ELSEVIER

Agricultural Economics 21 (1999) 279–294

AGRICULTURAL ECONOMICS

www.elsevier.com/locate/agecon

The effects of land sales restrictions: evidence from south India

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Received 23 July 1997; received in revised form 21 May 1999; accepted 12 July 1999

Abstract

The effects of land sales restrictions on credit use, land investment and cultivation decisions are investigated using data from two villages in south India. Sales restrictions are found to have little effect on credit supply and demand or demand for land improvements. Some household characteristics are found to affect investment demand on plots subject to sales restrictions in one village, suggesting that the 'transactions effect' of such restrictions may be inhibiting allocative efficiency. However, we also find that household characteristics influence investment on titled plots, and that the magnitude of impact of such characteristics is greater on titled plots. These results imply that sales restrictions are not a major source of inefficiency in the villages studied, and suggest that the nature of village credit and land markets and enforcement of sales restrictions are critical determinants of the impacts of such restrictions.

Keywords: Land sales restrictions; Transactions effects and investments; Land titling programs; South India

1. Introduction

In recent years, the benefits of land titling programs in developing countries have been debated in policy circles and the literature. Proponents of such programs argue that land titles promote investments in land improvement and more efficient allocation of land and use of inputs (Feder et al., 1988; Hoff, 1991). Critics argue that land title does not necessarily improve tenure security, and therefore, may not promote land investment, that increased marketability of land can lead to adverse distributional effects without significant efficiency gains, and that indigenous property rights systems evolve in an efficient manner in response to population pressure, changes in technology and commercialization (Atwood, 1990; Barrows and Roth, 1990; Migot-Adholla et al., 1991; Gyasi, 1994).

A growing body of literature is emerging that seeks to clarify the linkages between land rights, land investment and efficiency of resource use, and to test these linkages empirically. Three principal mechanisms by which land rights influence resource use efficiency are cited in this literature (Place and Hazell, 1993; Besley, 1995; Carter and Olinto, 1996; Gavian and Fafchamps, 1996; Lopez, 1996; Hayes et al., 1997; Feder et al., 1988):

- *the credit supply effect*, whereby increased transferability of land increases its collateral value, and thus, farmers' access to credit;

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[1] At the time this research was initiated, Dr. Pender was with Brigham Young University and Dr. Kerr was with Winrock International and the International Crops Research for the Semi-Arid Tropics. We are grateful to ICRISAT for its assistance in data collection and entry; the Ford Foundation, which funded Dr. Kerr's costs; to the College of Family, Home, and Social Sciences at Brigham Young University, which provided financial support for Dr. Pender's travel, and to the International Food Policy Research Institute, which supported the completion of the research.

0169-5150/99/$ – see front matter
PII: S0169-5150(99)00031-6

- *the investment demand effect*, whereby greater tenure security increases farmers' incentive to invest in land improvements; and
- *the transactions or gains from trade effect*, whereby increased transferability of land results in more efficient allocation of the land.

In their seminal study, Feder et al. found that land titles increased investment, input use and the productivity of land use in Thailand, mainly by increasing farmers' access to institutional credit. Lopez found similar results in his evaluation of land titling in Honduras, with the main benefit of title being the increased use of inputs enabled by increased access to credit. Carter and Olinto found that land title both increases access to credit and increases investment demand in Paraguay, though they argue that the benefits of increased credit access accrue mainly to larger farmers.

By contrast, several studies from Africa found little support for the credit supply hypothesis, in part because of the limited development of credit markets in the regions studied, but found some support for the investment demand and transaction effects. Hayes, Roth and Zepeda found that complete, transferable land rights enhanced long-term land investments in a peri-urban region of the Gambia, which in turn enhance yields. They did not investigate the credit supply hypothesis directly, but interpreted their results as indicating the effect of tenure security. Gavian and Fafchamps found no relationship between land sales restrictions and manuring decisions of farmers in Niger, though manuring was significantly affected by tenure security. They also found that land use productivity was influenced by household labor endowments, implying that the tenure system does not allocate land efficiently. Besley found significant effects of plot-level land rights variables but insignificant effects of household level rights on land investment in one of his study regions in Ghana, concluding that these results supported the investment demand but not the credit supply hypothesis. Besley found limited support for the gains from trade hypothesis, at least as it influences investment, and argued that endogeneity of land rights is an important consideration in the African context. Place and Hazell also found no support for the credit supply hypothesis but found limited support for the investment demand hypothesis in their study of land rights in Ghana, Rwanda, and Kenya.

This paper examines these issues using data from two villages in south India. Private land rights in these villages are generally well respected and include full rights to lease or bequeath; but some of the land was received through government land distribution programs and is subject to official limitations on sales. This provides an opportunity to focus on the effects of sales restrictions as distinct from tenure security or other restrictions on land rights. As the land subject to such sales restrictions was exogenously determined in earlier decades by government programs, this also reduces the analytical problem of endogenous land rights categories raised by Besley, although there may be endogenous differences in de facto rights in the villages due to differential enforcement of sales restrictions.

As in some previous studies, we examine the implications of land rights status for credit use and land improvement investments. We develop and estimate a disequilibrium model of credit supply and demand, accounting for censoring of the credit variable. We also analyze the determinants of plot level investment and whether plots were cultivated, using maximum likelihood estimation.

We find that sales restrictions have little effect on credit supply and demand or demand for land improvements. Some household characteristics are found to affect investment demand on plots subject to sales restrictions in one village, suggesting that the 'transactions effect' of such restrictions may be inhibiting allocative efficiency. However, we also find that household characteristics influence investment on titled plots, and that the magnitude of impact of such characteristics is greater on titled plots. These results imply that sales restrictions are not a major source of inefficiency in the villages studied.

2. Theory

2.1. Conceptual framework

Feder et al. developed a conceptual framework to explain how tenure security and transferable land titles can enhance farmers' investments and productivity. In their framework, the primary effect of transferability is to make land more valuable as collateral, thus increasing farmers' access to constrained formal sector credit. This contributes to greater land values, invest-

ment, use of variable inputs and yields per acre. These effects are separate from the 'demand side' effects of tenure security which increases farmers' demand for credit and investment.

If the tenure is secure, Feder's framework suggests that the effects of sales restrictions are due primarily to the limitation this imposes on farmers' access to credit. However, sales restrictions may also affect investment demand since they cause land improvement investments to be irreversible; i.e., farmers cannot recoup the value of land improvements by selling their land. If new information about the expected value of the investment may become available in the future, irreversible investments will be delayed due to the 'option value' of preserving the option to not invest (Dixit and Pindyck, 1994). Even if new information about the value of the investment is not expected, individuals with a precautionary motive for saving would find an irreversible investment less attractive than a reversible investment with comparable returns since they require liquid assets to be capable of smooth consumption in the event of adverse income shocks (Fafchamps and Pender, 1997).

Both the credit supply and investment demand effects will tend to reduce investment in land improvements, though the effect on credit supply operates at the household level while investment demand effects operate at the plot level. This provides the possibility of distinguishing investment demand from credit supply effects using plot level data, which we exploit in our empirical analysis. Reduced investment in land improvements, whether due to reduced credit supply or investment demand, will tend to reduce use of land and other inputs that are complementary to investment, as in Feder's framework.

In addition to these effects of sales restrictions, they may also affect land investment and land use by preventing land from being acquired by households most apt to invest in or use the land. To the extent that landowners are heterogeneous in their abilities, opportunity costs, or interest in farming, such restrictions may affect the likelihood that investments will be made or that land will be cultivated. This is an application of the transactions effect, and assumes that lease markets do not function perfectly. In the context of imperfect lease markets, household level characteristics may influence land investment and use, causing inefficiency in land allocation (Gavian and Fafchamps, 1996).

2.2. Econometric models

The dependent variables in our analysis include credit use, land improving investments, and whether particular plots were cultivated. In principle, one would like to estimate a structural model for all of these variables simultaneously, accounting for the dependence of investments on the availability of credit and the dependence of land use on both credit availability and prior land investment. It was not possible with our data to estimate the impact of credit use on land investment, however, because the data on investments are for investments prior to 1993, while our data for credit use are for credit use in 1993. Thus, we estimate the determinants of credit use separately from the determinants of investment and cultivation decisions.

2.2.1. Credit use

The factors potentially influencing credit supply include the physical and human capital endowments of the household as well as the land rights status of land owned by the household. Variables representing the physical assets of the household include the values of land, farm equipment, livestock, buildings, and other assets such as jewelry and financial assets. Binswanger and Rosenzweig (1986) ranked the different forms of farm household assets in terms of their value as collateral based on the transaction costs of assuming ownership and marketing the asset, and the risks to collateral value due to asymmetric information about asset quality. Based on these considerations, they argue that financial assets and jewelry should have the most value as security, followed by land, farm equipment and animals. We expect the effects of these variables on credit supply to be positive if credit constraints are binding.[2] According to some moneylenders in the study villages, caste is also an important indicator of credit worthiness, especially since government subsidized credit programs for scheduled castes may have undermined their incentives to repay loans. We take the age and education of the household head as measures of the human capital variables that affect credit supply. Since both experience and education may improve the reputation of a household, we expect their

[2] If credit constraints are not binding, the coefficients in the supply equation should not be statistically significant.

effects to be positive. The share of land that is subject to sales restrictions is expected to have a negative effect on credit supply.

Credit demand will be affected by many of the same variables. Land ownership should positively affect the demand for other assets and inputs, and hence, credit, while equipment, livestock, and liquid assets have ambiguous effects (Feder et al.). We do not expect buildings — which are primarily residences in the study villages — to significantly affect credit demand. The same human capital variables that affect credit supply — age and education — are also expected to affect credit demand, though their expected effects are ambiguous (Feder et al.). Other variables expected to affect credit demand are family size, the number of adult males, and the primary occupation of the head of household. On account of the irreversibility of land investment where sales restrictions apply, the share of land subject to sales restrictions may have a negative effect on land investment demand, and therefore, on credit demand.

We estimate the model first in reduced form, using a Tobit model to account for the fact that credit use is bounded below by zero. We then apply a disequilibrium model of credit supply and demand similar to the one developed by Feder et al. Given the evidence of binding credit constraints from previous studies in the study villages (Morduch, 1990; Pender, 1992, 1996; Chaudhuri and Paxson, 1994), it is appropriate to allow for that possibility in the present study. The primary difference between our model and Feder's is that we account for left censoring of credit demand and supply in the switching regression model.

The model is given by

$$C_i = \min(S_i, D_i)$$

$$S_i = \max(\beta_s x_{s_i} + u_{s_i}, 0)$$

$$D_i = \max(\beta_d x_{d_i} + u_{d_i}, 0)$$

where C_i is credit use by household i, S_i is credit supply to household i, D_i is credit demand by household i, x_s and x_d are vectors of observed variables affecting credit supply and demand (including the variables discussed above), and u_s and u_d are unobserved variables affecting credit supply and demand.

Assuming u_s and u_d are independent and normally distributed with mean 0 and standard deviations σ_s and σ_d, respectively, and that S_i and D_i are unobserved (sample separation unknown), the log likelihood function for this model is given by

$$\begin{aligned}\log L &= \sum_i (1 - I_i)\log\left[\Phi\left(\frac{-\beta_s x_{s_i}}{\sigma_s}\right) + \Phi\left(\frac{-\beta_d x_{d_i}}{\sigma_d}\right)\right] \\ &+ I_i \log\left[\frac{\varphi(C_i - \beta_s x_{s_i}/\sigma_s)}{\sigma_s}\left(1 - \Phi\left(\frac{C_i - \beta_d x_{d_i}}{\sigma_d}\right)\right)\right. \\ &\left. + \frac{\varphi(C_i - \beta_d x_{d_i}/\sigma_d)}{\sigma_d}\left(1 - \Phi\left(\frac{C_i - \beta_s x_{s_i}}{\sigma_s}\right)\right)\right]\end{aligned}$$

where $I_i = 1$ if $C_i > 0$ and 0 otherwise, and Φ and ϕ are the standardized normal distribution and density functions, respectively.[3]

2.2.2. *Land investment and land use*

The determinants of land improving investment (prior to 1993) and land use in 1993 are estimated jointly, accounting for the possible dependence of current land use on prior investment and correlation between unmeasured determinants of each. Land investment was measured as a censored variable, representing the value (in 1993 rupees) of investments made on each plot since it was acquired by the owner. Land use (whether cultivated in 1993 or not) was a binary variable. The joint maximum likelihood model for this problem could be referred to as a simultaneous tobit–probit model. We know of no previous application of such a model in the literature, so the likelihood function was derived for this application.

Land investment is assumed to depend upon several household characteristics, including the household's demographic make-up (the number of household members and the fraction of adult males), the primary occupation of the head (whether farmer or something else), the human capital of the household head (age and education), the household caste, the area of land owned by the household, and the share of the household's land subject to sales restrictions. If sales restrictions reduce the household's access to credit, we expect the share of land subject to sales restric-

[3] The term in brackets in the second part of the likelihood function is the same as the likelihood function for a switching regression model without censoring (see Maddala (1983) p. 298). The rest of the likelihood function accounts for censoring.

tions to have a negative impact on land investment and perhaps on the likelihood of cultivation.

Several plot level factors are also assumed to influence investment, including quality characteristics of the plot (size, soil type, slope, quality rank relative to other plots owned by the household), the tenure and property rights status of the plot (whether fully titled or subject to sales restrictions, the number of years the current owner has held the plot, how it was acquired (whether inherited, purchased, received as a gift, or encroached)), and the distance to the plot from the farmer's residence. Controlling for the share of land owned by the household that is subject to sales restrictions, we expect that sales restrictions on a particular plot may reduce investment demand due to the irreversibility this causes.

Sales restrictions may also affect land investment by preventing land from being acquired by households with greater ability or interest in investing (the transactions effect). In this case, the effect of sales restrictions would be dependent upon household characteristics, such as ownership of assets or human capital. Thus, we include in the econometric specification interactions of sales restrictions with such household level variables.

We assume that most of the same factors may also influence whether a plot is cultivated in a given year or not, except how the plot was acquired and how long it has been owned, which we assume have no effect on current land use, controlling for past investment. In addition, we assume that the value of non-land assets — including livestock, farm equipment, and other assets — may also affect land use.[4] We also assume that salinity problems on the plot may affect current land use.[5] As in the case of investment, we expect that sales restrictions may interact with household level factors to influence land use; thus, we include such interaction terms in the specification. Controlling for past investment and sales restriction–household interactions, we do not expect that sales restrictions, per se, will influence current land use, though we include this variable and test this null hypothesis.

The econometric model can be summarized as follows:

$$I^*_{hpt} = \gamma_x x^i_{ht} + \gamma_z z^i_{hpt} + \gamma_R R_{pt} + \gamma_{xR} R_{pt} x^i_{ht} + v_{hpt}$$

$$I_{hpt} = \max[I^*_{hpt}, 0]$$

$$U^*_{hpt} \delta_I I_{hpt} + \delta_x x^u_{ht} + \delta_z z^u_{hpt} + \delta_R R_{pt} + \delta_{xR} R_{pt} x^u_{ht} + w_{hpt}$$

$$U_{hpt} = 1 \quad \text{if} \quad U^*_{hpt} > 0, \text{ else } U_{hpt} = 0$$

where I_{hpt} is the investment through year t on plot p owned by household h, U_{hpt} equals 1 if household h cultivated plot p in year t and 0 if not, x^i_{ht} is the vector of household characteristics affecting investment by household h by year t, z^i_{hpt} is the vector of plot characteristics affecting investment, x^u_{ht} and z^u_{hpt} are household and plot characteristics affecting whether the plot is cultivated in year t or not, R_{pt} is a dummy variable equal to 1 if plot p is subject to sales restrictions and 0 otherwise, and v_{hpt} and w_{hpt} are unobserved factors influencing investment and cultivation decisions. We assume that (v_{hpt}, w_{hpt}) are distributed bivariate normal with zero means, standard deviations σ_v and σ_w, and correlation ρ. σ_w cannot be identified, so we set it to 1. The coefficient vectors γ_x, γ_z, γ_R, γ_{xR}, δ_I, δ_x, δ_z, δ_R, δ_{xR}, and σ_v and ρ are to be estimated using maximum likelihood. The likelihood function is given in Appendix A.

The hypothesis that sales restrictions influence investment by affecting access to credit can be tested by testing the coefficient of the share of the area owned by the household that is subject to sales restrictions (part of γ_x). The hypothesis that irreversibility caused by sales restrictions reduces investment demand can be tested by testing the sign of coefficient γ_R. The hypothesis that sales restrictions affect investment by restricting transfers of land to households more capable of investing can be tested by testing the significance of the coefficients of the interactions between sales restrictions and household characteristics (γ_{xR}).

Similar tests on the coefficients of the land use equation allow disentangling the effects of sales restrictions on current land use. The share of the household's land subject to sales restrictions may affect land use via its

[4] Such assets are not included as determinants of investment because these change over time, and may have been endogenously influenced by prior land investment. The other explanatory variables are more constant over time and less likely to be affected by prior investment.

[5] As with current assets, salinity problems may have been affected by prior investments and so are not included as a determinant of prior investment.

effect on access to credit. As mentioned previously, we do not expect sales restrictions to affect current land use directly (i.e., we expect $\delta_R = 0$), controlling for past investment. If we find that δ_R is non-zero, it may be due to unmeasured quality differences between plots with and without sales restrictions (i.e., omitted variable bias). For example, if plots subject to sales restrictions are of lower quality, and this is not adequately accounted for by the variables included, then we may find that δ_R is negative. We expect that sales restrictions may interact with household characteristics to affect land use due to the transactions effect (i.e., δ_{xR} may be non-zero).

An econometric issue in these regressions concerns the possible non-independence of observations for different plots operated by the same household. To address this issue, we used a modification of the Huber–White robust estimator (Huber, 1967; White, 1980) of variance developed by Rogers (1993) for cluster samples. This estimator allows for non-independence within clusters (households in our case), though it assumes independence across clusters. The robust estimator of variance is given by

$$V^r = V\left(\sum_{k=1}^{M} u_k^{(G)\prime} u_k^{(G)}\right) V$$

where V is the conventional measure of variance $(-\partial^2 \ln L/\partial\beta^2)^{-1}$ (where L is the likelihood function and β is the coefficient vector), and $u_k^{(G)}$ is the contribution of the kth cluster to the scores $\partial \ln L/\partial\beta$:

$$u_k^{(G)} = \sum_{i \varepsilon G_k} \frac{\partial \ln Lj}{\partial\beta}$$

If all observations are independent, this estimator is equivalent to the standard Huber–White robust estimator of variance. This estimator is also robust to heteroskedasticity. [6]

[6] Based on Monte Carlo simulations, Rogers (1993) points out that this variance estimator may be downward biased in small samples where the number of independent clusters is small. He argues that if the maximum number of observations per cluster is less than 5% of the sample, any bias will be negligible. In our sample, the maximum number of observations per household is five, less than 2% of the sample.

3. Data

The data for this study were collected in two villages in the Mahbubnagar district of Andhra Pradesh in India — Aurepalle and Dokur. [7]

3.1. Land rights in the study villages

Most agricultural land in Andhra Pradesh is held privately under formal title. Two broad categories cover the remaining land: assigned land and government land. Assigned land is land that has been granted mainly to poor, low caste people under various land distribution schemes. Recipients of such land received usufruct rights intended to be secure but not marketable (though leases are officially permitted). This arrangement is intended to ensure that poor beneficiaries retain access to the land so that it provides a permanent buffer against destitution. Most government land, part of which belongs to the state and part to the village government, is reserved for grazing and other non-cultivation uses. Some government land has been encroached upon illegally by private farmers.

Distribution of assigned land began in the mid-1950s, but most of it was allocated in the 1960s and early 1970s. About 450 acres of land have been assigned in Aurepalle, and virtually no cultivable government land remains available for assignment. Much of the assigned land in Aurepalle is in the infertile, sloped areas adjacent to the hillocks. Most assignees had to clear the land of brush and stones before cultivating it. To make it productive and protect it against rapid degradation, some also built terraces or field bunds. In Dokur, about 150 acres have been assigned, 40% of which is in the command area of an irrigation 'tank' (pond). To cultivate this land, farmers must build terraces, channels and bunds to manage the water. It is difficult to grow dryland crops on this land because of its high salt content. In very dry years, farmers in the tank command area leave the land fallow, unless they have access to a well.

Land assignment continues to the present, mainly covering encroached common land. In each succes-

[7] These villages have been studied since 1975 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Walker and Ryan (1990) provide detailed descriptions of these villages and their economies.

sive year, increasingly poor quality land is assigned because most of the better land has been distributed already.

Assigned plots are intended to retain their legal status permanently; assignees may not obtain full title. Knowledgeable villagers indicate that this regulation has been enforced, and although we cannot be certain of this, it is highly likely. This is so because assigned land generally was distributed in large, contiguous blocks and divided into numerous plots. As a result, most assigned plots are easily identifiable by all villagers.

Although assigned land appears to retain its separate legal status indefinitely, sales restrictions are not always enforced. In Aurepalle, much assigned land was sold until the early 1980s, but since then, sales have stopped almost completely. Very few sales have taken place in Dokur. Most sales have been unofficial, with the local land record keeper altering the records to hide the sale, though a few sales have been officially sanctioned. The official process requires a substantial amount of paperwork, and the record keeper receives a sizable commission. Differences between the two villages in enforcement of sales restrictions lead us to expect different impacts of assigned status in the two villages.

There are no official restrictions on leasing assigned land. Nevertheless, assigned plots are rarely leased out in either village.[8] Perhaps, owners of assigned land perceive a greater risk of losing ownership of assigned plots if they are leased out than they do for titled plots, or a low level of investment on these plots renders them less capable of being leased out. Tenancy laws in India undermine the incentive for landlords to provide long term leases since tenants acquire ownership rights after leasing for a specified period.[9] The prevalence of short term leases, with tenants often changing on a particular plot, increases the information and transaction costs of leasing. This may reduce the likelihood of landlords making land improvements to be able to lease out their plots, as well as the likelihood that tenants will make land improvements.

[8] At the time of the survey, only three assigned plots were leased out in Aurepalle and one in Dokur.

[9] Jodha (1981) found that 90% of land leases in Aurepalle and 85% in Dokur were for periods of 2 years or less.

Table 1
Means of acquiring sample plots

	Aurepalle		Dokur	
	Assigned	Titled	Assigned	Titled
Number of plots	188	133	104	138
How was the plot acquired?	Percent of plots		Percent of plots	
Inherited	32.5	47.0	48.1	67.4
Purchased	16.5	47.7	1.9	28.3
Received from Government	15.4	3.0	38.5	0.0
Encroached	31.9	0.0	8.6	0.7
Gift/other	3.7	2.3	2.9	3.6

3.2. Survey results

A survey of 165 households in Aurepalle and 126 households in Dokur was conducted in August 1993. The households selected for the sample included respondent households in the International Crops Research Institute's (ICRISAT) village level studies program, who were selected in 1989 using a stratified random sample. Only respondents who owned land in 1993 were included in the sample. In addition, owners of assigned land who were available for the survey were interviewed.

The survey included information on the demographic characteristics of the respondent households, the tenure structure of assigned and titled land, present ownership of assets, and credit and debt outstanding. For each plot owned or operated by the respondent, we determined its location, distance to the farmer's residence, area, tenure status, when and how it was acquired, land rights status (titled or assigned), the farmer's subjective quality ranking of the plot relative to other plots owned by the farmer, local soil type classification, slope, and whether the plot has salinity problems or not. For each plot, owners were also asked to state any land improvement investments they had completed — including estimates of the monetary costs, family labor time, animal labor time, and the cost of the investment if it were completed today — and whether the plot was being cultivated in 1993 or not.

Within our sample, there were 188 assigned plots and 133 titled plots in Aurepalle, 104 assigned plots and 138 titled plots in Dokur (Table 1). In Aurepalle, 16% of assigned plots were purchased, mainly prior to the mid-1980s, despite official restrictions on sales

Table 2
Characteristics of sample plots

Characteristics	Aurepalle		Dokur	
	Assigned	Titled	Assigned	Titled
	Percent of plots		Percent of plots	
Slope				
Flat	26.2	59.4	62.8	86.2
Moderate	65.8	39.8	33.3	13.8
Steep	8.0	0.8	3.9	0.0
Position on Slope				
Lowland	10.6	13.5	66.7	78.3
Midland	82.5	85.0	25.5	21.0
Upland	6.9	1.5	7.8	0.7
Salinity problems				
No	82.9	81.8	27.2	51.5
Yes	17.1	18.2	72.8	48.5
Soil type				
Deposited silt	21.3	27.3	19.0	52.2
Black	2.1	5.3	0.0	0.0
Red	28.2	22.0	13.0	16.7
Sandy	44.1	40.1	67.0	31.1
Lime	4.3	5.3	1.0	0.0
Plot rank				
1	40.4	67.4	44.8	52.2
2	40.4	25.0	33.3	33.3
3	16.9	4.6	17.7	13.0
4	2.2	3.0	3.1	1.5
Higher than 4	0.0	0.0	1.0	0.0

of these plots. Very few assigned plots have been purchased in Dokur, suggesting that sales restrictions have been more tightly enforced in Dokur than in Aurepalle.

Not surprisingly, assigned plots are of lower quality on average than titled plots. In both villages, a larger proportion of assigned plots than titled plots are moderate or steep in slope, of red or sandy soil type (lower water and nutrient retention than silt or black soils), and of lower subjective quality ranking (Table 2). In Dokur, assigned plots are also much more likely to have salinity problems. It is, thus, critical to control for such quality differences in attempting to determine the effects of land rights status per se.

Land improvements made by farmers include land clearing, building terraces and bunds, digging a well, constructing waterways, planting trees and constructing fences. In both villages, wells have been constructed on a much smaller fraction of assigned than titled plots (Table 3). In Aurepalle, waterways and terraces are also constructed on a smaller fraction of

Table 3
Land improvements on sample plots

Investment	Aurepalle		Dokur	
	Assigned	Titled	Assigned	Titled
	Percent of plots		Percent of plots	
Terraces	14.0	37.3	79.0	77.2
Bunds	56.7	58.1	73.0	70.9
Well/bore	7.6	28.1	12.0	38.6
Waterways	16.4	35.5	68.0	63.0
Land clearing	91.8	47.3	60.0	47.2
Trees planted	4.7	10.0	0.0	3.1
Fencing	15.2	15.5	0.0	0.0

assigned plots, while land clearing has been done on a much larger fraction of assigned plots. These results suggest that if assigned status reduces investment due to credit constraints, this is more likely to be a problem with respect to investments that involve a large monetary cost, such as constructing a well, than with labor intensive investments such as land clearing or constructing field bunds (Table 4). On the other hand, much of the assigned land that has been distributed requires investment in land clearing just to be usable, and may require other investments such as terracing and drainage as well. Thus, there may be greater demand for certain types of investments on assigned land, such as land clearing in both villages and terraces and waterways in Dokur.

Very few of the sample plots have never been cultivated, though the fraction is larger for assigned than titled plots in both villages (Table 5). Similarly, a much larger share of assigned plots in both villages was not being cultivated in 1993. In Aurepalle, the most common reasons given for not cultivating the plot in 1993 were lack of water, the plot being 'mortgaged' (leased to a moneylender in exchange for a loan) or sold, or that cultivation was not economically viable.[10] In a few cases, the respondent cited specific constraints or opportunities such as not having bullocks to work the field, sickness or being employed outside the village. In one case, the land was under dispute. In Dokur, virtually all of the respondents who offered an explanation for why plots were not cultivated claimed that lack of water was the reason. This does not explain

[10] The fact that assigned plots may be mortgaged to moneylenders in Aurepalle suggests that sales restrictions may have limited effect on access to moneylender credit in this village.

Table 4
Mean value of land improvements on sample plots, conditional on investment[a]

Investment	Aurepalle		Dokur	
	Assigned	Titled	Assigned	Titled
Terraces	972 (1580)	2856 (4339)	1820 (1676)	2318 (2757)
Bunds	196 (319)	890 (4946)	502 (705)	699 (1532)
Well/bore	21,269 (24,568)	16,593 (16,636)	13,902 (22,208)	9956 (10,592)
Waterways	472 (1811)	304 (474)	470 (544)	721 (1593)
Land clearing	481 (522)	591 (954)	764 (744)	626 (632)
Trees planted	72 (60)	50 (33)	–	882 (1416)
Fencing	174 (179)	2180 (3313)	–	–

[a] Standard deviation in parentheses.

Table 5
Usage of sample plots

	Aurepalle		Dokur	
	Assigned	Titled	Assigned	Titled
	Percent of plots		Percent of plots	
Has the plot ever been cultivated?				
No	5.4	0.8	12.7	0.0
Yes	94.6	99.2	87.3	100.0
Is the plot being cultivated in 1993?				
No	28.3	9.0	65.7	33.8
Yes	71.7	91.0	34.3	66.2
If not cultivated in 1993, why not?				
Not enough rain/water	30.7	25.0	59.7	61.4
No bullocks	3.8	0.0	0.0	0.0
Poor soil/not economic/plot far away	15.4	41.7	0.0	0.0
Land under dispute	1.9	0.0	0.0	0.0
Sold/mortgaged the plot	25.0	16.7	1.5	0.0
Employed outside village	1.9	0.0	0.0	0.0
Sick	1.9	0.0	0.0	0.0
No reason given	19.2	16.7	38.8	38.6

why the fraction of assigned plots not cultivated is so much larger than the fraction of titled plots not cultivated in Dokur, though this may be partly due to the high salinity of much of this land, which makes it unproductive in dry conditions.

In both villages, owners of assigned land own less land on average, are less likely to consider farming their primary occupation, are much more likely to be of low caste rank, and are somewhat less educated and older than other landowners in the survey (Table 6). These differences suggest that owners of assigned land may face greater constraints than other land owners in obtaining credit or in farming their land, irrespective of any constraints that land sales restrictions may place upon them.

4. Econometric analysis

Our empirical analysis focuses on the effects of sales restrictions and other factors on credit use, land improvements and cultivation decisions.

4.1. Credit use

We estimate the model first in reduced form. Two tobit regressions were run for each village corresponding to two different dependent variables: loans from formal lenders (banks and cooperative societies) and loans from moneylenders (Table 7). In three of the four regressions, the share of land that is subject to

Table 6
Characteristics of owners of assigned land and other land owners

	Aurepalle		Dokur	
	Land owners with assigned land	Land owners without assigned land	Land owners with assigned land	Land owners without assigned land
Number of Households	135	27	89	32
Mean land owned (acres)	4.0	6.5	2.5	4.0
Assigned	2.3	0.0	1.2	0.0
Full rights	1.7	6.5	1.3	4.0
Characteristics of household head	Percent of households		Percent of households	
Resident of village	98.5	100.0	83.1	83.9
Occupation				
Primary: farmer	19.8	26.9	12.4	32.3
Secondary: farmer	35.9	34.6	20.2	19.4
Caste[a]				
High	2.3	11.5	1.1	12.9
Medium	40.5	65.4	42.7	74.2
Low	57.2	23.1	56.2	12.9
Education				
None	75.6	70.4	82.0	75.0
1–4 years	16.3	18.5	11.3	9.4
Over 4 years	8.1	11.1	6.7	15.6
Age				
Under 30	5.2	3.7	6.7	9.4
30–59	63.0	77.8	68.6	68.7
60 and over	31.8	18.5	24.7	21.9

[a] High castes include the Reddy, Velama and Vysyas castes. Low castes include the Chippa, Ediga, Harijan, Madiga, Mala, Potmaker, Sevaka, Vaddera (stone cutter), Vastimi, Viswabrahmin, Yerkali, and Yerukula castes. All other castes are classified as medium caste rank.

sales restrictions has a negative effect on credit use, though this result is statistically significant only in the Aurepalle regression for moneylender loans.

We would like to know whether the negative effect of assigned land on credit use in Aurepalle is due to supply or demand effects (or both). For that, we apply the switching regression model discussed earlier. The results do not provide a definitive explanation of why owners of assigned land use less credit in Aurepalle (Table 8).[11] Ownership of assigned land has a negative but statistically insignificant effect on both supply and demand for formal sector and moneylender credit.

That we are unable to distinguish credit demand and supply effects of sales restrictions is perhaps not too surprising, given the relatively small number of positive observations (especially in the formal credit regressions) and the inability to account for plot level quality variations that may affect credit demand and supply in these regressions (though land value reflects land quality as well as quantity). Plot level regressions explaining investment in land improvements address these shortcomings.

4.2. *Land investments and cultivation decisions*

The results of the simultaneous maximum likelihood (tobit–probit) estimation of determinants of land investments and cultivation decisions are reported in Table 9.[12] We estimate the determinants separately for each village since differences in the market environment or enforcement of sales restrictions in each

[11] Estimation of the switching regression model for Dokur showed no significant effect of land rights status on credit, as in the reduced form regressions.

[12] To facilitate the estimation, we estimated transformations of σ_v and ρ ($\ln(\sigma_v)$ and $\ln((1+\rho)/(1-\rho))$) whose values are not restricted. A zero value of $\ln((1+\rho)/(1-\rho))$ implies that $\rho = 0$.

Table 7
Tobit regressions of credit use[a]

Variable	Loans from banks and cooperatives		Loans from moneylenders	
	Aurepalle	Dokur	Aurepalle	Dokur
Intercept	−635.9 (6838)	−12,486 (9056)	6237 (3220)	3669 (3613)
Assigned land share of land	−6089 (4096)	−5212 (4094)	−3966* (1771)	1146 (1797)
Land (Rs.)	−0.0122 (0.0271)	0.0358 (0.0365)	0.00562 (0.01516)	0.0440* (0.0193)
Livestock (Rs.)	0.0729 (0.1378)	0.0702 (0.1055)	0.03574 (0.07770)	−0.1860 (0.0974)
Equipment (Rs.)	0.1883* (0.0925)	0.5238 (0.5950)	0.02237 (0.04875)	0.0776 (0.3401)
Buildings (Rs.)	−0549 (0.1058)	0.0169 (0.0809)	−0.04084 (0.05287)	0.0230 (0.0406)
Other assets (Rs.)	0.0469 (0.0714)	−0.0916 (0.1517)	0.06141 (0.04256)	−0.0707 (0.0789)
Family size	−57.5 (559.7)	25.3 (807.2)	5.6 (294.1)	739.4* (378.6)
Adult males (share of family)	1009 (7108)	15,792 (9834)	5737 (3448)	2921 (4563)
Farming primary occupation	8300** (3082)	−3437 (3666)	3751* (1513)	4968** (1856)
Low caste (=1 if low caste)	−6308* (3054)	3277 (3126)	−1421 (1360)	−1055 (1420)
Age of household head (years)	−130.3 (113.4)	−86.0 (117.8)	−124.4* (52.8)	−144.7** (55.9)
Education of household head (years)	458.1 (517.0)	294.9 (626.7)	−136.1 (292.6)	−600.0 (322.1)
Number of positive Observations/ total number of observations	25/157	15/120	84/157	88/120

[a] Standard errors in parentheses.
* Indicates statistical significance at 5% level.
** Indicates statistical significance at 1% level.

Table 8
Censored switching regression of the disequilibrium credit model: Aurepalle[a]

Variable	Formal sector loans		moneylender loans	
	Supply	Demand	Supply	Demand
Intercept	1521 (4444)	−3768 (17,572)	8718 (6245)	1025 (5461)
Assigned land share of land	−1180 (3806)	−15711 (12,388)	−4413 (3597)	−3346 (3076)
Land (Rs.)	0.02062 (0.03285)	−0.04702 (0.07955)	0.03263 (0.02615)	−0.04062 (0.02803)
Livestock (Rs.)	0.3574 (0.3324)	0.0725 (0.3290)	0.5069 (0.2775)	−0.06176 (0.07097)
Equipment (Rs.)	0.5656* (0.2308)	0.1447 (0.2529)	−0.03663 (0.07115)	0.1012 (0.1153)
Buildings (Rs.)	−0.2082* (0.0932)		−0.05706 (0.07069)	
Other assets (Rs.)	0.5074 (0.2990)	0.0659 (0.1607)	0.1128* (0.0479)	−0.2550* (0.1008)
Family size		−185 (1277)		914.2* (434.3)
Adult males (share of family)		6971 (14,753)		5519 (4936)
Farming primary occupation		11,410 (8452)		27,992** (9659)
Low caste (=1 if low caste)	−3402 (2567)		−1594 (2436)	
Age of household head (years)	−80.38 (79.97)	−98.5 (303.5)	−114.5 (105.1)	2.37 (95.14)
Education of household head (years)	590.8 (594.6)	880 (1383)	−760.0 (629.9)	7130* (3675)
Number of positive observations/ total number of observations	25/157		84/157	

[a] Standard errors in parentheses.
* Indicates statistical significance at the 5% level.
** Indicates statistical significance at the 1% level.

village could cause different factors to have different effects on land investment or cultivation.

In both villages, we find that neither the share of the household's land subject to sales restrictions nor sales restrictions on the particular plot have a significant effect on investment. These findings do not support the hypotheses that sales restrictions inhibit investment due to either the credit supply or investment demand effects.

We do find evidence of significant interactions between sales restrictions and some household level variables in the Aurepalle regression, suggesting that

Table 9
Determinants of land investment and cultivation decisions; maximum likelihood estimates (robust standard errors in parenthesis)[a]

Variable	Aurepalle		Dokur	
	Investment	Cultivation	Investment	Cultivation
Household-level variables				
Area of land owned (acres)	238.8 (361.1)	−0.0496 (0.0578)	−361.9 (391.9)	0.0302 (0.0723)
Share of land subject to restrictions	4828 (3032)	0.5180 (0.4014)	−4188 (3731)	−0.9891* (0.4419)
Family size	−644.0 (441.8)	0.2255* (0.0898)	154.5 (520.4)	0.1300 (0.0787)
Adult males (share of family)	−14,578** (5402)	−0.396 (1.002)	−6878 (6414)	0.776 (1.526)
Farming primary occupation (=1 if primary)	11405** (3180)	0.6332* (0.2658)	6052 (3180)	1.078 (0.561)
Low caste (=1 if low caste)	39.8 (3656.7)	0.4626 (0.4742)	3561 (2690)	0.0406 (0.4015)
Age of household head (years)	39.8 (105.6)	−0.0085 (0.0182)	−93.55 (79.64)	−0.0207 (0.0119)
Education of household head (years)	−335.2 (429.3)	−0.0893 (0.0720)	142.4 (574.2)	−0.0546 (0.0757)
Livestock value (Rs. 1000)		0.0012 (0.0230)		−0.00148 (0.00719)
Equipment value (Rs. 1000)		0.0004 (0.0087)		−0.0394 (0.0614)
Other assets (Rs. 1000)		0.0976* (0.0499)		0.0309 (0.0226)
Land rights and interactions				
Assigned plot	−7637 (8455)	−0.125 (1.166)	−10,701 (8451)	−1.146 (1.386)
Assigned × family size	1533 (796)	−0.143 (0.104)	682.2 (928.4)	−0.100 (0.189)
Assigned × adult males	17,816** (6392)	1.983 (1.108)	9447 (8357)	−0.609 (1.627)
Assigned × farming primary occupation	−6291* (3147)	NE	−1552 (4480)	−0.536 (0.639)
Assigned × low caste	−2095 (4079)	−0.593 (0.519)	−4352 (3655)	−0.004 (0.530)
Assigned × age	−101.9 (124.6)	−0.0012 (0.0195)	192.0 (113.1)	0.0289 (0.0187)
Assigned × education	791.1 (682.7)	−0.0262 (0.0949)	462.5 (837.6)	0.1435 (0.1098)
Assigned × livestock		0.0252 (0.0241)		0.0195 (0.0159)
Assigned × equipment		NE		0.160 (0.154)
Assigned × other assets		−0.0961 (0.0503)		−0.0551 (0.0464)
Plot-level variables				
Investment on plot (Rs. 1000)		−0.0649** (0.0190)		−0.0255 (0.1208)
Quality rank of plot (1 = highest quality)	−3122** (1063)	0.0535 (0.1718)	−1120 (868)	−0.0165 (0.1480)
Soil types (c.f. red)				
Deposited silt	−2561 (2198)	−0.2508 (0.2756)	1622 (3366)	0.2022 (0.3403)
Black soil	−4105 (3181)	3.211** (0.502)	NA	NA
Sandy soil	1914 (1714)	0.0258 (0.2308)	−1441 (2663)	0.0527 (0.3506)
Lime soil	9088** (2556)	3.408** (0.586)	NA	NA
Slope (c.f. flat)				
Moderate slop (2–4%)	−3992** (1862)	−0.5114* (0.2011)	−3849 (2265)	−0.5387 (0.2846)
Steep slope (>4%)	3118 (4557)	−0.0209 (0.4981)	NA	NA
Presence of salinity problems (=1 if present)		0.1197 (0.2393)		0.5449 (0.3945)
Distance to residence (km)	506.3 (818.3)	−0.1991 (0.1149)	−3290 (2205)	−0.3889 (0.2444)
Area of plot (acres)	1253 (924)	0.1129 (0.0963)	2749* (1245)	0.1686 (0.2031)
Number of years plot owned	197.7** (74.0)		−61.7 (152.8)	
How the plot was acquired (c.f. inherited)				
Encroached	−736 (1201)		3150 (6473)	
Purchased	−253 (1384)		−2094 (4568)	
Gift	2054 (1873)		−208 (4576)	
Intercept	1304 (6669)	0.429 (1.086)	12,798 (7250)	0.425 (1.567)
$\ln(\sigma_v)$	9.194** (0.127)		9.239** (0.128)	
$\ln((1+\rho)/(1-\rho))$	2.496** (0.551)		1.064 (2.419)	
Number of positive observations/total observations	224/288	231/288	176/212	113/212

[a] Standard errors are adjusted for clustering within households and robust to heteroskedasticity.
* Indicates statistical significance at 5% level.
** Indicates statistical significance at 1% level. NE means not estimated NA means the variable does not apply in that village.

investment may be affected by the transactions effect in that village. However, the transactions effect appears to apply to titled as well as assigned plots. On titled plots, investment is less in households having more adult males and greater in households whose primary occupation is farming. [13] On assigned plots, investment is greater in households with more adult males or where the primary occupation is farming, although the effect of primary occupation is smaller than on titled plots.

Contrary to the expectations of a perfect land market scenario, land investment depends on household characteristics, potentially causing inefficient allocation of land investment and use (Gavian and Fafchamps, 1996). This dependence exists for both titled and assigned plots, but the direction of impact of household characteristics varies and the magnitude is greater for titled than for assigned plots. Thus, any inefficiency in land investment or use caused by the dependence of investment on household characteristics may be at least as large on titled plots as on plots subject to sales restrictions. [14]

Other factors significantly affecting investment in Aurepalle include plot quality (more investment on higher quality plots), soil type (more on lime than red soils), slope (less on moderate than flat slopes), and the number of years the plot has been owned (+). The effect of years of ownership could be due to greater tenure security, but it also may simply be the result of having more time to make investments. The only factor we find to have a significant effect on investment in Dokur is the area of the plot (+).

We find that the decision to cultivate a plot is not affected by whether it is subject to sales restrictions; this is consistent with our expectations. In Dokur, the share of land subject to sales restrictions has a negative impact on the probability of cultivation, suggesting that such restrictions may be inhibiting access to short term credit in this village. Unlike in the investment regressions, we find no significant coefficients of the interactions between land rights and household characteristics for either village, suggesting that the transaction effect is not affecting cultivation decisions.

Other factors significantly affecting the probability of cultivation in Aurepalle include family size (+), farming as the primary occupation (+), ownership of other assets (+), investment on the plot (−), soil type (cultivation more likely on black and lime soils) and slope (less likely on moderate slopes). The negative effect of investment on the likelihood of cultivation was not expected. The share of land subject to sales restrictions was the only factor with a significant effect on cultivation in Dokur.

One reason for so few significant coefficients may be multicollinearity. Variance inflation factors were greater than 10 for several of the land rights–household interaction terms used in both villages, indicating a potential problem of multicollinearity (Chatterjee and Price, 1991). On account of this, we reran the estimations in Table 9 excluding the interaction terms (Table 10). In this case, the largest variance inflation factor was 3.1.

The results in Table 10 are consistent with those in Table 9, except that some of the coefficients become statistically significant in this more parsimonious specification. The most important difference is that we find in Table 10 that assigned plots are less likely to be cultivated than titled plots in Aurepalle. This may be a result of the transactions effect since owners of assigned plots may be less prone to cultivate due to differences in their household characteristics, and the interaction terms that accounted for this in Table 9 have been removed from this regression. On the other hand, it could also be a result of omitted variable bias due, for example, to unobserved differences in the quality of assigned relative to titled land, as discussed previously. So we have evidence consistent with a transactions effect on cultivation decisions in Aurepalle, though we are not confident of it.

[13] The coefficients of the household characteristics without interactions in Table 9 represent the effect of that characteristic for titled plots. For example, the predicted effect of farming as the primary occupation is to increase investment by Rs. 11,405 on titled plots. For assigned plots, the effect of household characteristics are given by the sum of the household coefficient plus the interaction term. For example, the effect of farming as the primary occupation on assigned plots is to increase investment by Rs. 11,405–6291.

[14] For titled plots, the dependence of land investments on household characteristics may reflect imperfections in credit and savings markets and lease markets. First, people may hold transferable land without investing in raising its productivity because land is a good store of value, especially compared to the limited returns available from formal sector savings accounts. Second, as mentioned above, policies discouraging long term leases reduce the likelihood of either landlords making improvements to lease out their plots, or tenants making land improvements.

Table 10
Determinants of land investment and cultivation decisions (excluding land rights — household interactions)[a]; maximum likelihood estimates (robust standard errors in parenthesis)[b]

Variable	Aurepalle		Dokur	
	Investment	Cultivation	Investment	Cultivation
Share of land subject to sales restrictions	4210 (2931)	0.509 (0.379)	−2943 (3238)	−0.878* (0.446)
Assigned plot	325 (1941)	−0.763** (0.248)	984 (2108)	−0.249 (0.301)
Farming primary occupation	7176** (2262)	0.748** (0.264)	5009 (2599)	0.748* (0.296)
Education (years)	110.4 (300.3)	−0.1048* (0.0488)	325.1 (414.7)	0.0127 (0.0489)
Investment on plot (Rs. 1000)		−0.0700** (0.0168)		−0.0508 (0.0488)
Quality rank of plot	−2932** (1000)	−0.007 (0.156)	−1327 (855)	−0.050 (0.114)
Black soil (c.f. red)	−4162 (3333)	3.966** (0.544)	NA	NA
Lime soil (c.f. red)	9876** (2534)	3.512** (0.488)	NA	NA
Moderate slope (c.f. flat)	−3990* (1961)	−0.485* (0.207)	−3442 (2511)	−0.504* (0.244)
Distance to residence (km)	663 (872)	−0.203 (0.116)	−2981 (1929)	−0.403* (0.166)
Area of plot (acres)	1343 (844)	0.0924 (0.0786)	2569* (1138)	0.183 (0.118)
Number of years plot owned	233.0** (81.5)		−68.8 (126.4)	
$\ln(\sigma_v)$	9.220** (0.128)		9.259** (0.133)	
$\ln((1+\rho)/(1-\rho))$	2.430** (0.464)		1.727 (1.265)	

[a] Only variables with a significant coefficient in at least one regression are reported. Excluding land rights–household interactions, all explanatory variables are the same as in Table 9.

[b] Standard errors are adjusted for clustering within households and robust to heteroskedasticity.

* Indicates statistical significance at 5% level.

** Indicates statistical significance at 1% level. NE means not estimated. NA means the variable does not apply in that village.

5. Discussion and conclusions

Our empirical findings imply that land sales restrictions have had little direct impact on credit supply, investment demand or cultivation decisions in the villages studied. We do find evidence that the transactions effect is affecting land investment in one village, but the effect is present for titled plots as well as plots subject to sales restrictions (and with a larger magnitude of impacts of household variables for titled plots). Thus, sales restrictions do not appear to be causing any greater inefficiency of land allocation than may be occurring with respect to titled land. Balanced against the distributional concerns that motivated the sales restrictions, the lack of evidence of inefficiency resulting from these restrictions does not provide a strong rationale for relaxing those restrictions. Of course, this conclusion is based on evidence from only two villages, so it may not be broadly representative. More extensive research is needed to derive policy implications about the impacts of land sales restrictions in India.

Part of the explanation for the limited effect of land rights status is undoubtedly imperfect enforcement of sales restrictions. However, this does not explain why insignificant effects were found in Dokur, where restrictions appear to have been well enforced. Other factors, particularly the nature of credit and land markets, possibly affect what impacts sales restrictions will have even if effectively enforced. If lenders do not use land collateral to enforce credit contracts or to screen borrowers, sales restrictions may have little impact on credit supply. Similarly, if land is generally less marketable than other assets, as Binswanger and Rosenzweig argue, then the additional irreversibility due to sales restrictions may have little impact on investment demand since investments on titled land may already be subject to a substantial element of sunk costs.

Formal sector lending practices condition the effects of sales restrictions. For example, Heath (1992) found that small farmers on Mexico's ejidos (land reform land subject to transfer restrictions) received as much credit as private small farmers. He argued that practical constraints on the seizure of farm property make Mexican banks reluctant to view titled land as adequate loan security; thus, land title may offer little advantage in securing access to credit. This argument appears to apply as well to our study villages. Despite a high incidence of loan default to formal sector

lenders in our study villages, banks rarely recover assets pledged as collateral. Our evidence on credit supply does not show a significant effect of land values on credit supply, consistent with this argument.

Our findings regarding the limited effect of marketable land title on credit access are generally consistent with those of Place and Hazell, Migot-Adholla, et al., Besley, and Gavian and Fafchamps from several countries in sub-Saharan Africa. This is interesting because the level of credit market development is significantly greater in the Indian villages we studied than in the African regions these authors studied. Formal sector credit was virtually nonexistent in those African regions, while it is a major component of the credit supply in the villages we studied. However, formal sector credit may be tightly rationed in India due to interest rate restrictions, while informal lending is still very active, with most formal sector borrowers also borrowing from moneylenders at higher interest rates. Thus, formal sector credit may be largely irrelevant to marginal decisions about investment. And, as village moneylenders indicated to us, their lending decisions may be based more upon their personal relationship with borrowers than upon consideration of the transferability of their assets. [15] This is consistent with Feder's finding that the impact of transferable title was relatively unimportant in the one region they studied where informal lending was predominant. It, thus, appears that the nature and extent of informal credit markets is a critical determinant of the economic impacts of marketable property rights.

Appendix A. Derivation of likelihood function for the simultaneous tobit–probit model

First, we simplify the notation for the model:

$$I^* = \gamma_X X^I + v$$

$$I = \max[I^*, 0]$$

$$U = 1 \quad \text{if} \quad U^* > 0, \text{ else } U = 0$$

$$U^* = \delta_I I + \delta_X X^U + w$$

[15] Atwood makes a similar argument for why land title has little impact on credit in Africa.

Here, we have labeled the full vector of exogenous explanatory variables in each equation by X^I and X^U and dropped the subscripts h, p, and t.

The joint distribution of v and w ($g(v,w)$) is bivariate normal with zero means:

$$g(v, w) = BN(0, 0, \sigma_v, \sigma_w, \rho)$$

There are four parts of the likelihood function corresponding to each of the following four cases:

1. $I^* > 0$, $U^* > 0$
2. $I^* > 0$, $U^* \leq 0$
3. $I^* \leq 0$, $U^* > 0$
4. $I^* \leq 0$, $U^* \leq 0$

Case (1) $I^* > 0$, $U^* > 0$

$$L = \int_0^\infty f(I, U^*)\mathrm{d}U^*$$

where $f(I,U^*)$ is the joint density of I and U^*. Making the change of variables, we obtain

$$L = \int_{-\delta_X X^U - \delta_I I}^\infty g(I - \gamma_X X^I, w)\mathrm{d}w$$

Case (2) $I^* > 0$, $U^* \leq 0$

$$L = \int_{-\infty}^{-\delta_X X^U - \delta_I I} g(I - \gamma_X X^I, w)\mathrm{d}w$$

Case (3) $I^* \leq 0$, $U^* > 0$

$$L = \int_{-\infty}^{-\gamma_X X^I} \int_{-\delta_X X^U}^\infty g(v, w)\mathrm{d}w\mathrm{d}v$$

Case (4) $I^* \leq 0$, $U^* \leq 0$

$$L = \int_{-\infty}^{-\gamma_X X^I} \int_{-\infty}^{-\delta_X X^U} g(v, w)\mathrm{d}w\mathrm{d}v$$

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