# Wealth Distribution, Peasant Production and Poverty Traps in African Smallholder Agriculture

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## Abstract

A model is developed for peasant households in land abundant areas who choose between two technologies for land preparation: a manual one and one using draught animals. For draught a minimum number of animals is required so that a technological non convexity exists. It follows that certain households are poverty trapped, that the initial distribution of wealth fully determines aggregate production and that wealth redistribution is equity and efficiency enhancing.

Empirical evidence for Zimbabwe is presented to support the model's stylised facts, the technology described and the model's prediction with respect to the distribution of wealth. It is shown that collaboration between farmers is an alternative to wealth redistribution.

Keywords: peasant production; wealth distribution; inequality; poverty trap; empirical results
JEL Classification: D31; D63; O12; O16; Q12

## 1. Introduction

Cross-country comparisons show some support for a link between the initial distribution of wealth and economic growth (Persson and Tabellini 1994; Alesina and Rodrik, 1994; Clarke, 1995). Corresponding results for the sub-Saharan African rural sector, but based on detailed village level surveys, are reported by Dercon (1998) and Dercon and Krishnan (1996). Theoretical underpinnings for the breakdown in the separability of equity and efficiency can be found in Eswaran and Kotwal (1986), Galor and Zeira (1993), Banerjee and Newman (1993)

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and Aghion and Bolton (1997).[2] The underlying principle in all these papers is that if investments are needed to enter particular activities and in the presence of credit market imperfections, only the wealthier households may take up the activity, allowing them to grow richer while the other households remain trapped in poverty. In an effort to show that all households are vulnerable to such entry constraints, Dasgupta and Ray (1986) postulate a non convexity in the available labour power which depends on whether food intake exceeds a minimum threshold.[3] In this paper we focus on the case of sub-Saharan rural smallholder agriculture, and on Zimbabwean farmers in particular, to argue that not nutrition but the ploughing technique makes each smallholder farmer subject to the risk of a poverty trap.

The formulated model is close to the approach taken by Galor and Zeira (1993), who stress the role of a non convex production technology in an environment where the credit constrained poor family cannot overcome the minimum threshold size for investment in human capital. In this paper the source of the non convex technology is not in the indivisability of human capital but is associated with the use of draught animals. The model considers a rural household in a land abundant environment in the tropics where credit and land markets are dysfunctional. Households prepare their land for cultivation either manually or using animal traction. The ploughing technique and the number of beasts are important determinants of household income because they delineate the amount of land that can be prepared in the small time period when this is feasible. Field preparation before the first rains is not possible because the ground it too

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[2] Eswaran and Kotwal (1986) postulate the existence of fixed set up costs in agricultural cultivation and show that if credit constraints are linked to collateral requirements and if land can be used as collateral, then households with relatively low land endowments may not be able to cultivate all their land and instead will rent out some of their labour to households with larger land holdings. Galor and Zeira (1993) emphasise the role of a non convex production technology where the credit constrained poor family cannot overcome the minimum threshold size for investment in human capital. Banerjee and Newman (1993) show that poor people who are unable to afford the collateral required to be self-employed entrepreneurs or employers crowd the labour market and depress the wage rate and thereby the bequest they leave for their children; Aghion and Bolton (1997) focus on the capital market and the relationship between wealth inequality and the cost of borrowing and hence access to investment opportunities for the poor.

[3] Srinivasan (1994) has criticised this approach as being unrealistic and pointed out that: "*in India the cost of food containing adequate energy at the prevailing prices is surprisingly modest at an individual level, less than ten percent of the unskilled wage rate. […] If this is the case, it would seem*

hard to be worked; long after the first rains it is unattractive because the plants will germinate too late.

In addition, the market for draught services is imperfect. Binswanger and Rosenzweig (1986) describe the impediments to farming using rented draught animals which include: the erratic timing of the rains, the time boundedness of planting operations given, the premium to early service and the vulnerability of the animals to mistreatment. The latter implies that an owner is unlikely to rent out his animals unless the treatment of the animals can be monitored while the former implies that during the planting season she will be too occupied in her own fields to be involved in supervision. Though borrowing draught animals may be difficult, it will be shown that the benefits associated to the alleviation of the livestock induced technological non convexity are such that there is a considerable incentive for farmers with insufficient draught animals to collaborate so as to overcome the technological threshold.

The stylised facts behind this model are typical for rural African households (Binswanger and McIntire, 1987; Platteau, 1999):

1. there are no credit and land markets
2. there is an imperfect market for draught services
3. there is a technological non convexity

The result that the wealth distribution affects agricultural production is due to the absence of credit and draught power markets and the non convexity in production which keeps certain households poverty trapped. The latter is more than a theoretical artefact. Decompositions by Dercon and Krishnan (1998), for instance, show that between 1989 and 1994 poverty of rural households in Ethiopia did not decline for those without oxen, while it significantly declined for households which own at least one oxen. Cavendish (1999) reports something similar. He finds a widening in the dispersion of the wealth distribution for communal farmers in Zimbabwe in the four years that followed the 1992 drought in which 80 percent of all cattle died. He explains this from the fact that for given land holdings, and in contrast to those whose draught animals survived, farmers who lost all cattle were unable to recover. Temporary shocks thus appear to create a more permanent distributional shift for the worse.

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*that an explanation for the persistence of destitution has to be sought, not in a nutrition based theory of resource allocation […]* " (p. 1854).

That alleviating the livestock induced technological non convexity may lead to substantial reductions in poverty is illustrated by Datt et al. (1998) in a study on poverty in Mozambique. They show using a nationally representative survey, that after improvements in education, raising the number of livestock to "a substantial number"[4] is most effective in reducing poverty either measured as a headcount index or taking into account its distribution and measured as the poverty gap of squared poverty gap index. Given the gestation lags involved in educational investments, policies directed at livestock may then be the preferred choice for poverty reduction in the short run.

The organisation of this paper is as follows. In the next section the theoretical model is formulated. The sections that follow are empirical and use evidence from a six year panel survey for smallholder farmers in Zimbabwe. In section three the characteristics of the smallholder environment are described and related to the stylised facts used in the model. Using a fixed effects estimation of the relation between the possession of draught animals and the area cultivated, section four illustrates the existence of the non convexity in the production technology. Section five then considers the observed distribution of wealth and compares this to the model's predictions. Conclusions follow in section six.

## 2. The model

Consider a rural household in an environment where cattle are important. Cattle can be slaughtered and consumed, or they can be used as draught animals. To use cattle for the latter purpose a minimum number is required, preferably two (or more) oxen, though combinations of trained oxen and other cattle are also possible. Otherwise, field preparation is done by hand. Hence in abstracto, the choice is between two technologies, one allowing the farmer to cultivate a large area of land, ox-ploughing, and one confining him to a smaller acreage: manual preparation.

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[4] In this study a substantial number of livestock is defined as a binary variable taking the value of 1 if the number of a particular type of livestock possessed by the household was no less than the 75$^{th}$ percentile (approximately equal to the mean for all types of livestock involved) among households who owned at least one of that type of livestock.

The household offers labour in a fixed amount, which is normalised to one. It cultivates a plot of not transferable land which is sufficiently large to make the use of traction animals viable. Production per unit of land is constant and normalised to one. Hence total output is fully determined by the area of land ploughed. The household chooses the most profitable deterministic production technology depending on the availability of draught animals. The production choice is described by:

$$y_t = \max[y_t{}^{'}, y_t{}^{*}] \tag{1}$$

with

for $K_{t-1} < \overline{K}$: $\quad y'_t = y$

and

for $K_{t-1} \geq \overline{K}$: $\quad y^*_t = z + a(K_{t-1} - \overline{K}) \qquad z \geq y, \quad a > 0$

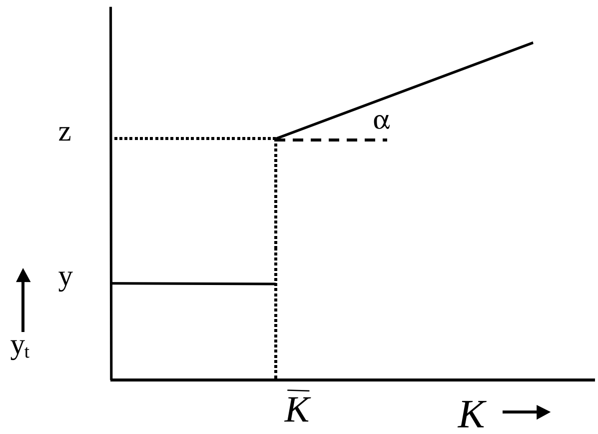
where *y*, *z*, $a$ and $\overline{K}$ are constants, $y_t$ is the area of land prepared, being either $y_t^{'}$ or $y_t^{*}$ depending on whether the household attained the threshold level $\overline{K}$ for capital $K_{t-1}$. If $K_{t-1}$ is expressed in draught animal units than $\overline{K}$ would typically be equal to two. With the labour supply fixed, $K_{t-1}$ can be interpreted as the capital/labour ratio.

If the household possesses less than the threshold level of capital, $\overline{K}$, then it cultivates a fixed amount of land $y$. Households with sufficient capital prepare at least an amount of land equal to *z*, ( $z \geq y$ ) and if the number of draught animals exceeds the minimum number required, then more land is brought under cultivation. There is a constant marginal return $a$ to draught animals exceeding the threshold level to reflect that with more draught animals available, animals become less tired if they work in spans of multiples of two, or, if they interchange each other at the yoke. The return is assumed to be constant for ease of modelling, but in fact with land and labour availability fixed the marginal return to capital is likely to be diminishing.

The shape of the production function is illustrated below.

Figure 1

Production function for the area cultivated




Cattle are not only productive through ploughing, they are also productive in an embodied sense: they reproduce, grow stronger and provide milk and manure. In addition they can be used for transportation purposes[5]. The embodied net return (total increase minus losses through death or theft) to cattle is assumed to be fixed and equal to *r*. Note that at capital levels above the threshold, the marginal rate of return to capital is $r+a$, so that the situation faced by a household switching from technology $y'$ to $y^*$ is analogous to the case where the rate of return on capital in the next period is higher.

The model is one with overlapping generations and no population growth. Each member of the household lives four periods, but only during two periods is one owner of productive assets. During these periods individuals are in a position to take decisions and these two lifecycle stages are modelled. In the periods that are not modelled one is a child for whom its parents take all relevant decisions. The parents produce in the first period using a certain amount of capital stock which they inherited from the previous generation. The parents (and not the children!) decide on how much capital to pass on to the second period. This period is a time of retirement when children support their parents but still do not have any rights over the assets. The parents, for altruistic reasons or for fear of not being supported once the assets run out in case of very old age, refrain from disinvesting in the assets but consume all current income earned. Hence the stock which was carried over from the first period to the second is also passed on to the next generation at the end of period two when the members of the old

[5] Cattle are also used as insurance substitute e.g. Fafchamps et al. (1998). This is not considered here because the model is deterministic.

generation die. After the inheritance the sequence starts afresh, but now with the formerly young generation taking the relevant savings decisions.

Households differ only in the amount of capital stock with which they start. Utility, $u$, is derived from consumption, $c_1$, in the first period and $c_2$ in the second. The bequest, $K_1$, is passed on to the next generation. The decision problem is to maximise at the beginning of the first period an additive lifetime utility function, subject to a discount factor $\frac{1}{(1+d)}$.

The household decision problem can be described as follows:

$$\begin{aligned}
&\max_{c_1 c_2} u(c_1) + \frac{1}{(1+d)} u(c_2) \\
&s.t. \\
&y_1 - c_1 + (1+r)K_0 = K_1 \\
&y_2 + rK_1 = c_2
\end{aligned} \qquad (2)$$

where subscripts indicate the relevant lifecycle stage and where the production technology is described by (1).

Faced with this choice problem there exist four possibilities with respect to the income generating process:

Table 1

Different regimes

| *Regime* | *household type* | *Period 1* | *period 2* |
|---|---|---|---|
| a. | poverty trapped | $y'$ | $y'$ |
| b. | transient | $y'$ | $y^*$ |
| c. | regressive | $y^*$ | $y'$ |
| d. | wealthy | $y^*$ | $y^*$ |

The income earned in the first period follows mechanically from the amount of capital inherited and the height of the threshold level. If $K_0 > \overline{K}$ then the land abundant production technique is chosen in period one, else the household has to cultivate less land. The income generating process used in the second period does not follow mechanically but depends on the savings decision in the first period. This decision is crucial to the future welfare of the household. Households in regime a. are poor and trapped in a low income situation in the sense that for them it is not attractive to save in period one the amount required to attain the threshold level so that in period two they cultivate little land. Those in regime b. manage to grow out of poverty: in the second period they use draught animals and henceforward cultivate a large area because through saving they managed to expand their capital base to at least the threshold level. Households in regime d. are sufficiently wealthy (initial capital exceeds $\overline{K}$) from the onset to use the ox plough in the first period, while the consumption decision they take is such that in the second period ox ploughing remains possible. Households in the third regime cultivate a large area in the first period, but choose to consume their capital base to below the threshold level so that they have to rely on manual land preparation in the second period. This is a possibility for farmers with a very high rate of time preference or if the cattle drawn production technique is not very rewarding. In this analysis no further attention is devoted to this regressive possibility.

The utility function is concave, so that the household has an in interest to smooth consumption over time. If for a certain generation it is not attractive to promote oneself out of poverty through saving (regime a.), it follows that it is attractive to consume part of the inherited capital for consumption smoothing reasons. The consequence is that the bequest left for the next generation is even smaller than that received from the previous generation: these households are in a downward spiralling poverty trap.

It was noted before that a regime switch from a. to b. is comparable to an increase in the rate of return on savings. In a two period model, such an increase leads to ambiguous results for the level of current consumption because of the opposite signs of the income and substitution effects that follow from the increase in the rate of return to capital. Our interest is not in the relative magnitude of these effects and therefore we abstain from it by assuming that the utility function takes the log form as this ensures that the income and substitution effects of a higher rate of return in the next period just cancel each other out.

In solving the system for consumption in the first period, it has to be taken into account that credit markets are absent so that the household cannot borrow against future income. For the solution of the model it is therefore assumed that the household first determines what it would like to consume as if the liquidity constraint were not binding, and then checks against its current resources whether this level of consumption is attainable. If this is not the case, the household has no choice but to consume all its current resources. The period one consumption solutions are indicated in table two.

Table 2

Consumption in the first period

| *Regime* | *consumption period 1* |
|---|---|
| a. | $\min[\frac{(1+d)}{(2+d)}\{y+(1+r)K_0+\frac{y}{r}\};y+(1+r)K_0]$ |
| b. | $\min[\frac{(1+d)}{(2+d)}\{y+(1+r)K_0+\frac{z-a\bar{K}}{r+a}\};y+(1+r)K_0-\bar{K})]$ |
| d. | $\min[\frac{(1+d)}{(2+d)}\{z+(1+r)K_0+a(K_0-\bar{K})+\frac{z-a\bar{K}}{r+a}\};z+a(K_0-\bar{K})+(1+r)K_0-\bar{K}]$ |

Households in regime d. consume more than those in regime a. because they cultivate a larger fixed amount of land ($z \geq y$ and $K_0 \geq \bar{K}$) and because they benefit from the higher marginal return to capital $a+r>r$. In regime b. the household would like to exceed the consumption level of regime a. because of the incentive to bring forward part of the increased earnings of the second period. But, the household in this regime has to acquire at least $\bar{K}$ in capital goods so that, at the same level of initial capital, a household that opts for regime b. consumes less in the first period than a household choosing regime a. Whether the household will opt for regime b. depends on the initial level of capital. It will decide to do so if the reduction in utility in the first period due to the additional savings required to attain the threshold is at least compensated by the extra discounted utility it will derive in the second period from the higher level of income the household can earn. Hence if

$$Log[c_1^a]+\frac{1}{(1+d)}Log[c_2^a]\leq Log[c_1^b]+\frac{1}{(1+d)}Log[c_2^b]$$

where a superscript indicates the regime, then the household grows out of poverty by switching to the productive technique $y^*$ in the second period.

Compared with a household which remains in regime a. a switching household has to make a jump in its savings rate. The reason is intuitive: a household with just insufficient capital to apply the productive technique in the first period is inclined to *add* to its inherited wealth in order to grow out of poverty. But a household which is far from the threshold capital level is inclined to smooth consumption and hence to *consume* part of the inherited wealth.

This is confirmed below. If $\hat{K}$ is the level of initial capital at which the household is indifferent between both regimes then for the case in which the liquidity constraint is not binding:

$$\hat{K} = \frac{\left(\frac{r}{a+r}\right)^{\frac{1}{2+d}} \left(\frac{(1+r)y}{r}\right) - \frac{z - a\bar{K}}{(a+r)} - y}{\left(1 - \left(\frac{r}{a+r}\right)^{\frac{1}{2+d}}\right)(1+r)}. \qquad (3)$$

It follows that at higher levels of $\bar{K}$ (or greater differences between initial wealth and the capital threshold level) the household prefers to remain poverty trapped. This too is intuitive: the larger the gap between the initial level of capital and the threshold, the greater the welfare consequences of the existence of a technological non convexity.

The consumption in period one can be used to determine the transition in capital stocks between the life cycle stages one and two which is, by construction, also the bequest left to the next generation. The results are self explanatory.

Table 3

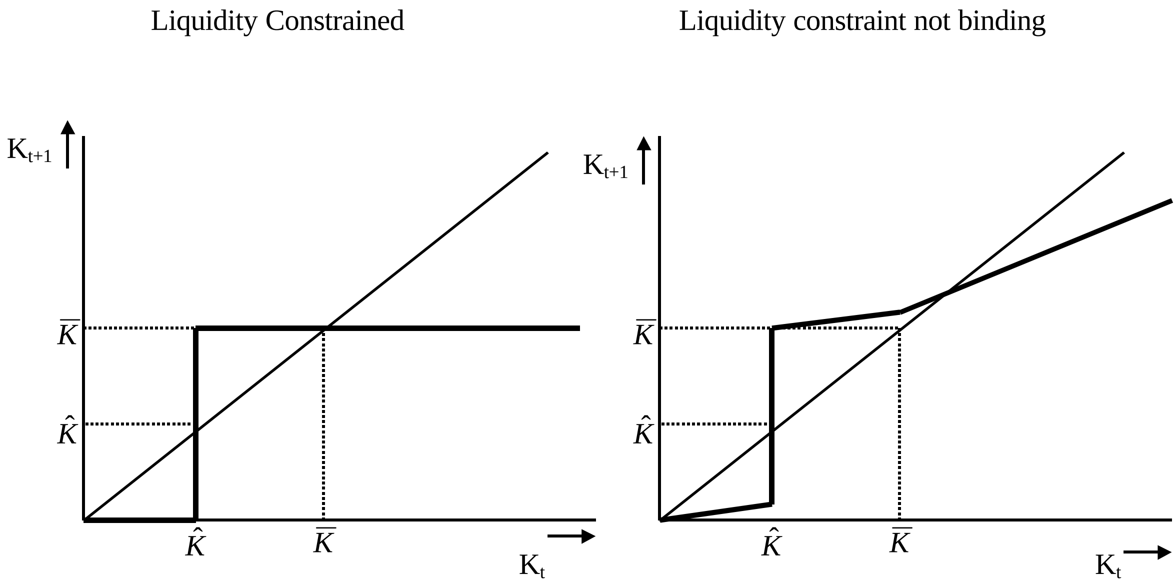
Capital passed on to the second period

| *regime* | *liquidity constrained case* | *liquidity constraint not binding* |
|---|---|---|
| a. | $K_1 = 0$ | $K_1 = \frac{(1+r)}{(2+d)} K_0 + \frac{y}{(2+d)} - \frac{(1+d)}{(2+d)} \frac{y}{r}$ |
| b. | $K_1 = \bar{K}$ | $K_1 = \frac{(1+r)}{(2+d)} K_0 + \frac{y}{(2+d)} - \frac{(1+d)}{(2+d)} \frac{z - a\bar{K}}{(r+a)}$ |
| d. | $K_1 = \bar{K}$ | $K_1 = \frac{(1+r+a)}{(2+d)} K_0 + \frac{z - a\bar{K}}{(2+d)} - \frac{(1+d)}{(2+d)} \frac{z - a\bar{K}}{(r+a)}$ |

The capital transition levels are indicated in figure two for the liquidity constrained and unconstrained cases. These graphs represent two polar cases and combinations of both graphs are possible. According to table three the slope of the capital curve in the case where the credit constraint is not binding is equal to $(1+r)/(2+d)$ for regimes a. and b. and $(1+r+a)/(2+d)$ for regime d.

Figure 2

Capital transition curves




The capital transition as indicated in figure two has implications for the distribution of wealth. Dissaving households are caught in a poverty trap if their stock of initial capital is below $\hat{K}$, while households with capital levels between $\hat{K}$ and $\overline{K}$ attain the threshold level in the next period. This implies a bimodal distribution of wealth: at the beginning of period two households have either no cattle, or at least as much as the threshold level. At the intermediate level, just below the threshold no, or in the unconstrained case very few, households should be found.

If $D_t$ describes the distribution of capital in period, *t*, and the distribution satisfies:

$$\int_0^\infty K_t dD_t(K_t) = \overline{\overline{K}}_t$$

then distribution $D_t$ fully determines the fraction of households, $H_t$, using the productive technology in period *t*:

$$H_t^d = \int_{\bar{K}}^{\infty} K_t dD_t(K_t) / \bar{\bar{K}}_t$$

those in transition out of poverty:

$$H_t^b = \int_{\hat{K}}^{\bar{K}} K_t dD_t(K_t) / \bar{\bar{K}}_t$$

and those in the poverty trap:

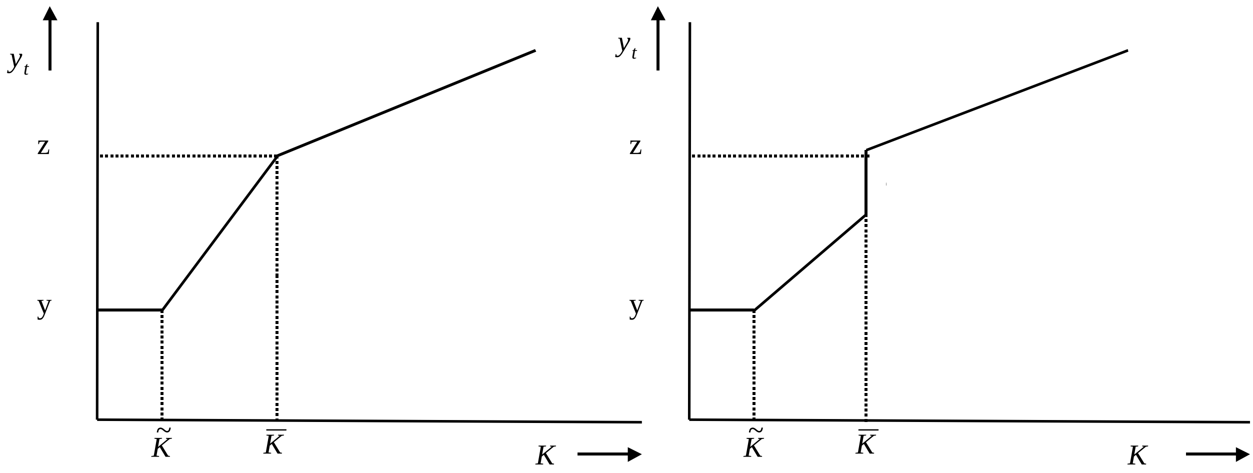
$$H_t^a = \int_{0}^{\hat{K}} K_t dD_t(K_t) / \bar{\bar{K}}_t$$

The distribution $D_t$ also determines the aggregate output. As long as there exist simultaneously households with less than the threshold of capital and households with capital levels greater than the threshold, and as long as the marginal returns from redistributed capital exceed that of capital employed above the threshold (hence if $a < (z - y) / \bar{K}$ ) then a redistribution of wealth toward those below the threshold increases aggregate output and the economically efficient outcome is attained if no households are poverty trapped or in transition out of poverty. If greater equity is defined by the absence of households in regime a. or b. and assuming that sufficient capital is available, then a redistribution of wealth toward the poor will attain two objectives at the same time: greater equity and greater efficiency.

Next increase the number of households and assume that they have identical preferences, identical plots of land and that they are of equal size. Households with less than the minimum required number of cattle have an incentive to look for partners to collaborate with and to reap the benefit of working together: *z*-*y*. Collaboration can take two forms. One possibility is that the partners share, proportionally to the amount of capital contributed to the joint undertaking, in the benefits of ploughing (*z*-*y*). This is shown on the left hand side of figure three. Another possibility is that one of the partners has the right of preferential use of the draught animals. The production function for this person is then as depicted by the left hand side of figure three, while his partner who is deprived of the privilege of early use, faces an opportunity cost indicated by o in the right hand case of figure three.

Figure 3

Joint production function without (left) and with (right) opportunity costs to sharing cattle




Collaboration can thus solve part of the problems associated with the non convexity in the production function and is, as such, an alternative to wealth redistribution. But it does not resolve all non convexities. Households who cannot contribute any draught animals but who possess some capital goods nonetheless (e.g. sheep, goats or other assets) are left out of the sharing arrangements and will have to prepare their land manually or to purchase draught services if this is feasible. The amount of capital these households possess is indicated by $\tilde{K}$ in figure three. Nonetheless, it follows that collaboration reduces the fraction of households trapped in poverty: the threshold level of capital is shifted to the left from $\bar{K}$ to $\tilde{K}$ so that the level of initial capital $\hat{K}$ at which it is attractive for a household to opt for regime two instead of the poverty trap is reduced (equation three). It also follows that households with between $\tilde{K}$ and $\bar{K}$ in capital are on a steep production curve. Compared to households with insufficient capital they both benefit from higher period one income, and they face a lower threshold ($\bar{K} - K_0$) so that such households are in a good position to increase their capital base and possess two or more draught animals in the next period.

## 3. The smallholder environment

The stylised facts used thus far, namely the absence or malfunctioning of markets, the existence of a non convex technology and the prediction of the existence of a bimodal wealth distribution, intentionally represent the African smallholder environment. Whether they do is considered below for the case of Zimbabwean farm households, who operate in an otherwise comparable economic environment but who are subject to different types of tenure: resettlement and communal smallholders in Zimbabwe.[6] The data have been kindly provided by Bill Kinsey and are described in Kinsey, Burger and Gunning (1998). The data set includes 400 resettlement and 150 communal households. The information for resettlement households is from annual surveys held between 1993-1998 and reflect the agricultural seasons 1991-92 to 1996-97. The information for the communal households is from annual surveys held in 1997 and 1998.

The assumption of land abundency, underlying this paper, implies that households live in isolated areas where population pressure is low and transportation and information difficulties large so that land and credit markets are dysfunctional. Data collected for the resettlement households in 1993 indicate that 70 percent of the households have to travel at least half a day and 30 percent at least a day to reach the nearest market; 85 percent have to travel half a day or more to the nearest post office and only half the households are able to reach a phone in less than half a day of travelling. For the communal households such information is not available but these households are located close to the resettlement areas. In addition they do not live clustered in villages as resettlement households do, but are scattered around. In principle the resettlement villages (and hence the households) can be reached by road, but this is much less the case for communal households. It thus seems likely that the communal households live in even more isolated circumstances than resettlement households do.

The households which were resettled just after independence in 1980, are better off than the communal ones. This is not due to superior skills on the basis of which these farmers could have been selected –rather, they were selected on their contribution to the liberation struggle– but has to be attributed to the fact that they possess more arable land of higher fertility, have more communal land available for grazing, so that their cattle are generally stronger, and they tend to have better access to services such as seasonal credit, agricultural extension and veterinary staff. But resettlement farmers have also been forced by the land redistribution authority to devote themselves exclusively to agriculture. Only repeated drought and the growing default rate on seasonal agricultural loans persuaded officials to relax the prohibition on non farm employment in the beginning of the 1990s. Few have responded to the easing of

[6] Resettlement farmers are the beneficiaries of a land reform program which was implemented just after Zimbabwe’s independence in 1980. The surveyed farmers were resettled in 1982 or 1983. The communal farmers are ‘normal’ peasant farmers. They were added to the survey as control group for the first time in 1997.

the regulations in taking up non farm activities, probably a result of the severe contraction of the labour market that has accompanied structural adjustment and which means that attractive jobs outside agriculture are hard to find. Income from off farm labour, business activities or remittances only contributes approximately 15 percent to total household income in normal years. For communal households this is different. They have never been constrained from entering off farm activities. Indeed, in many cases they were intended to serve as labour reserves for large scale commercial farming and for the urban based industrial and service sectors. It is for that reason that one finds that 43 percent of their total income comes from related sources either being off farm income, off farm business revenue or remittances (table four).

The differences between communal and resettlement households are reflected in the statistics. From data pertaining to seasons for which both resettlement and communal households were interviewed (1995-96 and 1996-97) it can be inferred that communal farmers have an output per acre for their most important crop, maize, which is approximately 60 percent of that of resettlement farmers. In addition they cultivate less land (4.6 acres against 8.3 for resettlement households) and possess about half the number of livestock of resettlement households. Though they earn a much higher share of total income through remittances, business activities and off farm income, communal households earn approximately 40 percent of what resettlement households do. Per head these differences are less pronounced as communal households consist of 6.4 members on average against 10.3 for the resettled ones.

Table 4

Breakdown of average household incomes (1995-96 and 1996-97)

| | *Resettlement Households* | *Communal Households* |
|---|---|---|
| gross total income[1] in Z$ 1990 | 2707 | 1041 |
| gross income from agriculture | 78% | 50% |
| gross income from livestock products[2] | 2% | 1% |
| gross off farm income from labor | 4% | 12% |
| gross business revenue | 9% | 12% |
| gross female income[3] | 5% | 6% |
| Remittances | 3% | 19% |

[1] Gross income comprises all components of income listed below. Home consumed agricultural production is valued at its sales price if the household also sold part of the crop and is valued at the median sales prices if no such information was available.

[2] Does not include reproduction.

[3] This is a separate entry in the questionnaire. It mainly comprises income earned from garden plots.

Source: Kinsey survey

Farming is the single most important source of income for all households, and there is no household in the sample which does not cultivate any land. This is important because implicit in the model is that agriculture, and cultivating land especially, is the primary occupation of the smallholder household. 62 percent of the communal household heads indicated that this is the case; for resettlement household heads this is naturally much higher: 90 percent. And if not the primary income source, then agriculture usually is the second most important income source (table 5).

Table 5

Which is the household's most important source of income

| | *Primary Source* | *Secondary Source* | *Primary Source* | *Secondary Source* |
|---|---|---|---|---|
| | Resettlement | Households | Communal | Households |
| Don't know | 0 % | 7 % | 0 % | 3 % |
| Farming | 90 % | 10 % | 62 % | 19 % |
| Wages from farm job | 1 % | 5% | 4 % | 9 % |
| Off farm wage | 8 % | 65 % | 21 % | 44 % |
| Remittances or pension | 1 % | 7 % | 11 % | 19 % |
| Other | 0 % | 6 % | 1 % | 4 % |

Source: Kinsey survey

That agriculture is the prime source of income is of interest because if this were not the case a livestock induced poverty trap would be less probable. But even if one finds a job outside agriculture, it is likely to be poorly paid. Stack (1996) for instance, finds in a survey covering 13 smallholder farming districts in Zimbabwe that available jobs mainly comprise seasonal agricultural work such as cotton picking, maize shelling, loading trucks, cutting grass or thatching. These jobs are poorly paid and many of the non farm activities appear to be undertaken for coping reasons. By their very nature, such jobs are usually the low entry jobs for which Dercon (1998) suggests, based on a survey in 20 Tanzanian villages, that they pay poorly. This is also found by Collier et al. (1986).

The model presumes a land abundant economy. This assumption has been made to warrant the conclusion that a land market is absent so that for poor farmers it is impossible to sell part of their land to attain the cash required to purchase a beast. Nonetheless the assumption is a strong one given the assertion to the contrary by researchers (Whitlow, 1980; Moyo, 1995) and Zimbabwean politician's alike, and in view of the first objective of the land reform program, which is to alleviate population pressure in the communal areas (Zimbabwe, 1980). Indeed, when asked whether the land they farm now is sufficient to support their family, 40 percent of the communal households indicated that this is not the case. Land constrained communal households cannot purchase extra land as their land tenure system is based on customary law, which does not allow ownership of land: it only gives individuals the right to use land and in most cases property rights therefore remain in the family (Shumba, 1992; Muir, 1994). One expects that the resettlement households are less affected by land constraints, if only because they have access to on average 146 acres of land per household of which, formally, only 12 can be usufructed for farming and of which the remainder are communal grazing grounds. Officially resettlement households are not permitted to cultivate more than 12 acres; in practice the cropped area often exceeds this. In normal years five to 10 percent of these farmers cultivate an area larger than allotted to them for cultivation purposes, and in the reasonably good 1996-97 season, nearly a third of the farmers exceeded this amount. The reason this happens is that resettlement farmers have extended their arable land over time, either with or without permission from the resettlement authorities. Though the available land is plenty, and the constraint on cultivating 12 acres not very hard, still 24 percent of the resettlement households indicate that they feel land constrained.

The land constraint is mainly confined to those households with at least one span of draught animals. Of these 25 percent indicated that insufficient land was available, as against six percent for the households with less than a team of draught animals. Land is more a constraining factor in communal than in resettlement areas. In accordance with this is the observation that in the resettlement areas, 63 percent of the households (versus 33 percent of the communal areas) fallowed land in 1997.

Given the land constraint it is unsurprising that a market for usufructural rights appears to have arisen in both areas. Nine percent of the households indicated that they were involved in borrowing or lending land in 1997 and 1998 for an average of two acres. A real market transaction this is not however. In 76 percent of the cases the land was made available for free, in the other cases payment was in cash (16 percent) or in kind (eight percent). But even in the few instances where money was received for land, the highest amount paid was less than one third of the median price of a trained oxen so that giving land in usufruct does not allow one to grow out of the poverty trap. So though it seems that in practise Zimbabwe cannot be characterised as a land abundant economy, the near absence of a land market and the fact that land is not a constraint for the households with less than a team of draught animals makes it a defensible stylised fact.

Another stylised fact put into the model asserts the absence of credit markets. Due to this absence households which have lost their livestock can not avoid the poverty trap by buying new ones using credit. Table six indicates that it is possible to borrow but that this is not the case for the purpose of buying livestock. Credit can also not be accessed to pay for ploughing. If all survey years are lumped together, one finds as few as ten households that were able to access loans to buy livestock. But it is unlikely that these were used to purchase draught animals. Of the households with a livestock loan, only one owned no livestock at all in the year previous to the purchase while 70 percent owned five or more beasts. This suggests that livestock loans were provided for other purposes, most likely cattle fattening.

Of course households could try to opt for seasonal or building material loans and then purchase livestock instead. In practise this is difficult as most of these loans are in kind.

Table 6

Number of loans outstanding and purpose of loans in percent

| calendar year[1] | 1995 | 1996 | 1997 | 1998 | 1997 | 1998 |
|---|---|---|---|---|---|---|
| | Resettlement | | | | Communal | |
| total number of loans | 372 | 201 | 334 | 414 | 38 | 22 |
| Reason for obtaining loan | | | | | | |
| to buy farm or implements | 17.2 | 2.0 | 8.7 | 1.0 | 0.0 | 0.0 |
| to buy seasonal inputs | 29.0 | 95.5[3] | 47.0 | 56.3 | 55.3 | 81.8 |
| to buy livestock | 1.3 | 0.0 | 0.6 | 1.0 | 0.0 | 0.0 |
| to pay for hired labour | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 |
| to pay for ploughing | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| to start an off farm business | 0.0 | 0.5 | 0.0 | 0.2 | 0.0 | 0.0 |
| to buy food and other goods for the family | 0.3 | 0.5 | 0.6 | 0.2 | 15.8 | 0.0 |
| to pay for travel expenses | 0.3 | 1.0 | 0.6 | 1.7 | 10.5 | 4.5 |
| to pay for building materials | 51.1 | 0.0 | 37.1 | 35.7 | 5.3 | 0.0 |
| to pay for health expenses | 0.0 | 0.0 | 0.6 | 1.2 | 0.0 | 0.0 |
| to pay for educational expenses | 0.5 | 0.0 | 0.3 | 1.4 | 0.0 | 9.1 |
| other | 0.3 | 0.5 | 4.2 | 1.0 | 13.2 | 4.5 |
| | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

1 1995 refers to the moment of the survey. The loan reported then reflects the 1995-96 season.

[2] Communal households

[3] 1995 was a drought year. Apparently many households depleted their cash resources to survive, so that loans are required to purchase seed and other inputs.

Source: Kinsey Survey

A final possibility to circumvent the absence of the draught animal credit market is by borrowing cattle. Binswanger and Rosenzweig (1986) suggest that the exchange of livestock markets is rare because draught animals are vulnerable to abuse. This does not hold in Zimbabwe, where for instance four percent of the animals in the resettlement areas and 15 percent of those in the communal areas do not belong to the farm household itself but have been given in care by others.[7] The fear of abuse is low most probably because such can be easily established. The skin of an overworked animal would be wounded from repeated beatings required to push the animal to its limits. Abuse thus leaves long lasting marks, and would for instance not go unnoticed at the frequent animal dippings where people would like to know who abused the animal. Such person would then be excluded from future arrangements. Apparently this is a sufficient threat and survey information for 1997 and 1998 reveals that a substantial number of households is involved in livestock exchanges: seven percent receiving livestock and ten percent providing draught animals. As expected the main beneficiaries of draught animals are those households with less than two beasts. Of these, 20 percent was active on the livestock borrowing market to access draught animals, against five percent of those with two beasts or more.

This suggests that poor farmers might be able to access drought animals for free, but this is not generally the case. Of the 18 households, for instance, who in 1997 had less than two beasts for at least four years, only one was able to obtain free draught animals, while 11 (61 percent) had to pay for them. That real poverty trapped farmers are excluded from these arrangements, conforms to the nature of mutual sharing relationships: those with little to offer are logically excluded. Case studies presented by Scoones (1996: 80-85) describe a similar phenomenon where households without draught animals and without significant kinship networks (in-migrants for instance) or with long term absenteeism (due to illness for instance) are the ones who have to rely on hiring draught animals while those with at least a few draught animals or strong (familial) relations are able to benefit from sharing arrangements.

The Kinsey data confirm this. Where on average 12 percent of the households paid for ploughing services, those with less than two beasts relied disproportionally on this possibility. As many as 37 percent of them purchased ploughing services as against eight percent of those with two beasts or more. Lack of resources probably implies that farmers with less than two beasts also purchase fewer ploughing services: they did so for Z$ 375 on average, against Z$ 534 for the better off farmers with two beasts or more.

[7] This does not imply that livestock is provided free of any obligation. Provision of livestock certainly obliges the borrower to express favours to the lender or to provide assistance when needed.

In conclusion it seems to be too strong an assumption to claim that no market for draught services exists. But it is clear that poor households have greater difficulty to access livestock through exchange arrangements. In addition, owners of livestock can make preferential use of them and it is common to find in Zimbabwe that non draught animals owners plant their crops late (Shumba, 1992; Scoones, 1996; Dercon (1998) reports the same phenomenon for Tanzania). This comes at a considerable cost as planting date trials showed maize grain yield reductions of 2.3 percent per day with late planting relative to planting at the start of the first effective rains (Shumba, 1992). If this is the case and everything else being equal, the lower marginal returns to land still imply that even if ploughing services for a fixed amount per acre can be afforded by a poor household it is optimal to prepare less land. As such, the absence of a draught power market can be defended as an acceptable stylised fact.

Now that the main stylised facts on the absence of markets have been evaluated, let me next consider the technology used. As already noted, farming is the main occupation of most of the surveyed farmers and livestock is identified as a crucial factor to successful farming in the literature (Shumba, 1992; Moyo *et al* 1992; Scoones, 1996; Kinsey, 1998). Table seven confirms the correlation between area cultivated and the presence of draught animals. It also suggests that there is reason to assume a break in the area cultivated at one or two animals.[8] Households with at least a span of draught animals cultivate 29 percent more land than households without draught power.

[8] In view of the sharing arrangements described earlier one could also put the break at one animal. In practise this does not affect the estimation results because only very few households possess one traction animal. This can also be read from figure five.

Table 7

Number of draught animals and area cultivated

(1990-91 - 1996-97)

| *Number of draught animals* | *Area cultivated* |
|---|---|
| 0 | 5.6 |
| 1 | 6.5 |
| 2 | 7.2 |
| 3 | 7.5 |
| 4 | 7.7 |
| 5 | 7.8 |
| more than 5 | 8.8 |

Source: Kinsey survey

29 percent is a lower bound for the expected difference in agricultural income because farmers with draught animals are not only in a position to cultivate more land they also attain a higher production per area cultivated because they can prepare their land better, apply manure etc.. This is illustrated by the difference in maize yield of nearly 70 percent (maize is a crop grown by all households) between resettlement households with at least one span of draught animals and those without. A rough calculation, and assuming that these differences are indicative for other crops, suggests that farmers with at least a team of draught animals earn at least twice as much from agriculture as those without a span of draught animals.

Table 8

Maize yield for resettlement households with and without draught power

| | *No draught team* | *At least one draught animal team* |
|---|---|---|
| 1992-93 | 680 | 976 |
| 1993-94 | 441 | 856 |
| 1994-95 | 109 | 276 |
| 1995-96 | 594 | 1174 |
| 1996-97 | 517 | 904 |

Source: Kinsey data

The importance of livestock can also be inferred from the reason why households fallow land. The survey data show that the prime reason to do so is insufficient draught power (table eight).

The absence of labour markets due to which labour availability becomes a problem during peak periods in the cropping season is also confirmed in the table.[9]

Table 9

Reason to leave land fallow in 1997, resettlement households only

| | *less than two beasts* | *two beasts or more* | *less than two beasts* | *two beasts or more* |
|---|---|---|---|---|
| | Percent of responses | | acreage left fallow | |
| Insufficient draught power | 38.4 % | 17.4 % | 6.7 | 3.2 |
| Insufficient labour | 7.7 % | 11.2 % | 4.8 | 4.3 |
| Insufficient cash for inputs | 26.9 % | 29.0 % | 4.8 | 3.8 |
| land is of poor quality | 19.2 % | 13.0 % | 3.6 | 2.4 |
| land left to rest | 3.9 % | 16.8 % | 6.0 | 3.4 |
| other[1] | 3.9 % | 12.6 % | 1.0 | 3.8 |
| Total | 100.0 % | 100.0 % | 5.2 | 3.5 |

[1] Waterlogging due the exceptionally heavy rains at the onset of this season was the most common other reason cited.

Source: Kinsey survey

Especially households with less than two beasts indicate that draught animals are a constraint. These are the households that leave the largest area fallow: 6.7 acres on average. In accordance with the model in which owning more than one span of draught animals increases the area cultivated, also households with the minimum number of animal traction leave land fallow for reasons of insufficient draught power, but this constraint is less serious for them and they leave on average less than half the area fallow (3.2 acres) as households with insufficient draught power do.

[9] That labour markets are malfunctioning so that labour needs to be internally provided could also be inferred from the fact that the average communal household is about 40 percent smaller than the average resettlement household.

# 4. The production technology

To explore more systematically the dependence of the area cultivated on the availability of draught animals and to consider whether a break in the production function can be found as depicted in figure three and suggested in table eight, a regression analysis is carried out. To this end, for the resettlement households information pertaining to the seasons 1992-93 up to 1996-97 is used. The information collected in 1993 on the 1991-92 agricultural year is not included because no data on household composition are available for this year. Communal households could not be included in the estimations. The reason is that use will be made of the panel character of the data set and that for communal households only complete cross sectional information is available. Though two survey rounds have been held, the timing of these surveys early in the agricultural season ensures that information collected on labour and livestock reflects the household's current situation, while the crop related information pertains to the past year. Hence two survey rounds are required to obtain a complete information set for any given year, leaving only a complete cross section for the communal households.[10] Since the data collection for the resettlement and communal households is an integrated undertaking, it follows that also for the resettlement households one year of information is "lost". This leaves for the estimations five years of complete information. Of the 400 resettlement households included in the data set, 108 were dropped either due to missing information in any of the survey years and the wish to maintain a balanced panel (99 cases)[11] or because of gross inconsistencies in the data over different survey years (9 cases).

In the estimation the (log) total area, $y_{i,t}$ , cultivated is to be explained. The key explanatory variables $X_{i,t}$ are the number of draught animals and the available labour.

$$\ln y_{i,t} = X_{i,t} b + e_{i,t}$$

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[10] Of course a cross section approach could be tried, but would require the use of instrumental variables to deal with the endogeneity problem that is associated with the inclusion of labour and livestock as explanatory variables. Convincing instruments were not available however.

[11] The attrition to maintain a balanced panel is high, but it affects the results in no significant way. In the appendix the regression results are reported for the case where the panel was unbalanced. These results are comparable to the ones presented here.

Included as traction animals are not only trained oxen but also heifers and cows as these are most commonly relied upon if households do not possess sufficient beasts.[12] Two types of labour are lumped together and included: those by adolescents (those between 10 and 15 years of age) and adults (those between 16 and 50 years of age). Children and the elderly are assumed not to be involved in the physically strenuous task of land preparation.

The estimated equation is linear. An obvious disadvantage of this approach, as opposed to a Cobb Douglas production function for instance, is that complete substitution between animal power and labour is allowed for, so that in theory production can take place even in the absence of labour. In the estimation this problem does not occur because there are no households without labour for the straightforward reason that if there are no persons in a household it seizes to exist. But it does happen that land is cultivated while no draught animals are available. It is precisely this flexibility offered by the linear approach which makes it the preferred choice.

Expected is a break at two draught animals as this is the minimum number required for ploughing the heavy loam soils which the surveyed farmers possess. To find out whether this is indeed the case, the model is estimated in piecewise linear form in the number of draught animals. In addition the model includes a constant term for households with at least one span of draught animals. In the figures presented in section two, it was suggested that possessing a draught animal team increases the area cultivated ($z > y$) and the incorporation of this variable is to check this assumption. Note however that the model does not depend on whether this assumption actually holds, as the relevant condition for $z$ is: $z \geq y$. Nonetheless, given the prominence many observers attach to inter household co-operation (e.g. Scoones, 1996) one expects there to be an economic ground for it, in this instance in the form of a significant increase in the area cultivated for households with a least two draught animals relative to those without them. As it is likely that there are diminishing returns to the use of draught animals, they are also included in squared terms and are expected to have a negative sign. In addition, to reflect that hiring draught services does take place (though on a limited scale), the monetary outlays spent on such services (in real 1990 Zimbabwe dollars) are included in the estimation.

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[12] Cows are spared whenever feasible to ensure that their reproductive capacity is not affected in the exhausting ploughing (Moyo et al. 1992).

There may be concern of a potential bias in the parameter estimates due to endogeneity or omitted variables. For instance, it could be argued that agro-ecological factors, local weather conditions or farming skills that determine the productivity of land are omitted from the regression, and hence implicitly included in the error term of the model. If these factors are a significant determinant of the area cultivated, the error term will not converge to zero in the probability limit, and the parameters for the included explanatory variables will be inconsistent.

Another variant of this problem could be described by the argument that some of the determinants themselves depend on omitted variables. For instance, household size may depend on the omitted farming skills, for instance if a successful farmer marries an additional wife or if he becomes host to a larger than average number of extended family members. Because the omitted factors are subsumed by the error term, these determinants are now correlated with the error term, and hence give rise to inconsistent parameter estimates.

One solution to the potential problem of omitted variables is the use of a fixed effects model. Mundlak (1978) shows that the BLU estimator is the fixed effects within estimator for the case where all exogenous variables are not truly exogenous which is the case here. The regression results show that omitted variables are indeed a problem, as the estimated correlation between the individual fixed effects and the right hand side variables is 0.25. The fixed effects estimator is however robust to such correlation and the estimates reported are unbiased.

The estimated equation looks as follows:

$$(\ln y_{i,t} - \ln \bar{y}_i) = (X_{i,t} - \bar{X}_i)b + (e_{i,t} - \bar{e}_i)$$

where $\ln \bar{y}_i = \sum_t \ln y_{i,t} / T_i$, $\bar{X}_i = \sum_t X_{i,t} / T_i$ and $\bar{e}_i = \sum_t e_{i,t} / T_i$ and in which $e_{i,t}$ is the independent and identically distributed error term, $T_i$ the total number of periods included, $X_{i,t}$ the vector of explanatory variables and $y_{i,t}$ the area under cultivation.

Reverse causality where planting a larger acreage leads to more livestock and labour bears little realism. But the previous year’s harvest could affect the current decision on the acreage planted if a good harvest leads to increased means to purchase inputs. Because farming is rain fed and rainfall is the main determinant of the harvest produced (the correlation coefficient between average maize output per acre and average rainfall is 0.86), a variable which indicates the absolute deviation of previous year's rainfall from this century's mean average rainfall is included. To allow for the fact that farmers are sequential decision makers, the absolute deviation from this century's mean of the current year's rainfall is taken as an indicator of the state of the season. To capture information about changes in household level skills and abilities, the past year's output per acre of maize (a crop grown by all respondents) is included. Finally a variable reflecting local conditions (being it the timing of the start of the rainy season, the rainfall pattern, the availability of seed, the social cohesion within the village etc.) is added: the village level average acreage planted. This variable is constructed in such a way as to avoid spurious correlation and comprises the average acreage planted by all *other* households interviewed in the village.

Table 10

Piecewise fixed effects estimation of area cultivated by resettlement households

| | *Coefficient* | *T-Stat* | *P value* |
|---|---|---|---|
| Threshold Dummy[2] | 0.2534 | 2.29 | 0.02 |
| Draught Animals | -0.1287 | -1.90 | 0.06 |
| (Draught Animals – 2)* Dummy[3] | 0.1386 | 2.03 | 0.04 |
| Draught Animals Squared | -0.0002 | -1.69 | 0.09 |
| Labour | 0.0171 | 2.88 | 0.00 |
| Absolute Difference of Current Rainfall | -0.0000 | -0.19 | 0.85 |
| Absolute Difference of Previous Rainfall | 0.0003 | 2.40 | 0.02 |
| Acres Planted in Village | 0.0318 | 2.74 | 0.01 |
| Last Year's Yield for Maize | 0.0001 | 2.53 | 0.01 |
| Real 1990 Cost of Ploughing Services | 0.0009 | 0.03 | 0.98 |
| Constant | 1.538 | 13.63 | 0.00 |
| | | | |
| Obs: | 1460 | | |
| T : | 5 | | |
| n: | 292 | | |
| | | | |
| $R^2$ within[4] | 0.03 | | |
| $R^2$ between | 0.28 | | |
| $R^2$ overall | 0.15 | | |
| F (10, 1158) | 3.70 | | |

[1] Included are own animals and those in the care of others

[2] The threshold dummy is one if a household has at least two draught animals and zero otherwise

[3] Dummy equals one if there are two or more draught animals; zero otherwise

[4] Household fixed effects estimation has several advantages, but the procedure comes at a cost if there is a high degree of noise in the data due to date-specific measurement errors. For instance, if two individual- and date specific variables are given by an individual-specific time mean plus a date-specific white noise error process, then differencing will entail regressing white noise on white noise with a poor fit as a result (Deaton, 1994). This is not an argument against using a first difference approach (it does allow to control for unobervables), but it calls for caution in the interpretation of poor fits.

Source: Kinsey survey

The results reported in table ten confirm the piecewise linear description of the draught technology and the importance of the threshold effect. All coefficients have the correct signs and the level of significance of each of the variables is within an acceptable range. Possessing at least a span of draught animals allows a household to cultivate substantially more land. Using the estimated parameters $\hat{b}$ , predictions of acreage cultivated per household can be generated as: $\hat{y}_i = e^{\hat{b}\, X_i}$ . Thus evaluated at the mean values for labour, rainfall, ploughing costs and average acreage planted in the village[13], a household with no livestock is predicted to cultivate 7.35 acres. An additional beast, increases the area cultivated marginally: to 7.42 acres, while the transition to two beasts augments the predicted acreage to 9.65 acres or an increase of 31 percent relative to the acreage planted in the absence of draught animals. Evidence for diminishing returns in the use of draught power (draught animals squared is negative) is weak. The implied turning point for livestock is at about 25 beasts, or at the 98th percentile of the sample.

The presence of labour significantly contributes to the acreage under cultivation, but is not as important as livestock. Evaluated at mean variable values, an additional labourer in the household increases the prediction for cultivated acreage by 0.13 acres. Previous rainfall, household experience and knowledge and village level conditions all determine the acreage planted. Deviations from current rainfall and expenses for ploughing services are not significant.

## 5. The distribution of wealth

So far the discussion has made clear that the conditions with respect to the absence or malfunctioning of the draught service, credit and land markets are acceptable abstractions from reality, though that they probably are not as hard as suggested in the first section of this paper.

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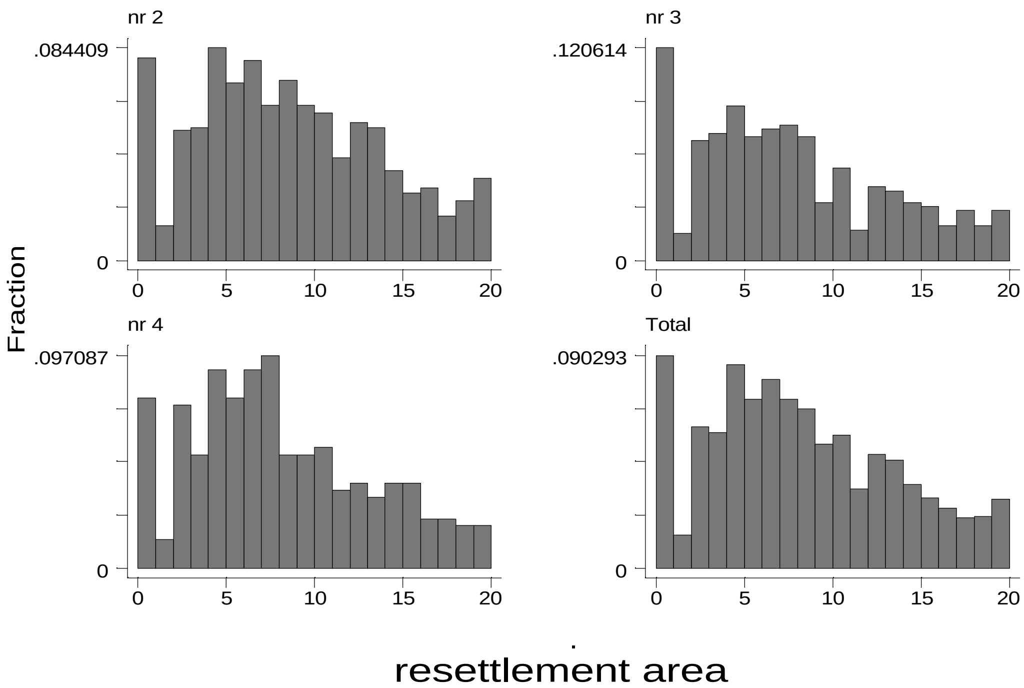
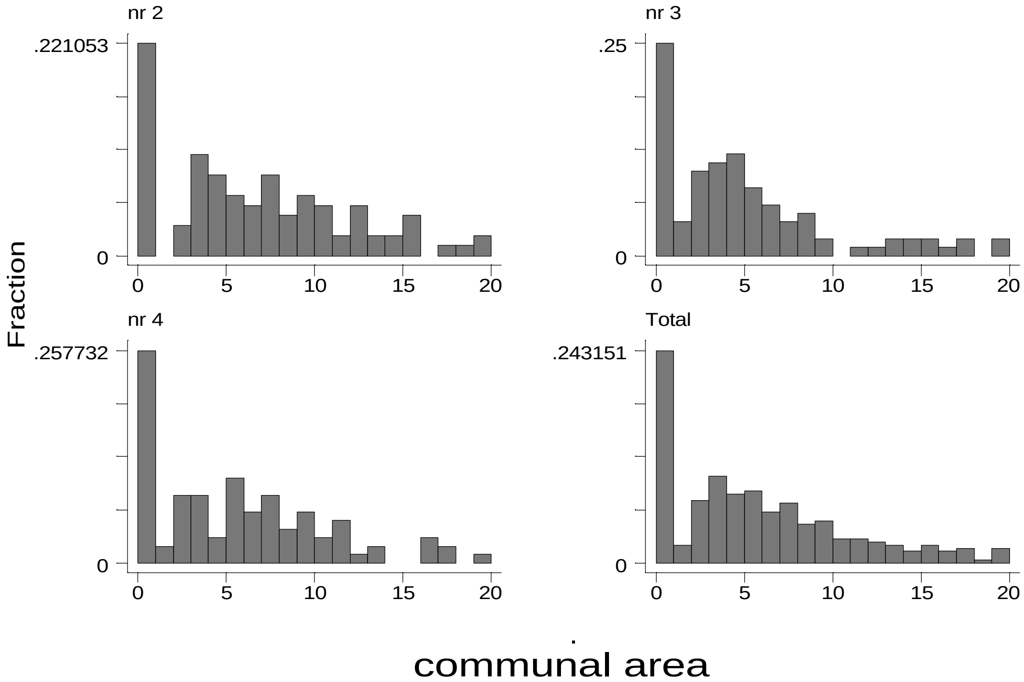
[13] These values are for households without livestock 5.3 for labour, 96.14 for the absolute difference in current rainfall, 169.37 for the absolute difference in past rainfall, 7.77 for the average acreage planted in the village, 314.4 for previous year's maize yield and 0.15 for the cost of ploughing services. For the average sample household, these values are respectively, 7.05, 108.02, 153.7, 7.98, 530.33 and 0.06, with additional values for the threshold dummy of 0.87, 6.25 for draught animals, 4.48 for the piecewise variable and 73.17 for draught animals squared.

Evidence of a non convex production technology has been presented in the previous section. An important test on the relevance of the model is in considering its prediction with respect to the distribution of wealth, which should be bimodal. To this end figure four presents distributions of the number of draught animals kept. To check whether the predictions are robust, distributions are presented for the different natural regions (nr) in which households are located. Natural region two is the most favourable and natural region four the least favourable to agriculture, with natural region three taking an intermediate position. In addition a distinction is made by type of land tenure (resettlement or communal).

Figure 4

Histograms of distribution draught animals by tenure type and natural region






Source: Kinsey surveys

Figure four shows in accordance with the theoretical predictions that households either have no capital stock or that they have sufficient capital. This distribution is not exclusive for the Zimbabwean situation and has been found in other countries as well. Collier et al. (1986) reports for a survey held amongst 3200 rural households in Tanzania that only around 20 percent of the rural households own any cattle, but that among these households the number held is approximately twelve. And Datt et al. (1998) report a similar distribution for Mozambique in that only 15 percent of the rural population had some livestock, 20 percent at least the critical mass and 65 percent no livestock at all.

In each of the wealth distributions in figure five, the livestock threshold level, $\overline{K}$ , is at two beasts and the poverty trap level, $\hat{K}$ , is at one beast.  Very few households (approximately one percent) are in transition and the fraction of households in poverty varies between eight and 26 percent. The wealth distributions presented do not originate from a unimodal normal or a lognormal distribution. Shapiro-Wilk tests, convincingly reject this possibility at above one percent levels of significance for each of the wealth distributions presented. The shape of the distributions is independent of the type of land tenure and natural region. Households living in less favourable conditions (communal households, those in natural region four) generally possess less cattle and are more likely to be poor. The resettlement households are better off than the communal households and the differences between communal areas and resettlement areas are pronounced. The differences between households in natural region three and four are limited, probably because the worse environmental conditions in natural region four are compensated by the fact that households in this region live relatively close to an urban centre (Hwedza) offering them better opportunities for marketing, information and off farm employment.

Though on theoretical and empirical grounds it seems reasonable to assume that households with less than two animals are poor and maybe even poverty trapped, it is relevant to assess whether the households themselves perceive this similarly. Answers of respondents in the 1997 survey are suggestive of this: a close correlation can be inferred between whether a households considers itself poor relative to its neighbours and the presence of sufficient draught animals (table 11).

Table 11

Wealth status of the household compared to other households in the village[1]

| | *Poor* | *Neither poor nor well off* | *Well off* | *Total* |
|---|---|---|---|---|
| Less two animals | 63 % | 29 % | 8 % | 100 % |
| Two or more animals | 20 % | 65 % | 15 % | 100 % |

[1] This question was asked to resettlement households only

Source: Kinsey survey

Further evidence is presented by Kinsey (1998) who compares 1997 survey results with those collected by the 1995 representative Poverty Assessment Study Survey (Zimbabwe, 1997) and finds that: (i) lack of land is not perceived by resettlement or communal households as constraining factor on the route out of poverty, and (ii) that the most important step households would like the government to take to reduce poverty is, after the provision of irrigation, the provision of livestock or tillage.

But not all households without cattle should be classified as poverty trapped. Transition analysis shows that households which possess no draught animals in a given year have a probability of 30 percent of possessing draught animals the next year. This transition rate is similar for resettlement and for communal households.

Table 12

Yearly transition rates in percent of number of cattle owned of households with less than five beasts

| | *number* | *Following* | *year* | | |
|---|---|---|---|---|---|
| Initial number | 0 | 1 | 2 | 3 | 4 |
| 0 | 70% | 9% | 13% | 5% | 3% |
| 1 | 17% | 25% | 31% | 22% | 6% |
| 2 | 9% | 11% | 43% | 23% | 14% |
| 3 | 4% | 5% | 26% | 36% | 27% |
| 4 | 7% | 3% | 20% | 20% | 51% |

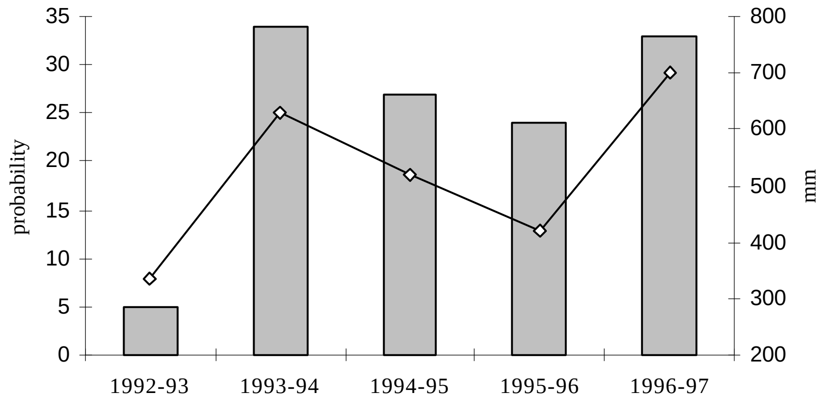
Source: Kinsey survey

Table 12 considers yearly transition rates between 1992-93 and 1996-97 for resettlement households with less than five beasts.[14] It shows that 70 percent of those without draught animals in the first year, still do not possess them the following year, while 21 percent (13 + 5 + 3) is able to acquire two or more beasts. Of those who possess one beast in the initial year, 17 percent fall back into the poverty position, 25 percent maintain their position and 56 percent (31 + 22 + 3) is able to increase the number of draught animals to two beasts or more. Whether or not a household can make a transition for the better not only depends on its own preferences, resources and characteristics, but is also related to the one factor which is of critical importance in non-irrigated farming: rainfall. Figure five illustrates this point by presenting the transition probabilities of households with zero draught animals in the initial and at least one in following year and the rainfall in the initial year.

[14] This years correspond with the ones included in the estimations presented in the next section.

Figure 5

Transition probability of obtaining at least one beast for resettlement households with no draught animals (column) and average rainfall (line)




Source: Kinsey data

One way to assess whether a household is in transitory or poverty trapped, is by observing the number of years in which the household is in poverty. The largest fraction of resettlement households (87 percent) is not poor at all. But five percent of them have less than two beasts in at least four of the five survey years. These households are poverty trapped and this is further illustrated by the fact that half of these farmers do not even possess a plough. This while of all resettlement farmers only three percent do not possess a plough! Nonetheless, five percent poverty trapped households is a fairly low percentage. In the communal areas, where most Zimbabwean farmers live, the problem is much more severe however. Here 24 percent as opposed to nine percent do not possess any cattle in any given year, and 17 percent do not possess a plough.

Whether a household really is poverty trapped also depends on the other sources of income available. It is not the case, however, that the farmers who go without livestock for a number of years and who do not possess a plough have well paid jobs outside agriculture. For the resettlement households without a plough 70 percent indicated that agriculture is their prime income source, 15 percent work in low paid farm jobs and for the remainder 15 percent one could assume that they have found proper work outside agriculture. Of the communal households 55 percent of the households without at least a team of draught animals indicated that farming is their prime source of income and another 25 percent work as farm labourers. If one accepts the absence of a plough as an indicator reflecting that the household has been in poverty for a number of years then one might tentatively infer that ten to 15 percent of these households is likely to be poverty trapped.

## 6. Conclusion

In this paper it is argued that peasant households in land abundant areas, typically African smallholder farmers, choose between two technologies for land preparation: a manual one and a mechanical one using the plough. The latter allows the farmer to cultivate more land but requires a minimum number of draught animals. Hence there exists a technological non convexity which implies that the savings function is not smooth.

From the model based on these assumptions follows that certain households may be poverty trapped and that aggregate production is fully determined by the initial distribution of wealth. It follows that a redistribution of wealth is equity and efficiency enhancing and that collaboration between farmers may achieve much the same results.

The model is developed under very strict conditions on the absence of markets. This was to reflect the empirical reality of smallholder agriculture in Africa, which is usually characterised by such conditions. Galor and Zeira (1993) and others have shown that under much weaker conditions similar results for the existence of a poverty trap can be attained. The contribution of this paper is that it presents a very concrete example of a technological non convexity to which most smallholder farmers in Africa are subject.

Empirical evidence for peasant farmers in Zimbabwe supports the assumptions made for the production technology and shows that there is a substantial economic incentive to collaborate. The model’s prediction on the existence of a bimodal distribution of wealth, which has been observed in many rural areas in Africa, is confirmed for Zimbabwe. It is inferred from this that households who do not obtain livestock for a number of years, and who do not have rewarding off farm jobs are poverty trapped. Since so much fewer resettlement than communal households are in this situation, this is implicit support for the resettlement program though it is not clear for which aspect of the resettlement program: the abundant allocation of land, the allocation of fertile land or the improved access to services and infrastructure. The results also point toward a potential role for livestock in poverty eradication programs. Especially after shocks in cattle possessions, such as the 1992 drought in Zimbabwe, restocking programs can be of great value in containing the permanent increase in poverty that otherwise might follow from the loss of draught animals.

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# Appendix

Piecewise fixed effects estimation of area cultivated by resettlement households: unbalanced panel, at least three observations

| | *Coefficient* | *T-Stat* | *P value* |
|---|---|---|---|
| Threshold Dummy[2] | 0.2022 | 1.93 | 0.05 |
| Draught Animals | -0.0993 | -1.60 | 0.11 |
| (Draught Animals – 2)* Dummy[3] | 0.1033 | 1.66 | 0.10 |
| Draught Animals Squared | -0.0001 | -1.05 | 0.29 |
| Labour | 0.0112 | 2.20 | 0.03 |
| Absolute Difference of Current Rainfall | -0.0000 | -0.01 | 1.00 |
| Absolute Difference of Previous Rainfall | 0.0003 | 2.67 | 0.00 |
| Acres Planted in Village | 0.0359 | 3.23 | 0.00 |
| Last Year's Yield for Maize | 0.0000 | 2.34 | 0.02 |
| Real 1990 Cost of Ploughing Services | 0.0142 | 0.58 | 0.56 |
| Constant | 1.586 | 15.32 | 0.00 |
| | | | |
| Obs: | 1838 | | |
| T : | 4.88 | | |
| n: | 377 | | |
| | | | |
| $R^2$ within | 0.02 | | |
| $R^2$ between | 0.36 | | |
| $R^2$ overall | 0.18 | | |
| F (10, 1451) | 3.31 | | |

[1] Included are own animals and those in the care of others

[2] The threshold dummy is one if a household has at least two draught animals and zero otherwise

[3] Dummy equals one if there are two or more draught animals; zero otherwise

Source: Kinsey survey