters regarding the impact of specific inputs in the production function. Furthermore, use of instrumental variable estimators allows us to estimate the impact of time invariant productivity shifters such as producers' endowments of physical assets, human capital, and their access to public services. Both the structural parameters for specific inputs and the productivity shifters enable us to derive more precise policy recommendations.

Instead of relying on a survey that was specifically fielded for this purpose and the small sample that is generally associated with such efforts, we use data on farm production from a panel of 4853 farm households from the Central Statistical Office's Post Harvest Surveys for 1993/94 and1994/95. The data were collected sufficiently long after initiation of the reforms for them to have shown at least some impact. While the time period covered is rather short, it coincides with significant variability in the economic and agro-climatic environment such as the final closure of official credit institutions, and a drought in 1994/95. As a result, there is sufficient "within" household variation in input use for panel data methods to be meaningful and allowing us to estimate a production function and input demand functions for labor, fertilizer, and credit. Before describing the data in detail, we discuss the conceptual model and estimation issues.

3. MODEL AND ESTIMATION ISSUES

Conceptual Framework

Consider a household i that at time t may undertake production employing a *Cobb-Douglas* technology given by:

$$(1) \qquad \ln(Y_{it}) = \ln(A_{it}) + \beta_1 \ln(T_{it}) + \beta_2 \ln(F_{it} + 1),$$

where T_{it} is the total area cultivated, F_{it} is the total amount of fertilizer applied, A_{it} is an index that measures the total factor productivity (TFP) achieved by household i at time t, and β_1 and β_2 are technology parameters assumed to be constants across households and time. For simplicity we assume that other inputs--as labor effort, seeds, mechanical and animal power--are employed in fixed proportions to the cultivated area, i.e. T_{it} represents the area of prepared and planted land.[1]

We assume that the TFP index A_{it} is determined by household/farm i's observed and unobserved characteristics at time t, specifying the following log-linear equation for A_{it}:

$$(2) \qquad \ln(A_{it}) = \alpha_0 + \alpha_1' \boldsymbol{X}_{it} + \alpha_2' \boldsymbol{Z}_i + \eta_i + \mu_{it}.$$

In (2), $\boldsymbol{X}_{it}$ and $\boldsymbol{Z}_i$ are vectors of observed household/farm specific time-variant and invariant characteristics, respectively, which will be described below. The error term in (2) has two components: (i) η_i is a household/farm specific time-invariant effect, which is known to the household at the time production decisions are made, but is unknown to the econometrician; and (ii) the stochastic exogenous shock μ_{it}, which is assumed to be independent and identically distributed (iid) across households and time, and is observed neither by the households nor the econometrician. For tractability we assume that the decision making household's conditional expectation of $\exp(\mu_{it})$ given $\boldsymbol{X}_{it}$, $\boldsymbol{Z}_i$, T_{it}, F_{it} equals one.

Thus, household i chooses T_{it} and $(F_{it}+1)$ in order to maximize expected profits at year t which are given by:

$$(3) \qquad P_{it} = \mathrm{E}[Y_{it} \mid \boldsymbol{X}_{it}, \boldsymbol{Z}_i, T_{it}, F_{it}] - r_t T_{it} - q_t(F_{it}+1) + q_t,$$

where r_t is the market rental rate of prepared land, and q_t is the market price (plus transportation and application costs) of a unit of fertilizer.

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[1] This specification captures the fact that fertilizer is not an essential input, so that $F_{it}=0$ does not imply in $Y_{it}=0$.

The first order necessary conditions (FONCs) for maximum profit are respectively given by:

(4.a) $P_{T} - r_t \leq 0$, $(P_T - r_t)T_{it} = 0$, and $T_{it} \geq 0$;

(4.b) $P_{F+1} - q_t \leq 0$, $(P_{F+1} - q_t)(F_{it}+1) = 0$, $F_{it} \geq 0$.

The solution to system (4) yields the reduced form demand equations for fertilizer and cultivated area, which are given by:

(5.a) $\ln T_{it} = \psi_0(w_t, q_t, r_t; \beta) + \psi_1(\beta)(\alpha_0 + \alpha_1' \boldsymbol{X}_{it} + \alpha_2' \boldsymbol{Z}_i + \eta_i)$;

(5.b) $\ln(F_{it}+1) = \gamma_0(w_t, q_t, r_t; \beta) + \gamma_1(\beta)(\alpha_0 + \alpha_1' \boldsymbol{X}_{it} + \alpha_2' \boldsymbol{Z}_i + \eta_i)$,

where γ_k, ϕ_k, ψ_k, for $k = 0,1$ are functions of the structural parameters in β and the exogenously given prices w_t, q_t. Thus, under the above specification, the resulting reduced form demand equations are linear in the household/farm specific effects η_i, and moreover, η_i has a time-invariant coefficient that can be eliminated by using fixed effects estimation techniques.

Econometric Model and Estimation Issues

The Production Function

Equations (1) and (2) suggest the estimation of the following regression equation:

$$(6) \qquad \ln(Y_{it}) = \alpha_0 + \alpha_1' \boldsymbol{X}_{it} + \alpha_2' \boldsymbol{Z}_i + \beta_1 \ln(T_{it}) + \beta_2 \ln(F_{it} + 1) + \nu_{it},$$

where ν_{it} is a random disturbance with two components: i.e., $\nu_{it} = \eta_i + \varepsilon_{it}$, where η_i is defined above, and ε_{it} is a idiosyncratic household/farm shock in productivity which might be observable by the household but not by the econometrician.

To estimate the structural parameters in (6), we must confront the problem of endogeneity of cultivated area $\ln(T_{ir})$, fertilizer use $\ln(F_{it} + 1_{it})$, and asset endowments ($\boldsymbol{Z}$), a common feature in the estimation of production functions with household and farm level data. As seen in the reduced form equations (4.a)-(4.b), both $\ln(T_{ir})$ and $\ln(F_{it} + 1_{it})$ are functions of unobserved time-invariant household/farm characteristic η_i, which is a component of ν_{it}, the error term in (6). Therefore, $\ln(T_{it})$ and $\ln(F_{it} + 1_{it})$ are clearly correlated with the disturbance ν_{it}, which implies that the OLS estimator of the parameters in (6) will be biased and inconsistent.

As discussed in Mundlak (1996), panel-data can provide a wealth of Instrumental Variable (IV) estimators that tackles this common identification problem in the estimation of production functions via a primal approach. In what follows we discuss three IV estimators: (i) The within (or fixed-effects) estimator, (ii) the two-stage least squares estimator of Hausmann and Taylor

(1981), hereafter the HT estimator, and the Amemyia and MaCurdy (1989), hereafter the AM estimator. These are discussed below.

The Within Estimator: To simplify notation, rewrite equation (6) as:

$$y_{it} = \pi_1' x_{it} + \pi_2' z_i + \eta_i + \varepsilon_{it}, i = 1,..,N; t = 1,..,T,$$

where x_{it} is a K x 1 vector collecting all the time-variant explanatory variables in equation (7), z_i is a G x 1 vector collecting all the time-invariant explanatory variables, and π_1 and π_2 are conformably dimensioned parameter vectors. We assume that the disturbances ε_{it} are *iid* $N(0,\sigma_\varepsilon^2)$ and the individual effects η_i are *iid* $N(0,\sigma_\eta^2)$. The time and household-variant component ε_{it} are assumed to be orthogonal to both the explanatory variables and the individual effects, while η_i may be correlated with parts of x and z.

Combining all NT observations we can write (8) as:

$$y = x\,\pi_1 + z\,\pi_2 + V\eta + \varepsilon$$

where y and ε are NT x 1, x is NT x K, z is NT x G, and V is an NT x N matrix of individual-specific dummy variables. Now define the matrix $\boldsymbol{P_V} = V(V'V)^{-1}V$ as the projection onto the column space of V. Thus, $\boldsymbol{P_V}$ is a matrix that transforms a vector of observation into a vector of individual means across time: i.e., $\boldsymbol{Pv}y_{it} = (1/T)\Sigma_t y_{it} \equiv y_i$. Then, $\boldsymbol{Q_V} = \boldsymbol{I} - \boldsymbol{P_V}$ is defined as the projection onto the null space of V, i.e., $\boldsymbol{Q_v}$ produces a vector of deviations from individual means: i.e., $\boldsymbol{Pv}y_{it} = y_{it} - y_i$.

The within estimator is computed by projecting (9) onto the null space of V and performing least-saquares. Because $\boldsymbol{Q_v z} = \boldsymbol{0}$, and $\boldsymbol{Q_v}\mathbf{n} = \boldsymbol{0}$, only π_1 can be estimated. Therefore, the within estimator of π_1 is:

$$(10) \qquad \pi_{1w} = (\boldsymbol{x' Q_v x})^{-1}\boldsymbol{x' Q_v y},$$

and is consistent whether or not the explanatory variables are correlated with the individual effects η_i. The problem with the within estimator is that it does not allow for the estimation of the vector π_2. In what follows we explore two estimators that will be consistent under some mild orthogonality assumptions.

2SLS Estimators: As explained in Hausmann and Taylor (1981), a more efficient IV estimator can be computed if we are willing to assume that some explanatory variables in x and z are orthogonal to the individual effects η_i. Consider the partition of x and z given by $x = (x_1, x_2)$ and z

= (z_1, z_2), such that x_1, and z_1 are orthogonal to η_i, but x_2 and z_2 are not. The HT 2sls estimator is therefore given by:

$$[\hat{\pi}_1 , \hat{\pi}_2]' = [(x, z)'\Omega^{-1/2}P_A \Omega^{-1/2}(x, z)]^{-1} (x, z)'\Omega^{-1/2}P_A \Omega^{-1/2}y$$

where $\Omega^{-1/2} = Q_v + \theta P_V$, is a weighting matrix such that $\theta = \sigma_\varepsilon^2(\sigma_\varepsilon^2 + T\sigma_\eta^2)^{-1}$, $P_A = A(A'A)^{-1}A$ is the projection onto the column space of A. For the HT estimator, A is a matrix of instruments given by:

$$A = (Q_v x_1, Q_v x_2, P_v x_1, z_1)$$

Thus, each variable in x_1 provides two instruments ($Q_v x_1$ and $P_v x_1$), while the variables in x_2 and z_1 provide one instrument each ($Q_v x_2$ and z_1). The order condition for identification gives the result that the number of columns in x_1 must be at least as large as the number of columns in z_2.

Amemyia and MaCurdy (1986) suggests the following set of alternative instruments:

$$A = (Q_v x_1, Q_v x_2, x_1^*, z_1)$$

where x_1^* is a NT x TK matrix where each column contains values of x_{1it} for a single time period. The AM estimator uses each of the x_1 variables as $(T+1)$. Its order condition for existence is that T times the number of columns in x_1 must be greater than or equal to the number of columns in z_1. As shown by Amemyia and MaCurdy (1986), consistency of the AM estimator will depend on a stronger exogeneity assumption than the HT estimator. While the HT estimator requires only the means of the x_1 variables to be orthogonal to the individual effects, the AM estimator requires orthogonality at each point in time. Nevertheless, as Amemyia and MaCurdy (1986) and Breusch, Mizon and Schmidt (1989) point out, orthogonality between $P_v x_1$ and the individual effects n is likely to result from the orthogonality between x_1^* and n.

Input demand equations

The IV methods described above are also employed to estimate the parameters of the reduced form of a demand for cultivated land equation. However, because fertilizer demand is censored at zero, a Tobit specification is required. We use two types of estimators for these censored equations: (i) Bo Honore's (1992) trimmed least squares estimator (TLS) for fixed-effects panel data models, and a simulated maximum likelihood (SML) estimator which assumes that the individual-specific random effect are orthogonal to the explanatory variables.[2]

[2] For a description of SML estimators for panel data Tobit type models, see Gourieroux and Monfort, 1993.

As indicated in equations (5.a) and (5.b), we cannot identify the own- and cross-price elasticities of demand since the functions $\psi_0(w_t,q_t,r_t;\beta)$ and $\gamma_0(w_t,q_t,r_t;\beta)$ do not vary across cross-sectional units. Therefore we focus on estimating the effect of the household specific variables X_{it} and Z_i on demand for inputs so that we can compute their overall expected effect on farm output. For instance, the total impact of ox ownership on output is given by:

$$\frac{dY}{dX_j} = \frac{\partial Y}{\partial X_j} + \frac{\partial Y}{\partial T}\frac{\partial T}{\partial X_j} + \frac{\partial Y}{\partial (F+1)}\frac{\partial (F+1)}{\partial X_j} = \alpha_j + \beta_1 \frac{\partial T}{\partial X_j} + \beta_2 \frac{\partial (F+1)}{\partial X_j}$$

where estimates of α_j, β_1, and β_2, are obtained through the estimation of the production function, and estimates of $\frac{\partial T}{\partial X_j}$ and $\frac{\partial (F+1)}{\partial X_j}$ are obtained through the estimation of the input demand equations (5.a) and (5.b). Note however, that the estimates of $\frac{\partial T}{\partial X_j}$ and $\frac{\partial (F+1)}{\partial X_j}$ are themselves functions of the production parameters β_i, and the total factor productivity parameters α_i.

Variables included in the estimation

Time-varying explanatory variables included in the production function are cultivated area, fertilizer used, household population, the value of cattle owned by the household, the stock of draught animals (oxen) and farm equipment, the amount of credit received, and a "weather shock" variable. "Weather shocks" are defined as the percentage deviation of precipitation from its 30-year average during the planting season, two growing periods, and one harvesting season. The implicit assumption that too much rain can be as harmful as too little of it seems to be quite realistic under Zambian conditions. Higher order terms (i.e. the weather shock variable squared, cubed and raised to the forth power) are introduced to account for possible non-linearities. Animal-owners' ability to perform farming operations in a more timely manner is likely to be of particular relevance under abnormal climatic conditions. To account for this possibility, we interact the weather shock with the value of the farm's stock of draught animals and farm equipment. Of the time varying variables, -household population, the non-interacted weather variables, the time trend and district dummies-time trend interactions are assumed to be exogenous while the remainder are assumed to be endogenous (i.e., correlated with unobserved individual effects).

Time-invariant explanatory variables are the sex of the household head, access to extension, primary and secondary education dummies and sixty district dummies. Extension and the education dummies are assumed to be endogenous while the remaining time-invariant explanatory variables are assumed exogenous. Unfortunately, input price data are not available for the first year of the data and only selectively in the second year. Adding 60 district dummies and their interaction with time (not reported) will avoid bias due to omission of price variables.

4. RESULTS

4.1 Descriptive statistics

Before discussing econometric estimation results it is of interest to describe intertemporal and inter-regional variation in the data using descriptive statistics. As illustrated in table 1, rural producer households in Zambia had on average 6.2 members and cultivated 1.9 hectares. The the mean age of the household head was 45 and about 20% of households were female headed. 56% and 15% have completed primary and secondary education, respectively, and 24% of households had access to extension. Both value of total production and area cultivated show significant variation across regions, with output value ranging from K 407,000 in Central to 116,000 in Western region (corresponding to mean areas of 2.82 and 1.44 hectares).

Looking at changes over time, one notes that output value changed little over time even though area cultivated decreased and market participation, measured as the percentage of output (in value terms) sold decreased for almost all provinces. The share of producers with access to credit decreased significantly, from 19.2% to 9.8%, in addition to a significant drop in the mean amount received. This decrease in access to financing seems to have precipitated a reduction both in the share of producers having access to fertilizer (from 35% to 27%) and a halving of the amount spent on fertilizer by those who use it. To examine the implications of this for production in more detail we turn to econometric analysis.

4.2 Econmetric results

Results from the production function estimation (table 2) point to a number of interesting results. First, availability of *family labor* is an important determinant of output, indicating that labor markets in rural Zambia are thin or non-existent. The elasticity of output with respect to household population is between 0.07 and 0.12, suggesting that even once other factors such as area, fertilizer use, and ownership of oxen are controlled for, larger households tend to be more productive than small households. The rationale for such a relationship is that, as one would expect in an environment where land is relatively abundant, larger households would have less difficulty to muster the necessary labor to complete critical tasks during seasons of peak demand (e.g. weeding) when spot labor markets dry up.

Second, the data also allow ascertaining the impact of *fertilizer* on output without the biases intoduced by unobserved land quality and farmer skills which commonly plague cross-sectional analysis. This is of interest in view of the heated policy discussion on whether or not use of fertilizer will still be profitable at the increased post-liberalization prices for this input. We find that the output elasticity of fertilizer varies between 0.07 and 0.08. To interpret this figure, we have to distinguish between farmers who apply fertilizer to their fields and those who do not. For the first group, the marginal benefit from applying additional amounts of fertilizer is slightly lower than the marginal cost, pointing towards consistency with profit-maximizing behavior. This strongly supports the hypothesis that, even at the increased post-liberalization prices, fertilizer use is economically profitable and that farmers with access to fertilizer therefore apply more or less the "optimum" amount and do not appear to be quantity-rationed.

By contrast, producers who are rationed out of the fertilizer market, seem to forgo significant productivity and welfare benefits. Estimates suggest that providing producers without fertilizer access with the average amount of fertilizer applied by users (170kg) would increase their income by about US$85, generating a 70% return on the investment of US$ 50.[3] This high return points towards non-price rationing, whereby *access* rather than *price* appears to be the relevant problem. The policy implication emerging from this is that, instead of aiming to curb "speculative excess" by traders through continuing government involvement in fertilizer procurement, encouraging private sector entry would be expected to result in increased and more optimal use of this input. Descriptive statistics, which indicate that that many farmers close to the line of rail bought more than double the amount of fertilizer they actually used, support this notion and furthermore suggest that government subsidies constituted a de-facto transfer to the rich who have advantageous access to infrastructure (Deininger et al. 1998).

Third, to identify the impact of time-varying factors, the instrumental variable techniques described earlier also allow us to identify the effect of time-invariant or slowly changing conditions such as household headship, distance to infrastructure, education, and access to extension services. We find that female-headed households are as productive as their male counterparts, i.e. the dummy is negative but not significant. While the state of rural infrastructure is often viewed as a major obstacle to expansion as well as diversification of agricultural production, our estimates suggest that a producer's distance to markets does not affect total factor productivity, although it has an impact on factor use.

Similar conclusions hold for education (separated into primary and secondary) which does not seem to increase productivity, but, as can be seen from the fertilizer demand function and credit use equation (tables 3 and 4), affects input use in what can still be considered an environment with numerous market imperfections. One explanation might be that agricultural experience, rather than formal education, is of greater relevance for increasing total factor productivity. The share of individuals in any village who have access to extension (excluding the producer under concern) has a positive but statistically insignificant impact on total factor productivity. This would support the claim that the government's system has not yet adjusted to fully incorporate the realities and requirements of a liberalized environment.

Fourth, the results of the production function estimation allow to make inferences on the impact of credit access. They indicate that there is a positive and statistically significant relationship between the amount of *credit* received by a farm household and total factor productivity. Thus, an extra US $100 (100,000 K) of credit received by an average farm household, is expected to increase output by between 2.6 and 4%, even when other inputs are held constant. Moreover, we note that increasing access to credit from zero to the mean value for the sample of credit users (K 150,000) would, according to the estimates, augment output of non-borrowers by 3% due just to this increase in total factor productivity. This is surprising, as one would normally expect any impact of credit pre-planting season rain is below the long-term average) possession of animals would allow to complete soil preparation area faster once soil moisture has reached workable levels, thus minimizing the yield loss incurred. Obviously, owners would tend to till their own fields before renting out to others, implying that farmers who own draught animals are –at least to some extent– less vulnerable to climatic shocks. This is of particular interest since a similar interaction term between the number of household members and rainfall (suggesting that larger households have an advantage in mobilizing family labor quickly) is insignificant.

In addition to its impact on total factor productivity, ownership of productive assets (in this case draught animals) is also a key determinant of expected land demand, which in turn has a large impact on production.[5] The estimates imply that by exogenously receiving one pair of oxen

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[3] The fertilizer price is the real cost ex depot. This is needed because the survey contains too little detail on modalities of payment for prices to be useful. Adding transport costs for a distance of 500 km (at a cost of US $ 0.1 per t-km) reduces the return to about 45%, which should still be sufficient to finance the input on credit.

[4] Under the assumptions discussed in the appendix the IV estimators are not biased by the likely correlation between unobserved managerial skills and credit access.

[5] Recall from the results of the production function regression that land has a production elasticity of between 0.6 and 0.7.

valued at K310,000, non-ox owners would be able to increase their area of cultivation by approximately 25 percent, which in turn represents an expected increase in income of approximately 18 percent (or K45,000, given that the average non-ox-owner generates approximately K250,000 of farm output). If we add the 4-12 percent increase in total factor productivity computed above, we conclude that non-ox-owners would be able to pay back the pair of oxen plus interest in approximately 4 to 7 years (given a total increase in income of approximately K40,000 to K80,00.0 per year).

The estimated effect of draught animal ownership on producers' propensity to apply fertilizer is ambiguous (table 3). While large and statistically significant under the SML model, the impact is small and insignificant under the TLS model. Since the SML estimate is only consistent under the assumption of orthogonality between the farm-specific random effect and the explanatory variables, whereas the TLS estimate is consistent even when this orthogonality condition does not hold, we conclude that there is no significant direct impact of draught animals ownership on fertilizer demand. To Another way in which ownership of draught animals may affect farm output is through its impact on fertilizer use and area cultivated via increased credit access. That is, because draught animals may serve as collateral in credit transactions, draught animals owners may have better access to credit than non-owners. To test this hypothesis, we estimate a credit access random-effects Probit model. Results, presented in the last column of table 4, suggest that, indeed, draught animal ownership has a significant impact on credit access.[6] Taking all of these effects together ox ownership would increase household income by about 22% or K 56,000 per year. Even with a real interest rate of 15%, the capitalized value of this benefit would be greater than the cost of the investment, suggesting that even in a high-interest rate environment, and neglecting indirect benefits, acquisition of oxen would be a profitable investment and that the issues involved should be explored in more detail.[7]

5. CONCLUSION

In this paper we explored whether structural factors or lack of profitability are at the root of the apparently very limited supply response by rural producers in Zambia. Using data that were

[6] We opt for a random-effects Probit model instead of a fixed-effects Tobit model because we cannot determined ex ante whether observed credit use is determined by supply, in which case use would indicate access, or demand. If farmers who own more draught animals demand more credit but are also less likely to be credit rationed, the fixed-effects Tobit model, would likely yield an upward-biased estimate of the impact of oxen ownership on access to credit. The reason is that it departs from the implicit assumption that all producers are credit rationed. Such bias would be smaller under a random-effects specification since poor farmer with zero loans are less likely to implicitly demand zero credit.

[7] The purpose of this example is to highlight the implication from regression results rather than to provide an in-depth economic calculation. We therefore implicitly assume that the cost of feeding the animal is approximately equal to the indirect benefits such as manure, milk, beef, insemination services, etc. from the animal that are not captured in our output measure.

collected 3-4 years after a comprehensive set of reforms had been initiated, one observes only a very limited responses from the productive sector. Three main conclusions emerge.

First, using panel data methods we can clearly reject the hypothesis that farmers reduced use of purchased inputs because this is no longer profitable – and that therefore government should intervene to improve the functioning of markets and reduce input prices faced by producers. By contrast, the fact that use of purchased inputs is highly profitable points to the importance of non-price factors. Policies that would increase private sector activity in this industry and remove producers' non-price rationing through provision of public goods that increase input demand could have significant productivity benefits. This is consistent with the finding emerging from a large number of participatory assessments according to which unreliable delivery–which is clearly related to Government intervention in physical input distribution- is a more serious problem for producers than the non-affordability of agricultural inputs (Milimo 1995). Given the high returns from increasing access to fertilizer, and the failure of public sector involvement to guarantee such access in the 1992-95 post-liberalization period, there appears little justification for continued Government involvement in physical distribution of inputs.

Second, under Zambian conditions of land abundance, ownership of productive assets is a key constraint to enhanced productivity, increases in cultivated area, greater use of credit and purchased inputs, and better adaptation to the vagaries of climate. Regression coefficients suggest that purchase of a pair of oxen is a profitable venture even at high real interest rates. Greater focus on factors related to accumulation of productive assets (such as lack of knowledge on management practices, threat of infectious diseases, and non-availability of financial infrastructure to obtain longer-term capital) may be a more promising focus for government policy than continued concern about -and self-defeating intervention to ensure- the proper functioning of input markets. The fact that lack of long-term credit facilities to allow acquisition of productive assets such as cattle is one of the key concerns emerging from participatory assessments (Tembo et. al 1995; Francis et al. 1997) supports our analysis and suggests that more detailed study of mechanisms addressing this constraint could have a high payoff.

Finally, attempts to increase agricultural productivity and rural well-being through provision of public services have thus far largely been unsuccessful. Education has a very significant impact on input demand but not on agricultural productivity andthe impact of extension is insignificant. Our interpretation is that the constraints facing rural producers in Zambia are still related more to market access and the ability to obtain the necessary inputs in a highly volatile economic environment rather than the application of more productive technology. At the same time, this calls for a thorough assessment of the technology available and the messages that are being disseminated through public technical assistance. Unless these can be adapted more to the prevailing economic environment and the incentive structure facing producers, greater public spending on technical assistance may be difficult to justify.

From a methodological point of view, our results suggest that farm-level panel information can provide policy-relevant insights that avoid the difficulties inherent in the interpretation of cross-sectional data. While the panel underlying our study was collected more by accident than by design, greater emphasis on collection of panel data, adoption of the necessary protocols to ensure data quality, and inclusion of other household characteristics (e.g. asset endowments) is likely to increase the usefulness of such data to yield policy relevant conclusions.

From a substantive point of view, our analysis supports the notion that without "re-emphasizing" the role of agriculture, it will be difficult for African countries to lay the basis for sustained growth and prevent a reversal of policy that would undo much of the progress and potential from recent liberalization. It is now recognized that, even though Africa faces specific challenges in the field of health, most of the stagnation of the rural sector has been policy-induced, that the gap between potential and actual output is greatest in Africa, and that demand is unlikely to become a constraint any time soon (McPherson 1999). This reinforces the importance of providing public goods, in addition to price policies, to bring about a sustained agricultural supply response (Schiff and Montenegro 1997). The fact that use of purchased inputs is way below the optimum, that credit constraints prevent investment in productivity-enhancing technology such as livestock, and that public services are not (yet) effective in delivering the needed technology, suggests that much remains to be done to address non-price related constraints to agricultural production, generated and disseminate technology, and thus help rural producers make better use of the resources at their disposal.

References:

Alwang,-Jeffrey; Siegel,-Paul-B.; Jorgensen,-Steen-L. 1996, Seeking Guidelines for Poverty Reduction in Rural Zambia, *World-Development*, 24(11) 1711-23.

Amemyia, T. and T.E. MacCurdy, (1986), "Instrumental variables estimation of an error components model", *Econometrica*, **54**, 869-880

Breusch, T.S., G.E. Mizon and P. Schmidt, (1989), "Efficient estimation using panel data", *Econometrica*, 57, 695-700.

Deininger, Klaus, Pedro Olinto, Mukata Wamulume, and Dennis Chiwele, "Agricultural sector performance in a post-reform environment: Implications for second generation reforms in Zambia, World Bank, mimeo.

Francis Paul A et al. 1997, Listening to farmers: Participatory assessment of policy reform in Zambia's agriculture sector, World Bank Technical Paper 375, Washington, D.C.

Gourieroux, C. and A. Monfort (1993). "Simulation-Based Inference: A Survey with Special Reference to Panel Data Models," *Journal of Econometrics*, 59:5-33.

Hattink,-Wolter; Heerink,-Nico; Thijssen,-Geert 1998, Supply Response of Cocoa in Ghana: A Farm-Level Profit Function Analysis, Journal-of-African-Economies;7(3), October 1998, pages 424-44.

Hausmann, J. A. and W. Taylor, (1981) "Panel data and unobservable individual effects", *Econometrica*, **49**, 1377-1399

Hazell, Peter B. R.; Hojjati, Behjat 1995, Farm/Non farm Growth Linkages in Zambia, *Journal of African Economies*;4(3):1995, 406-435

Holden, Stein T.; Taylor, J. Edward; Hampton, Stephen, 1999, Structural Adjustment and Market Imperfections: A Stylized Village Economy Wide Model with Non-separable Farm Households, *Environment and Development Economics*; 4(1):1999, 69-87.

Honoré, B.E. (1992). "Trimmed LAD and Least Squares Estimation of Truncated and Censored Regression Models with Fixed Effects," *Econometrica* 60:533-565.

Jansen, Doris J and Rukovo, Andrew 1992, Agriculture and the Policy Environment: Zambia and Zimbabwe, Technical Paper # 74 for the research programm on Developing Country Agriculture and International Economic Trends, OECD Development Center, Geneva 1992

Jansen, Doris J. (1991), The Political Economy of Agricultural Pricing Policy: Volume 3: Africa and the Mediterranean: Zambia, in: Krueger, Anne O.;Schiff, Maurice; Valdes, Alberto, eds. The political economy of agricultural pricing policy. Volume 3. Africa and the Mediterranean., Johns Hopkins University Press, Baltimore and London: 268 327.

Keyser, J. 1996, Zambia's Comparative Advantage, Report prepared for the World Bank, Lusaka

McPherson, M.F. 1995, The Sequencing of Economic Reforms: Lessons from Zambia, Harvard Institute for International Development , Discussion Papers 516, 1995

McPherson, M.F 1999, Sustaining Trade and Exchange Rate Reform in Africa: Lessons for Macroeconomic Management, HIID Development Discussion Papers 713, Cambridge MA

Milimo, John T. 1995, An Analysis of Qualitative Information on Agriculture from beneficiary assessments, participatory poverty assessment and other studies which used qualitative research methods, The Participatory Assessment Group, Lusaka mimeo

Mundlak, Y., (1996), "Production Function Estimation: Reviving the Primal", *Econometrica*, **64**, 431-438.

Mwanaumo, Anthony; Masters, William A.; Preckel, Paul V. 1997, A Spatial Analysis of Maize Marketing Policy Reforms in Zambia, *American Journal of Agricultural Economics*;79(2), May 1997, 514-23.

Rosenzweig, Mark R. 1996, When Investing in Education Matters and When It Does Not, *Challenge* **39**(2) 22-29

Savadogo,-Kimseyinga; Reardon,-Thomas; Pietola,-Kyosti 1995, Mechanization and Agricultural Supply Response in the Sahel: A Farm-Level Profit Function Analysis, Journal-of-African-Economies;4(3), December 1995, pages 336-77.

Schiff,-Maurice; Montenegro,-Claudio-E. Aggregate Agricultural Supply Response in Developing Countries: A Survey of Selected Issues, *Economic-Development-and-Cultural-Change*;45(2):393-410.

Tembo, S, Nkomeshy, A., Ntalasha, H., Kalumbi, J. 1995, Pre-ASIP Study of the Status of smallholder farming and agricultural services in Sinazongwe and Zimba, Southern Province of Zambia, Institute for African Studies, University of Zambia, Working Paper 2, Lusaka

World Bank 1992, Zambia Agriculture Sector Strategy: Issues and Options, Washington DC, mimeo

Table 1: Descriptive statistics

	Total	*Central*	*Copperbelt*	*Eastern*	*Luapula*	*Lusaka*	*Northern*	*Northwest*	*South*	*West*
Household size	6.19	7.37	5.99	5.93	5.49	6.98	5.93	5.55	8.71	5.58
Female headed	20.52%	16.67%	18.43%	21.35%	21.22%	16.20%	19.47%	18.31%	12.07%	31.22%
Access to extension	23.77%	14.08%	22.44%	30.76%	13.43%	24.22%	29.18%	28.34%	27.24%	15.66%
Primary education	56.46%	58.11%	50.00%	57.20%	60.10%	47.22%	55.87%	50.00%	66.84%	53.01%
Secondary education	14.84%	22.81%	26.28%	8.52%	13.92%	16.67%	17.47%	10.83%	16.71%	11.06%
Age	45.44	45.72	44.42	45.40	44.45	45.44	44.34	45.29	46.09	48.31
Area cultivated (hectares)	1.89	2.82	1.58	2.24	1.18	1.72	1.60	1.20	3.30	1.44
Value of production (1000 K)	231.44	407.08	224.36	257.93	139.38	157.37	230.35	171.65	358.46	116.18
Value of sales	90.12	212.61	101.09	92.94	34.78	47.80	92.01	68.27	123.51	37.50
Share of sales	38.94%	52.23%	45.06%	36.03%	24.95%	30.37%	39.94%	39.77%	34.46%	32.27%
Posession of cattle	19.14%	27.85%	9.49%	27.67%	1.10%	21.30%	8.42%	6.37%	60.88%	19.84%
Value of cattle (1000 K)	152.62	240.77	69.38	162.71	3.82	172.22	33.43	42.25	712.81	172.64
Ownership of draught animals	14.86%	26.75%	8.03%	22.92%	0.17%	18.52%	2.32%	1.43%	57.56%	12.20%
Access to credit	14.53%	21.71%	4.56%	24.58%	9.85%	23.61%	13.51%	5.25%	16.05%	5.45%
Amount of credit received (1000 K)	160.75	210.88	165.64	134.23	132.56	81.47	136.63	70.09	281.45	252.27
Use fertilizer	31.21%	61.51%	25.73%	27.42%	17.74%	75.00%	35.58%	19.75%	48.28%	10.24%
Value of fertilizer used	80.36	96.42	106.18	108.48	45.92	51.49	58.74	46.25	79.91	118.00
No of observations	9,706	912	548	2,042	1,178	216	2,198	628	754	1,230
					1994					
Area cultivated	2.01	3.07	1.68	2.34	1.28	1.77	1.71	1.07	3.77	1.53
Value of production (1000 K)	227.93	386.76	208.32	247.76	123.51	184.61	243.52	166.15	376.35	106.27
Value of sales	95.32	207.41	99.35	84.49	32.76	62.89	114.62	73.12	149.09	37.87
Share of sales	41.82%	53.63%	47.69%	34.10%	26.53%	34.07%	47.07%	44.01%	39.62%	35.64%
Ownership of cattle	18.61%	27.85%	9.49%	25.47%	1.53%	21.30%	8.55%	5.73%	59.42%	19.84%
Value of cattle (1000 K)	127.01	228.55	64.16	141.74	4.79	169.44	28.39	32.10	505.78	157.37
Ownership of draught animals	15.66%	27.19%	8.76%	24.19%	0.34%	18.52%	2.55%	1.59%	58.36%	14.63%
Access to credit	19.23%	26.54%	5.47%	29.29%	14.43%	32.41%	21.02%	9.87%	19.89%	6.67%
Amount of credit received (1000 K)	31.97	59.29	10.04	41.86	14.02	26.93	30.35	6.87	62.47	20.19
Use fertilizer	34.82%	65.57%	22.26%	31.54%	22.75%	87.04%	40.49%	26.75%	48.28%	11.22%
Value of fertilizer used	97.46	112.94	192.83	131.77	51.09	58.63	73.30	53.31	94.41	144.73
					1995					
Area cultivated	1.76	2.58	1.48	2.14	1.07	1.67	1.48	1.33	2.82	1.35
Value of production (1000 K)	234.96	427.39	240.40	268.10	155.26	130.12	217.19	177.16	340.57	126.10
Value of sales	84.93	217.81	102.83	101.39	36.80	32.71	69.39	63.42	97.93	37.12
Share of sales	36.14%	50.96%	42.78%	37.82%	23.70%	25.14%	31.95%	35.80%	28.75%	29.44%
Ownership of cattle	19.68%	27.85%	9.49%	29.87%	0.68%	21.30%	8.28%	7.01%	62.33%	19.84%
Value of cattle (1000 K)	178.24	252.98	74.60	183.67	2.85	175.00	38.47	52.39	919.84	187.92
Access to credit	9.83%	16.89%	3.65%	19.88%	5.26%	14.81%	6.01%	0.64%	12.20%	4.23%
Amount of credit received (1000 K)	10.31	22.59	3.55	16.90	8.46	8.08	4.60	0.35	19.51	5.11
Ownership of draught animals	14.05%	26.32%	7.30%	21.65%	0.00%	18.52%	2.09%	1.27%	56.76%	9.76%
Use fertilizer	27.59%	57.46%	29.20%	23.31%	12.73%	62.96%	30.66%	12.74%	48.28%	9.27%
Value of fertilizer used	58.88	77.57	40.11	77.06	36.77	41.71	39.70	31.44	65.57	85.07

Table 2: Summary of regression results

	Production function equation				Land demand equation			
	Within estimator		IV Estimator		Within estimator		IV Estimator	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
Ln(area)	0.6292	46.8726	0.7157	37.322				
Ln(HH population)	0.1238	5.6355	0.0908	3.857	0.247	12.6558	0.4185	7.6
Value of Cattle (1000 K)	0.0001	9.189	0.0001	8.018	0.00001	1.6613	0.0000	1.208
Credit Received (1000 K)	0.0003	3.1614	0.0004	4.122	0.001	15.2649	0.0016	5.407
Value of Oxen & implements (1000 K)	0.0004	4.2267	0.0001	2.455	0.0002	2.5575	0.0008	8.171
ln(Fert+1)	0.0723	17.1508	0.0755	5.684				
Dummy for 95	-0.7321	-2.7064	0.337	2.841	-0.125	-5.982	-0.1683	-2.651
Rainfall deviation I (pre-planting period)	0.114	4.7054	0.0198	1.993	0.0072	6.0029	0.0079	2.715
Rainfall deviation I squared	-0.0047	-4.373	-0.0005	-1.071	-0.0001	-3.8391	-0.0002	-3.056
Rainfall deviation I cubic	-0.0001	-4.4121	0.00002	-1.267				
Rainfall deviation I fourth power	0.00002	4.4256	0.00001	1.263				
Rainfall deviation II (growing period)	0.0056	6.2458	0.0019	3.876				
Rainfall deviation III (harvest period)	-0.0092	-3.687	0.0005	0.511				
Rainfall deviation I x Fertilizer	-0.0008	-6.1354	-0.0004	-1.928				
Rainfall deviation I x Oxen	-0.00002	-2.0854	-0.00004	-3.001	-0.00004	-6.7952	0.0000	-0.821
Rainfall deviation I x Oxen squared					0.00001	5.5469	0.00003	2.426
Rainfall deviation I x HH pop	0.0001	0.235	-0.001	-1.207	-0.0017	-2.8529	-0.0015	-1.231
Rainfall deviation I x HH pop squared					0.00001	1.9335	0.0001	2.503
Female headship I dummy			-0.0691	-0.703			-0.4231	-1.512
Distance to market			-0.003	-0.172			-0.0915	-1.725
District Extension %			0.0109	1.456			-0.0223	-1.392
Primary education			-0.0463	-0.099			-1.0837	-0.863
Secondary education			0.3193	0.668			0.5431	0.585

Table 3: Demand for Fertilizer / ha.

EXPLANATORY VARIABLES	***SML estimator***		***TLS estimator***	
	ESTIMATES	*STD. ERRORS*	*ESTIMATES*	*STD. ERRORS*
Intercept	-3.01**	0.22		
Time Trend (T)	-0.41**	0.12	-0.59**	0.13
Log of HH adult population (POP)	1.01**	0.09	0.54**	0.18
Credit Received (1000 Ks)	0.48**	0.02	0.13*	0.07
Cattle Stock (1000 Ks)	0.05	0.07	0.11	0.10
Draught Animals and Implements (1000 Ks)	1.21**	0.25	0.46	0.77
DM01	-0.01**	0.00	-0.04	0.04
Sex of HH's head (Women = 1)	-0.68**	0.13		
Distance to Markets	-0.22**	0.02		
Extension	-0.15	0.20		
Primary education	-0.09**	0.12		
Secondary Education	1.53**	0.11		
	3.34**	0.01		
Mean Log- Likelihood	-1.10792			
Number of Observations	9706		9706	

* Indicates statistically different from zero at the 10% significance level.

** Indicates statistically different from zero at the 5% significance level.

Table 4: Credit Use Equation

EXPLANATORY VARIABLES	*SML estimator*		*TLS estimator*		*Random effect probit*	
	ESTIMATES	*STD. ERRORS*	*ESTIMATES*	*STD. ERRORS*	*ESTIMATES*	*STD. ERRORS*
Intercept	-450.65**	36.94				
Time Trend (T)	-161.94**	13.98	-170.48**	28.97		
Log of HH adult population (POP)	113.35**	13.69	112.22**	56.31	0.335365**	0.042109
Cattle Stock (1000 Ks)	-37.44**	13.98	-56.11**	29.13	-0.00018**	0.000046
Draught Animals & Implement (1000 K)	386.62**	56.84	333.18	236.07	0.000976**	0.00014
Sex of HH's head (Women = 1)	-90.40**	18.23			-0.37624**	0.065369
Primary education	5.80**	1.54			-0.12828**	0.009673
Secondary Education	64.80**	15.93			0.005	0.057659
Distance to Markets	-34.98**	2.94			0.170135**	0.054838
s^2	359.20**	19.83			0.6915	0.0485
Mean Log- Likelihood	-1.27					
Number of Observations	9706		9706		9706	

* Indicates statistically different from zero at the 10% significance level.

** Indicates statistically different from zero at the 5% significance level.

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