Property rights and investment in agriculture: Evidence for Ghana

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Abstract

This article develops a theoretical framework to examine the relationship between land tenure agreements and households' investment in land improvement and conservation measures. It then analyzes this relationship with a multivariate probit model based on a survey data from a sample of 560 plots belonging to 246 farmers from 6 villages in the Brong-Ahafo region of Ghana. A major hypothesis tested is that investment in productivity enhancing and conservation techniques are influenced by land tenure systems. The theoretical analysis and empirical results generally reveal that land tenure differences significantly influence farmers' decisions to invest in land improvement and conservation measures. Furthermore, reduced-form productivity regressions show that tenure differences do affect land productivity.

Key words: Land tenure, property rights, investment, optimal control, multivariate probit

JEL classification: O13 ; O55; Q12; O1

1. Introduction

The role of land tenure on investments in productivity enhancing measures in developing countries has been widely documented in the economic literature. Particularly in Sub-Saharan Africa, where land is central to the social and economic development of a vast majority of the people, the link between indigenous tenure arrangements and productivity enhancing investments has attracted the attention of both researchers and policy makers. While studies by Dorner (1972) and Harrison (1987) argued that indigenous tenure systems provide insufficient security to induce farmers to undertake land improving investments, Noronha (1985) pointed out that these arrangements are dynamic and evolve in line with factor prices. The significance of this debate has attracted a great deal of attention among economists (Binswanger and Rosenzweig 1986; Besley, 1995; Brasselle et al., 2002; Place and Otsuka, 2002; Goldstein and Udry, 2008).

A central issue of the related empirical investigations is the effect of tenure security on investment and productivity. On theoretical grounds, three main arguments have been advanced for a positive link between tenure security and investment. First, secured property rights is expected to provide a guarantee for farmers to undertake long-term investments in land-improving and conservation measures, since there would be no fear of expropriation. Some authors have even suggested that the lack of secured land rights encourage farmers to adopt measures that lead to environmental degradation (e.g., Afikorah-Danquah, 1997).[1] Second, it has been argued that secured land rights make it easier to use land as collateral to obtain loans to finance agricultural investments (Feder and Feeny, 1991). The third effect operates through better possibilities for trade. As noted by Besley (1995), investment in land-improving measures is encouraged if improved transfer rights enhance the factor mobility, making it easier for farmers to sell or rent their land. An issue that has gained increasing significance in the recent empirical analysis is the endogeneity of land rights in estimating the effect of tenure security on agricultural investment. Authors like Besley (1995), Place and Otsuka (2002), Brasselle et al. (2002) have rightly noted that farmers may undertake land-improving investments in order to gain tenure security.

The empirical investigations into the land rights-investment relationship appear to be inconclusive. Studies on Africa by Migot-Adholla et al. (1994) and Pinkney and Kimuyu (1994) reveal that the impact of land rights on land improving investments and planting of tree crops is quite low. On the other hand, work by Carter and Olinto (2003) on Paraguay and Besley (1995) on Ghana show that tenure security exerts a positive and significant impact on investments. Brasselle et al. (2002) report that land tenure security is influenced by investment, and that once the endogeneity bias is properly controlled, increased land rights do not appear to stimulate investment. Deiniger et al. (2003) indicate that the effect of tenure security on investment differs according to the type of investment and they found in their study on Ethiopia that tenure insecurity actually encouraged the planting of trees, but discouraged investment in terraces. Place and Otsuka (2002) also found that coffee planting is used by farmers to enhance tenure security, supporting the notion that farmers consider tenure implications when making investment decisions.

Most of the studies that have examined the tenure security-investment relationship have employed reduced-form specifications–with the notable exception of Besley (1995) and Cater and Olinto (2003) – that do not distinguish between the impacts of different tenure arrangement on investment decisions. This article contributes to the debate by developing a framework that captures the impact of different land tenure arrangements on investment decisions of farmers. The model embodies behavioral assumptions consistent with investment decisions that characterize investment in productivity-enhancing inputs in the agricultural sectors of most sub-Saharan African countries. First we use a theoretical model to examine the effects of 4 different tenancy agreements on investment decisions of farmers. We then use variations in tenure agreements between different plots obtained from a survey of 246 farmers from 6 villages in the Brong Ahafo region of Ghana to analyze the impact of property rights on investment in land-improvement and conservation measures. The empirical part of the article also examines the relationship between tenure agreements and crop productivity. The main contributions of the article reside in the fact that the results from the theoretical analysis hold for a wide range of situations and are as such independent of case specific data. Moreover, the empirical analysisconsiders a) endogeneity between land rights and investment decisions and b) interdependence between the different investment decisions.

The rest of the paper is organized as follows. Section 2 discusses land tenure in Ghana. In Section 3, we present a theoretical model on soil capital and forest use on plots where farmers can undertake short-term and long-term investments in land improvements. In Section 4, a multivariate probit model is employed to investigate the probability to invest in land improvements on rented and owner-cultivated plots. Section 5 discusses the survey data. The empirical results are discussed in Section 6, while the final section presents some concluding remarks.

2. Land Tenure in Ghana

As in several other African countries, land is traditionally owned by the community in Ghana. Control of the land is transmitted through the elders, who are custodians of land. Each herdsman therefore sees to it that all members of his lineage have portions to farm (Gildea, 1964). With the development of the cocoa industry in the country, practices of landholding have become individual ownership in contrast to family control of segments of the community land. Particularly in the Ashanti and Brong Ahafo regions, the procurement of large bundles of land by wealthy investors changed the old order. These investors either moved into previously unclaimed land or acquired secured rights to community land in exchange for money or influence. Some of these large-scale farmers sometimes reside somewhere else and supervise the operations on their land (Benneh, 1989). Even among migrants, land rights have become more clearly individualized, with members of the family qualifying for inheritance of land in the event of the death of the family head (Quisumbing et al., 2001). There is a complex system of communally owned land in the rural northern regions of the country, with many local variations. Land tenure is generally based on the community's social organization, and the basic unit of ownership is the family or clan.

Given that full ownership of rights over land traditionally resides with the community, one becomes less concerned with overall land tenure security than with rights that the individual holds over specific land parcels (Place and Hazell, 1993). We therefore focus on the long-term interests farmers have on land parcels, in terms of their rights to cultivate the land on continuous basis for long periods of time and their ability to rent or sell the land. As argued by Place and Hazell (1993), these features of land control are best captured by tenure measures based on the individual use and transfer rights that farmers possess over land. To capture these features, we collected detailed information on individual rights–basically use rights and transfer rights–for each parcel operated by the farmers in the sample.

Four main types of land tenure arrangements were identified in the survey area. These include owner-operated with full property rights, owner-operated with restricted property rights, fixed-rent and sharecropping arrangements. The owner-operated with full rights involves farmers owning and cultivating their own plots. Farmers cultivating these parcels have transfer rights, including rights to sell the parcels, although in some cases family approval has to be acquired before the land can be sold. Owner-operated with restricted rights involves plots that are acquired as grants, but cannot be transferred or inherited. The fixed-rent agreement involves land owners renting out parcels to tenants, who are normally migrants from other areas. Under sharecropping contract, an arrangement is made between the landlord and the cultivator, such that one-third of the output is given to the landlord as compensation for using the land.

3. Theoretical Model

The model presented below analyzes the link between land tenure agreements and investment in land improvement and conservation measures within a dynamic framework. The previous literature, considers standing forest (Angelsen, 1999, and Babier, 2004) or soil capital (Ehui et al., 1990) as a renewable or non-renewable resource. In this article, we model soil capital and forest as a renewable resource and analyze their interdependencies with agricultural production. It is assumed here that farmers combine investments in both mineral fertilizers, $X_M(t)$, such as NPK and organic fertilizers, $X_O(t)$, such as mulch and manure where t indicates calendar time. We control for cultivated plots and plots whose areas of production have been used for tree planting. Farmers are also assumed to choose production methods that improve soil fertility and increase productivity. Although crop yields normally increase with higher rates of mineral fertilizer, yields may decline with time, if other factors are held constant. The decline in yields may result from soil degradation, which then erodes the original purpose of investments.

Given these potential negative impact of continuous application of mineral fertilizer, profit maximizing farmers normally invest in organic fertilizers that naturally replenish nutrients in the soil with relatively less cost. The underlying economic reasoning being the returns farmers obtain from these investments. Let us assume now that the production function is defined for one hectare. Under this assumption, the agricultural production function per hectare can be defined as $f(S(t), X_M(t), X_O(t))$, where $S(t)$ represents soil capital, and $X_M(t)$ and $X_O(t)$ are as defined above. The application of organic fertilizers augments soil capital according to the function $h(X_O(t))$, with $h'(\cdot) > 0$. Moreover, since the soil, mineral and organic fertilizers are close substitutes, we can write function $f(\cdot)$ as a sum of expressions that reflect individually the effect of $S(t), X_M(t),$ and $X_O(t)$. Hence, the cross derivatives of the function $f(\cdot)$ is zero if there is no multiplicative effect between the variables, or it is constant if the multiplicative effect is the product of two variables. The volume of the biomass of trees (wood) is given by $W(t)$. The farmers have the choice to plant young trees, with volume denoted by $P(t)$. The planted trees grow according to the logistic growth function $g(W(t))$, with $g'(\cdot) > 0$. Standing forest increases soil capital specified by the function $y(W(t))$, with $y'(\cdot) > 0$, but reduces the acreage that is available for agricultural production. This reduction in acreage can be expressed as $\alpha W(t)$ with $\alpha > 0$. The size of the entire farm is normalized to one and the share of the land that is used for agricultural production is denoted by $L(t)$. Under the restriction that $0 \le L(t) \le 1 - \alpha W(t)$, $W = 0$ implies that the entire land will be used for crop cultivation, whereas $W = 1/\alpha$ implies using the entire land for growing trees.

Since current decisions tend to affect the evolution of the natural resources over time, we analyze the farmer's decision problem within a dynamic context and take into consideration the fact that the planning horizon of the farmer depends on land tenure arrangement. We further assume that agricultural households maximize farm net benefits subject to agronomic and biophysical constraints (the evolution of the soil and forest) over a planning horizon of length T, and the residual value of the trees and soil capital is given by $r\left(S(T), W(T)\right)$. The function $r(\cdot)$ will be zero for owners with restricted property rights, fixed-rent tenants and sharecroppers, because they do not have the possibility to sell the land. Given that restricted property rights are usually not limited over time, it is assumed that owners with full or with restricted rights have the same long-term perspective[2] while tenants (fixed-rent or sharecropping) have a planning horizon that corresponds to the stipulated tenure duration. Given these assumptions, the farmer's decision problem can be stated as

$$\max_{L,X_M,X_O,P,C} J \equiv \int_0^T e^{-\varphi t}\left[\left(pf(S(t),X_M(t),X_O(t)) - p_M X_M(t) - p_O X_O(t)\right)L(t)) - p_L(\cdot)\right. \\ \left. + p_W C(t) - p_P P(t)\right]dt + r\left(S(T),W(T)\right) \tag{1}$$

subject to

$$\dot{S}(t) = h(X_O(t))L(t) + y(W(t)) - \delta f(S(t),X_M(t),X_O(t))L(t), \quad \text{with } S(0) = S_0,$$

$$\dot{W}(t) = g(W(t)) - C(t) + P(t), \quad \text{with } W(0) = W_0,$$

$$0 \le L(t) \le 1 - \alpha\, W(t) \text{ and } X_O(t), X_M(t), C(t) \ge 0,$$

where $p_L(\cdot) = (1-\theta)\overline{p}_L + \theta\beta_1 pf(\cdot)L(t) + \theta\beta_2 p_W C(t)$ represents the cost of the land cultivated with agricultural crops and planted trees, with $\theta = 0,1$. In the case of sharecropping $\theta = 1$ and $p_L = \beta_1 pf(\cdot)L(t) + \beta_2 p_W C(t))$, where β_1 and β_2 indicate the share of the yields that accrue to the owner of the land.[3] In the case of no sharecropping (owner and fixed-rent tenant), $\theta = 0$, the cost of the land is given by the constant $\overline{p}_L$ which, however, is not identical for the owner and the tenant.

The parameters to be considered in the model are p = price of the cultivated crop, p_M = price of mineral fertilizer, p_O = price of organic fertilizer, p_W = price of the wood minus the logging and transportation cost, p_P = price of the seedlings of the trees and its plantation, δ = degradation of the soil capital, and φ = discount rate.

To simplify the notation we suppress the argument t of the variables as well as those of the costate variables and Lagrange multipliers to be introduced later, and define the current value Lagrangian L by

$$
\begin{aligned}
\mathrm{L} = & \left(pf(S, X_M, X_O) - p_M X_M - p_O X_O\right) L - p_L(\cdot) + p_W C - p_p P + \mu_1 L + \mu_2 (1 - \alpha W - L) \\
& + \xi_1 X_M + \xi_2 X_O + \xi_3 P + \xi_4 C + \lambda_S \left(h(X_O) L + y(W) - \delta f(S, X_M, X_O) L\right) \\
& + \lambda_W \left(g(W) - C + P\right),
\end{aligned} \tag{2}
$$

where λ_S and λ_W are the corresponding costate variables, μ_1 and μ_2 are Lagrange multipliers associated with restrictions related to the availability of land, and ξ_1 to ξ_4 are Lagrange multipliers related to the non-negativity of the control variables. The first order conditions are given by

$$
\frac{\partial \mathrm{L}}{\partial L} = pf - p_M X_M - p_O X_O - \theta \beta_1 pf + \lambda_S \left(h - \delta f\right) + \mu_1 - \mu_2 = 0 \tag{3}
$$

$$
\frac{\partial \mathrm{L}}{\partial X_M} = \left(pf_{X_M} - p_M - (\theta \beta_1 p + \lambda_S \delta) f_{X_M}\right) L + \xi_1 = 0 \tag{4}
$$

$$
\frac{\partial \mathrm{L}}{\partial X_O} = \left(pf_{X_O} - p_O - \theta \beta_1 pf_{X_O} + \lambda_S \left(h' - \delta f_{X_O}\right)\right) L + \xi_2 = 0 \tag{5}
$$

$$
\frac{\partial \mathrm{L}}{\partial P} = -p_P + \lambda_W + \xi_3 = 0 \tag{6}
$$

$$
\frac{\partial \mathrm{L}}{\partial C} = (1 - \theta \beta_2) p_W + \xi_4 - \lambda_W = 0 \tag{7}
$$

$$
\dot{\lambda}_S = \varphi \lambda_S - \left((p - \theta \beta_1 p - \lambda_S \delta) f_S L\right) \tag{8}
$$

$$
\dot{\lambda}_W = \varphi \lambda_W + \alpha \mu_2 - \lambda_S y' - \lambda_W g'(W). \tag{9}
$$

For an interior solution, $(\xi_1 = 0)$, the solution of equation (4) is presented in figure 1.[4] Owners of land with secured tenure will consider the shadow cost of the soil (λ_S), whereas tenants or sharecroppers will not consider these costs. Hence, fixed-rent tenants apply X_M^{Te}, sharecroppers X_M^S, and owners X_M^O. While it is clear from figure 1 that tenants apply more mineral fertilizer than owners, a direct comparison between sharecroppers and owners is not possible in the analysis. The behavior of sharecroppers will depend on the value of β_1. In the case that the owner chooses $\beta_1 = \lambda_S \delta / p$ owner and sharecropper will tend to apply the same amount of mineral fertilizer.

The optimal amount of organic fertilizer, which can be derived from an interior solution of equation (5) is presented in figure 2. Given that owners take into consideration the shadow cost of the soil (λ_S), they apply more organic fertilizer than a tenant, provided that the soil improvement effect of organic fertilizer, h', is greater than the soil degradation effect (δf_{X_O}) of the cultivation. This situation is depicted in figure 2 by comparing X_O^{Te} with $\tilde{X}_O^O$. It is however significant to note that tenants may apply more organic fertilizers than owners under specific conditions. Such a situation may arise if the soil improvement effect of organic fertilizer is lower than the soil degradation effect, as depicted in figure 2, which compares X_O^{Te} with X_O^O. According to figure 2, sharecroppers apply less organic fertilizer, X_O^S, than fixed-rent tenants. A direct comparison between sharecroppers and owners is however not possible. If the share that corresponds to the landlord is equal to $\frac{\lambda_S}{p}\left(\frac{-h'}{f_{x_0}} + \delta\right)$, owners and sharecroppers apply the same amount of organic fertilizer.

Condition (6) indicates that it is optimal to plant young trees if their in-situ value, l_W, is equal to their planting cost. Otherwise, x_3 presents the difference between planting cost and in-situ value of the young trees, and it is optimal to plant no trees. Cutting of trees results in $C > 0$, and therefore $\xi_4 = 0$ in equation (7). Hence, for tenants and owners, the unit price of wood needs to be equal to the in-situ value of the standing trees, while an additional $b_2 p_W$ has to be subtracted from the net price of wood for sharecroppers. If the net price minus $qb_2 p_W$ is not equal to the in-situ value, the difference will be reflected in the value of ξ_4. It is also evident in equation (7) that for cases where $C > 0$ that λ_W is equal to $p_W(1-\theta\beta_2)$, indicating that λ_W is a constant, and therefore $\dot{\lambda}_W = 0$. This condition holds outside the steady state equilibrium where farmers cut trees. Moreover, the condition $\dot{\lambda}_W = 0$ holds at the steady state equilibrium by definition. Hence, the following discussion holds for the two described situations. In this case, utilizing the definition of λ_W in equation (7), equation (9) can be written as:

$$0 = \left(\varphi - g'(W)\right)(1-\theta\beta_2)p_W \; + \; \alpha\mu_2 \; - \lambda_S y'(W). \tag{10}$$

Let us assume for now that $y' = 0$ and the farmer leaves some land fallow, i.e.,. $\mu_2 = 0$ since the opportunity cost for land is zero. It corresponds to the case where some of the land is used neither for agriculture nor for trees. Thus, equation (10) reduces to

$$0 = \left(\varphi - g'(W)\right)(1-\theta\beta_2)p_W. \tag{11}$$

Equation (11) holds if we choose W such that $g'(W)$ is equal to φ, in which case the marginal growth rate of the biomass will be equal to the discount rate. This case is depicted in figure 3 for $W = W^*$, a result that is standard in natural resource economics, since the optimal stock is to the left of the maximum sustainable yield, W^{MSY}.

However, if the entire agricultural land is cultivated and $y' \neq 0$, the term μ_2 defines the quasi rent of the land which, according to equation (3), is given by $\mu_2 = pf - p_M X_M - p_O X_O - \theta\beta_1 pf + \lambda_S (h - \delta f)$.

Hence, the optimal W for owners is given by

$$
\begin{aligned}
0 &= \left(\varphi - g'(W) + \frac{\alpha\mu_2}{p_w} - \frac{\lambda_S y'}{p_W} \right) p_W \\
&= \left(\varphi - g'(W) + \frac{\alpha}{p_W} \left(pf - p_M X_M - p_O X_O + \lambda_S \left(h - \delta f - \frac{y'}{\alpha} \right) \right) \right) p_W
\end{aligned} \tag{12}
$$

and for sharecroppers and tenants by

$$
\begin{aligned}
0 &= \left(\varphi - g'(W) + \frac{\alpha\mu_2}{(1-\theta\beta_2) p_W} \right) (1-\theta\beta_2) p_W \\
&= \left(\varphi - g'(W) + \frac{\alpha}{(1-\theta\beta_2) p_W} \left(pf - p_M X_M - p_O X_O - \theta\beta_1 pf \right) \right) (1-\theta\beta_2) p_W .
\end{aligned} \tag{13}
$$

It needs to be noted that the optimal W cannot be unambiguously determined from equations (12) and (13), since the term μ_2 is not identical for the different tenure regimes. Hence, the graphical solution of equations (12) and (13) can only be obtained under the assumption that the differences in μ_2 are relatively small and do not alter the ranking of the optimal W for the different tenure regimes. The empirical analysis undertaken with primary data addresses the situation where the above assumption is not applicable. Provided that the term μ_2 is relatively small, figure 3 shows that the opportunity to cultivate fallow land leads in the case of a tenant to a decrease in W, from W^* to W^{Te}. Likewise, we observe in the case of an owner that the optimal W decreases from W^* to $\tilde{W}^O$ or W^O. However, it cannot be determined whether the decrease of the owner is below or above the optimal W of the tenant, W^{Te}. Similarly, we have to leave the determination of the optimal W of the sharecropper for the empirical part of the paper.

The foregoing analysis has considered the case where trees are cut, $C > 0$. In the specific case where $C = 0$ we know from the relationship $\dot{W} = g'(W) - C + P$, that W is defined by $\frac{dW}{dt} = g'(W) = \int dW = \int g'(W)dt$, in which case $W(t) = W_O + \int_0^t g'(W)dt$. Trees grow during this phase without being cut.

4. Estimation Specification

The first order conditions (4) – (9) imply that farmers invest in land-improving or conservation measures if it leads to an increase in the aggregated expected net benefit over the planning horizon. However, the expected net benefit is not observable, since it is subjective. What is observed is the decision to invest or not to invest, i.e. the planting of trees, application of mineral fertilizer, as well as organic fertilizer such as mulch and organic manure. The empirical analysis focuses on the factors that influence the likelihood of farmers engaging in these investments. In line with the maximization problem outlined in equation (1), farmers invest in soil improvement and natural resource management measures, if the net benefit from the investment is positive, that is, if the value of J is greater than zero. As indicated earlier, changes in J are not observable, but can be expressed as a function of observable elements. Let us define the underlying latent propensity variable for investment in each of the four soil improvement and natural resource management strategies as J_h^*. The underlying propensities can then be related to the plot's observed characteristics and farmer related variables, Z_h, and unobserved characteristics, ε_h, in the following latent variable model:

$$J_h^* = Z_h'\beta_h + \varepsilon_h \qquad (h = \text{Trees, Fertilizer, Mulching, Organic Manure}) \qquad (14)$$

where h is used to index the four different investment options in soil improvement and natural resource management measures. Variables in Z_i include tenure security, household characteristics such as age, sex, and years of formal schooling of farmer, access to credit, as well as plot-specific characteristics such as plot size, distance of plot from home and geographic location. Denoting trees, fertilizer, mulching and organic manure as *T*, *F*, *M*, and *O*, respectively, equation (14) can simply be transformed into a binary probit equation for participation for each investment option under the following mapping from the latent variable to its observed realization:

$$J_h = \begin{cases} 1 & \text{if } J_h^* > 0; \\ 0 & \text{if } J_h^* \le 0. \end{cases} \qquad (h = T, F, M, O) \qquad (15)$$

Let's assume that $\varepsilon_h (h = T, F, M, O)$ jointly follow a multivariate normal distribution with mean zero and variance 1, and the covariance matrix Σ.[5] This can be expressed as $(\varepsilon_T, \varepsilon_F, \varepsilon_M, \varepsilon_O)' \sim MVN(0, \Sigma)$, where

$$\Sigma = \begin{bmatrix} 1 & \rho_{TF} & \rho_{TM} & \rho_{TO} \\ \rho_{TF} & 1 & \rho_{FM} & \rho_{FO} \\ \rho_{TM} & \rho_{MF} & 1 & \rho_{MO} \\ \rho_{TO} & \rho_{OF} & \rho_{OM} & 1 \end{bmatrix}$$

Maximum likelihood method can then be employed to estimate the parameters and the four correlations of the error terms (Greene, 2008). However, because the probabilities that enter the likelihood are functions of high dimensional multivariate normal distributions, they are simulated using GHK algorithm (Greene, 2008, p. 582). Other studies on investments in soil improvement and natural resource management measures have employed single-equation techniques, with the assumption that ε_h independently follows univariate distributions with $\rho_{hi} = 0$, ($h,i = T, F, M$ and O; $h \neq i$).[6] However, because of the substitutability or complementarity between these investment options, and the fact that the plots in the sample are similar across equations, it is most likely that the error terms of these equations will be correlated.

As indicated earlier, tenure security might be influenced by investment, resulting in endogeneity of the tenure variables in the multivariate probit model. When the dependent variable is discrete, the usual two-stage least square method will not be able to address the endogeneity problem.[7] Woodridge (2002) argues that the most useful two-step approach to examine endogeneity in a probit model is the one proposed by Rivers and Vuong (1988). To illustrate this approach which is termed Two-Stage Conditional Maximum Likelihood (2SCML), rewrite equation (14) in the form

$$J_h^* = R_h'\beta_h + Y_h'\gamma_h + \mu_h \qquad (h = T, F, M, O) \tag{16}$$

where R_h' is a vector of exogenous variables and Y_h' is a vector of potentially endogenous variables. In the present paper, owner-operated with full property rights, fixed-rent and sharecropping are the tenure agreement variables, with owner-operated with restricted property rights used as the base variable. The 2SCML approach involves estimating each variable in the vector Y_h' with least squares and then including the predicted values, $\hat{V}_h'$, from the regression in the specification below

$$J_h^* = R_h'\beta_h + Y_h'\gamma_h + \hat{V}_h'\delta_h + \mu_h \quad . \qquad (h = T, F, M, O) \tag{17}$$

The probit estimates of γ_h in equation (17) are consistent (Blundell and Smith, 1989; Wooldrige, 2002).[8] A significant feature of the approach is that the usual probit *t*-statistics on δ_h are valid tests of the null hypotheses that the variables are exogenous.[9] A linear probability model is employed in the first-stage estimation of the four tenure rights variables. The predicted values from the first-stage estimations are then included in the multivariate probit specifications and estimated with simulated maximum likelihood.[10] To ensure identification in the estimation of the probit model, some of the variables included in the first-stage estimation of tenure rights are excluded in the investment specification. Specifically, ethnicity and non-labor income which were included as variables in the tenure rights equation were deleted from the investment specification. The overidentication test statistic suggested by Lee (1992) is employed to test the validity of the excluded instruments.[11]

For each plot, tenure right is represented by four categories that include owner-operated with transfer rights, fixed-rent and sharecropping contracts, as well as owner-operated with restricted rights. Farm implements are used to capture wealth status. In addition to the tenure dummies and wealth variables, distance of plot from home, household size, education of household head, sex of household head, farm size, and soil fertility are included in the models to capture their effects on probability to invest in land improvement measures. Since investment is a trade off between current consumption opportunities for increased future consumption, we combine in each estimation, 4 different set of choice alternatives that do not provide similar effects. The investment options considered include tree planting, mineral fertilizer, mulching and organic manure. As indicated in the theoretical analysis, the magnitude of the influence of different tenure agreements on investment decisions of farmers, as well as the sign of the influence on some investment decisions cannot be determined *a priori*, and therefore needs to be determined empirically, which is done below.

5. Data and Definition of Variables

The data used in the analysis were collected during January and October 2003 in six villages in two districts–Techiman and Nkoranza–in the Brong Ahafo region of Ghana. A stratified random sample of 246 farm households with 560 plots was selected from four villages in Techiman District and two villages in Nkoranza District. The locations sampled in Techiman include Twimea-Nkwanta, Aworopata, Woraso and Nkwaeso. In Nkoranza District, Dromankese and Ayerede were sampled. The sample was taken to ensure representation of the various land tenure arrangements in the area. Specifically, it consisted of 65 owner-cultivated households with 214 plots, while the remaining 346 plots were cultivated under sharecropping or fixed-rent contracts by 181 farm households. As indicated earlier, the productivity-enhancing investments undertaken by farmers included mulching, mineral fertilizer, organic manure and planting of trees such as orange, mango, teak and indigenous trees.

Information on household characteristics, such as number of years of schooling and age of farmer, as well as the sex of farmer were included. As noted by Barrett et al. (2002), improved natural resource management practices such as mulching and manure preparation and application are knowledge-intensive and require considerable management input. In particular, formal schooling may enhance latent managerial ability and greater cognitive capacity. The other data included number of implements owned by farmer, livestock value and access to credit. In many developing countries, incomplete information between lenders and borrowers and uncertain conditions in agriculture and financial markets lead to imperfections in the credit market, including credit constraints that affect investment decisions. However, it might be misleading to classify farmers as credit-constrained simply because they did not use any credit. Hence, farmers were classified as liquidity-constrained if (1) they already had credit but expressed interest in borrowing more at the prevailing interest rate and (2) if credit was unavailable because their request was rejected, or there was no access to formal or informal lenders.

Differences across plots in term of quality and location also affect the suitability of the plots for various investments. Information on plot characteristics was therefore collected to address this issue. The plot-level characteristics gathered include distance of plot from home, and whether plot is fertile or not. The descriptive statistics of the variables used in the analysis are provided in Table 1. The incidence of investment is measured by dummy variables that take on the value of one when a household has undertaken a particular investment and zero when no investment has taken place. Four variables are employed in the study to examine tenure security. These include owner-operated with full rights, owner-operated with restricted rights, fixed-rent cultivation and sharecropping contract. All these variables are measured with dummy variables. The average tenure duration on fixed-rent plots in the sampled area is about 2 years.

6. Empirical Results

The empirical results for investment in land improvement measures are presented in Table 2. Four investment alternatives are considered in the estimation. These include tree planting, which is a long-term investment option, as well as mineral fertilizer, mulching, and organic manure, which are largely considered as short-term land improvement alternatives. The estimated correlation coefficients are all positive and significantly different from zero at the 1% level of significance, indicating that unobserved variables involved in each investment option are significantly positively related, and confirms that it is more efficient to model the investment in all four options jointly rather than separately. The overidentification tests statistics for the validity of the instruments failed to reject exclusion of the instruments used in the estimations, indicating consistency of the estimates.[12]

The variable representing owner-operated with rights is positive and significantly different from zero in all four investment options, suggesting that land rights matter for investments. It is significant to note that these results confirm our theoretical findings where we showed that owners apply more organic fertilizer in the form of manure and mulching ($\tilde{X}_O^O$ in figure 2) than sharecroppers and fixed-rent tenants, if the soil improvement effect is greater than the soil degradation effect of organic fertilizer. Likewise, the empirical analysis supports our theoretical finding that owners plant more trees ($\tilde{W}^O$ in figure 3) than fixed-rent tenants. The theoretical and empirical results also indicate that owner-operated with rights do invest less in mineral fertilizer than fixed-rent tenants (figure 1) while the behavior of the sharecroppers cannot be determined unambiguously.[13] The positive and significant impact of tenure rights on investment is in line with the results reported by Besley (1995), but contrasts with the findings by Quisumbing et al. (2001), who rather found in their study that the incidence of tree-planting and field management are unaffected by land tenure regimes in Ghana. .

The variable for sharecropping is also positive in all four specifications, but significant for only organic manure. The findings here clearly show that owner-operated with full rights are more likely to invest in these activities than sharecroppers. This result is consistent with the Marshallian disincentive theory on sharecropping contracts which stipulates that incentives for cultivators to invest in yield-enhancing inputs is much lower, since they receive only part of the benefits (Shaban, 1987). Consistent with the theoretical analysis, the variable for fixed-rent is negative and significant for trees, mulch and organic manure, but positive and significant for inorganic fertilizer. This indicates that relative to owners, plots on fixed-rent contracts are less likely to attract investment in trees, mulching and organic manure, but are more likely to attract investment in inorganic fertilizer for short-term benefits.

Trees are more likely to be planted by farmers with higher education, more assets, and larger plot sizes. In particular, education appears to have a positive and significant impact on all the four investment options, a finding that is in line with the human capital theory. According to the theory, farmers with more schooling and information will be better informed about the performance of different yield-enhancing technologies and will be more likely to make efficient investment decisions (Huffman, 2001).

Distance of the plot from home appears to influence investments in tree planting and mulching, with a negative and significant coefficient for tree planting and positive for application of mulch. Thus, controlling for tenure arrangements and other farmer's and plot-level characteristics, plots closer to the residence of the household are more likely to be used for tree planting than those farther away, while mulch is more likely to be applied on plots that are farther away from home. Older farmers appear to be less likely to invest in trees. This is probably because younger farmers have more periods in which to benefit from making a profitable investment in soil improvement measures that lead to long-term benefits. In particular, if farmers are not credit constrained and take future generations into account, younger farmers will be more likely to invest in conservation measures than older ones.

Almost all the village dummies are significantly different from zero, indicating significant cluster effects, and probably revealing agroclimatic variation and access to infrastructure.[14] As noted by Besley (1995), they could also be representing village-level variation in tenure arrangements. Noteworthy is the statistical significance of all the variables representing the residuals derived from the first-stage regressions for tenure agreements, indicating that the variables are exogenous and the coefficients have been consistently estimated.

Results of the reduced-form regression on plot-level productivity are presented in Table 3. Given the significant diversity of crops and intercrops on the plots, we employed value of crop output per acre as the dependent variable (Place and Hazell, 1993; Place and Otsuka, 2002). Separate analysis for each cropping pattern was not undertaken because of the relatively small sample sizes that arise from the data set. Dummy variables for cropping patterns were however introduced in the regression to capture the effects of the individual crops.

Given the potential endogeneity of the access to credit variable, it was instrumented by first estimating a probit model of determinants of access to credit and then using the predicted values in the productivity estimation. This is because in some cases, land or a crop itself can be used as collateral to obtain credit. The results from this first-stage regression are presented in Appendix A.[15] The estimates in Table 3 indicate a positive and statistically significant effect of the ownership variable, suggesting that ownership of land results in higher output. This finding is in line with the results by Migot Adholla et al. (1991), who found a positive and significant impact of land rights on agricultural productivity in Rwanda.[16] It is, however, in contrast with the findings reported by Place and Hazell (1993) and Place and Otsuka (2002) who found no significant relationship between tenure and productivity of crop farming in their studies.

The fixed-rent variable also showed a positive sign, but is not significantly different from zero at conventional levels, while the sharecropping variable is negative, but not significant. It is significant to note that the investments considered are either land-conserving or productivity enhancing inputs, and ownership tends to positively influence investment in these productivity enhancing measures. The results also indicate positive and statistically significant effects of access to credit and extension services. Plots farther away, as well as those planted with crops such as cassava, beans and plantain also indicate positive and significant effects on productivity. As is evident in Appendix A, which presents the probit results of determinants of access to credit, a positive and significant relationship is found between owner-operated with rights and access to credit. This indicates that individualized rights like ownership do necessarily help in securing formal or informal credit, a finding that lends support to the notion that secured land rights make it easier to use land as collateral to obtain loans to finance agricultural investments.

7. Conclusions

This article developed a framework to examine the relationship between different land tenure agreements and households' investment in land improvement and conservation measures in the Brong-Ahafo region of Ghana. The land tenure agreements considered include owner-operated with full property rights, owner-operated with restricted rights, fixed-rent agreement, and sharecropping contract. Variations in tenure agreements between different plots were used to estimate plot-level regressions relating tenure agreement to investments in tree planting, mulching, organic manure as well as inorganic fertilizer application. The impact of tenure security on crop productivity was also analyzed using reduced-form productivity equations.

The empirical results support our theoretical findings and show that better land rights tend to facilitate investment in soil improvement and natural resource management practices. In particular, farmers who owned land with secured tenure were more likely to invest in tree planting, mulching, organic manure, as well as mineral fertilizer. Farmers on fixed-term contracts were also found to be likely to attract investments in yield increasing inputs such as inorganic fertilizers, but are less likely to invest in tree planting, mulching and organic manure. These findings tend to support the widely held view that farmers with short-term fixed-rent contracts have little incentives to invest in long-term soil improvement measures, but are more interested in reaping the benefits from short-term measures. An examination of the impact of tenure rights on productivity, using reduced-form equations showed a positive and significant effect of land ownership on crop productivity. Access to credit was also found to positively influence crop productivity.

The major policy implication of these findings is that, ensuring tenure agreements that confer rights to cultivators would enhance investment in both soil improvement and natural resource management practices. In addition, the results provide productivity-based arguments for enhancing farmers' access to capital. Thus, policies and programs that improve farmers' access to credit would encourage productive allocation of resources and increased production.

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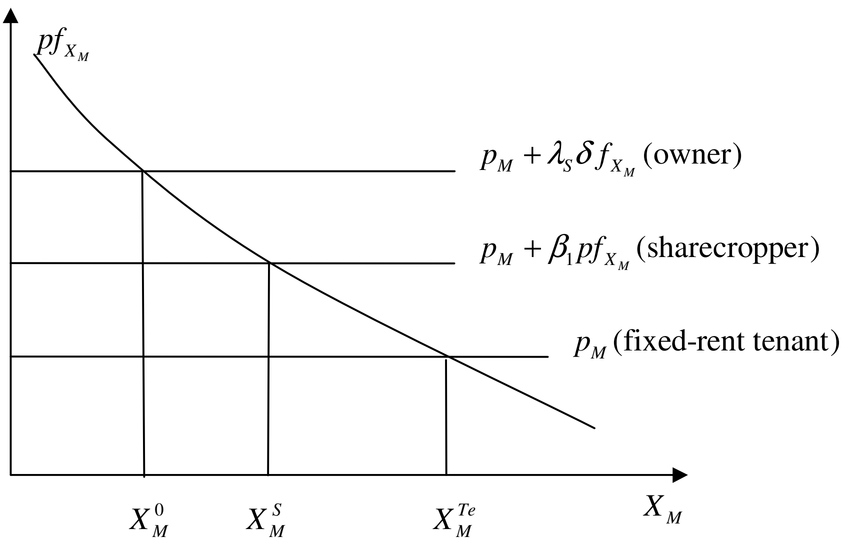

Fig. 1. The optimal amount of mineral fertilizer.

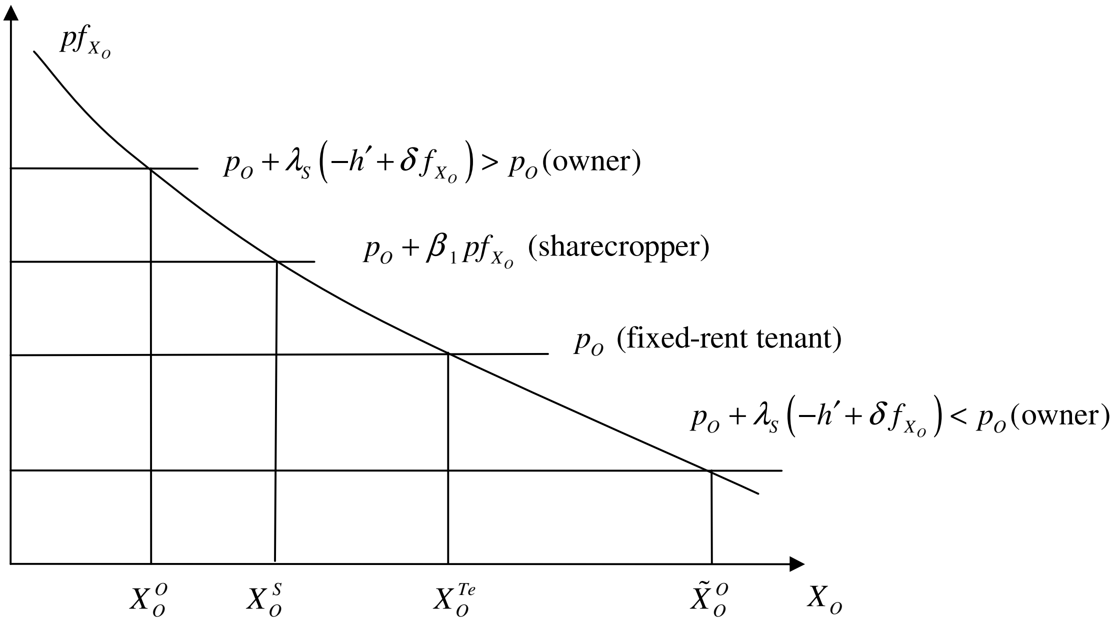

Fig. 2. The optimal amount of organic fertilizer.

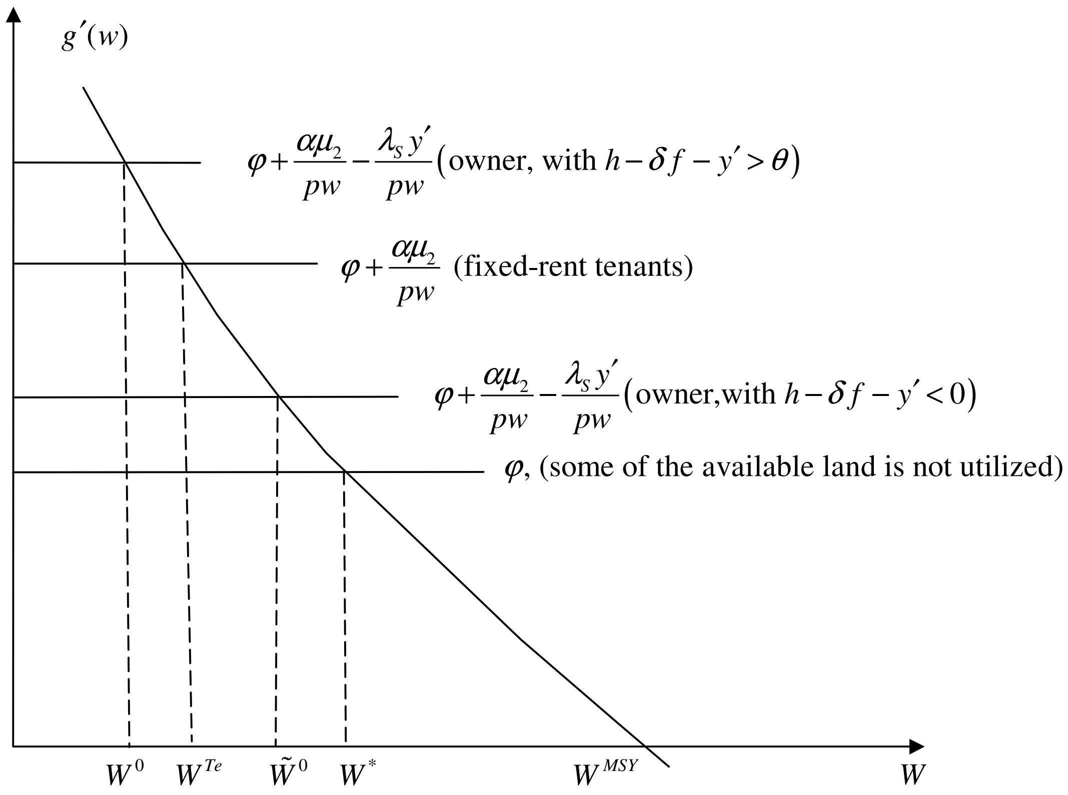

Fig. 3. The optimal "number of trees" in the presence of agricultural production.

Table 1
Descriptive statistics of variables used in the regression models

Variable	Definition of variables	Mean	S.d
Dependent variables			
TREES	1 if farmer plants trees	0.43	0.50
FERT	1 if farmer applies fertilizer	0.42	0.49
MULCH	1 if farmer applies mulch	0.35	0.48
MANURE	1 if farmer applies organic manure	0.14	0.34
YIELD	Output per acre (¢ x 10^{-6})	0.48	0.25
Tenure variables			
OWNER	1 if land is under own-operated with rights	0.36	0.48
FIXRENT	1 if land is under fixed-rent contract	0.28	0.45
SHARECROP	1 if land is under sharecropping contract	0.17	0.38
OTHER	1 if land is under owner without rights	0.19	0.26
Household characteristics			
AGE	Age of farmer (years)	49.98	13.67
EDUCN	Years of formal education of farmer	3.76	4.88
LIVEST †	Value of livestock wealth (¢ x 10^{-6})	11.20	26.11
SEX	If farmer is a male	1.05	0.22
IMPLTS	Number of implements owned by farmer	13.47	8.78
EXTEN	If farmer received extension visit	0.38	0.49
CREDIT	If farmer has access to credit	0.64	0.48
Plot characteristics			
PLTDIST	Distance of plot from home (km)	2.33	1.91
FSIZE	Farm size (acres)	2.94	2.03
PLOTFERT	1 if plot is on fertile land	0.14	0.35
Crops			
PLANTAIN	If farmer cultivates plantain on plot	0.09	0.29
CASSAVA	If farmer cultivates cassava on plot	0.06	0.24
VBEANS	If farmer cultivates beans on plot	0.46	0.49
LEGUME	If farmer cultivates beans and groundnuts	0.41	0.49
Location dummies			
TWIMEA	1 if farmer resides at Twimea-Nkwanta	0.22	0.41
AWOROPAT	1 if farmer resides at Aworopata	0.13	0.34
WORASO	1 if farmer resides at Woraso	0.18	0.38
AYEREDE	1 if farmer resides at Ayerede	0.27	0.44
DROMA	1 if farmer resides at Dromankese	0.08	0.28

Note: The dependent variable is a discrete choice variable =1 if investment is undertaken on a plot and 0 otherwise. Exchange rate: US $1=¢8500 in 2003. ¢=Ghanaian Cedis.
† Represents estimated variables in the regression models.

Table 2
Multivariate Probit Regression of Investment in Land Improvement Measures

VARIABLE	TREES	MULCH	FERTILIZER	MANURE
CONSTANT	-2.6968***	-1.2350*	-1.2849***	-1.371*
	(-4.28)	(-1.65)	(-2.44)	(-1.85)
OWNER	0.7954***	0.7135***	0.1271**	0.2792**
	(4.26)	(2.89)	(2.06)	(2.33)
SHARECROP	0.2725	0.1325	0.0579	0.1291*
	(1.32)	(1.087)	(0.92)	(1.78)
FIXRENT	-2.374***	-0.4505***	0.2884**	-0.3761*
	(-10.36)	(-2.36)	(2.31)	(-1.71)
PLTDIST	-0.0585*	0.0103*	-0.0053	-0.0551
	(-1.89)	(1.76)	(-0.15)	(-1.06)
FSIZE	0.031**	-0.0219	0.1067***	-0.1188**
	(2.17)	(-0.58)	(2.69)	(-2.10)
PLOTFERT	0.09	0.7866***	-0.1586	0.8984***
	(0.34)	(3.15)	(-0.74)	(2.80)
SEX	-0.4876	-0.9764**	0.3264	-0.311
	(-1.46)	(-2.10)	(1.04)	(-0.64)
AGE	-0.0502***	0.0086	0.0052	0.0166
	(-4.53)	(0.86)	(0.56)	(1.34)
EDUCN	0.0957***	0.0529***	0.0277*	0.0056*
	(4.55)	(2.73)	(1.84)	(1.88)
HHSIZE	0.0171	-0.0276	-0.0252	0.0199
	(0.64)	(-1.20)	(-1.12)	(0.75)
LIVEST	-0.0058	-0.0021	0.0048*	0.0118***
	(-1.11)	(-0.03)	(1.79)	(2.62)
IMPLTS	0.5119***	0.0177	0.565*	0.3182
	(3.89)	(0.16)	(1.81)	(1.56)
TWIMEA	-0.2047	0.2247***	0.1468	0.7554
	(-0.62)	(4.94)	(0.55)	(2.37)
WORASO	0.5229*	0.238	0.3725	-0.5085
	(1.65)	(0.49)	(1.48)	(-0.16)
AWOROPAT	0.265	0.5863***	0.5108*	-0.0421
	(0.81)	(3.46)	(1.89)	(-0.12)
AYEREDE	0.219	0.2283***	0.9834***	0.0971
	(0.69)	(5.13)	(3.98)	(0.31)
DROMA	-0.0824	0.1037**	0.0892	-0.3091
	(-0.21)	(2.08)	(1.5)	(-1.07)
RESOWNER	0.173**	0.0132***	0.057*	0.0931**

	(2.28)	(2.87)	(1.93)	(2.36)
RESFIXED	0.0335**	0.0147**	0.0248**	0.0412***
	(2.06)	(2.19)	(2.32)	(3.09)
RESSHARE	0.132**	0.0872**	0.0615**	0.1173**
	(2.31)	(2.08)	(2.42)	(2.16)
Overidentification				
χ^2 *-statistic*	0.72	0.47	0.58	0.63
(*p-value*)	(0.49)	(0.36)	(0.41)	(0.44)
Cross-equation correlations				
ρ_{TF}		0.216**		
ρ_{FM}		0.234***		
ρ_{TM}		0.307***		
ρ_{TO}		0.419***		
ρ_{FO}		0.208***		
ρ_{MO}		0.332***		
Mc Fadden R^2		0.249		

Note: Absolute *t*-values in parentheses. RESOWNER, RESFIXED and RESSHARE denote the residuals from the first stage regressions for owner cultivation, fixed-rent and sharecropping contracts respectively.

***Denotes significant at 1%, ** denotes significant at 5%, * denotes significant at 10%

Table 3
OLS Regression Results Showing the Determinants of Productivity at Plot Level

VARIABLE	COEFFICIENT	t-VALUE
CONSTANT	1.1709***	4.89
OWNER	0.5068**	2.55
FIXRENT	0.4221	1.26
SHARECROP	-0.0069	-1.04
PLTDIST	0.0511*	2.24
FSIZE	-0.2619	-1.23
PLOTFERT	0.0790*	1.86
EXTEN	0.3270***	2.71
PLANTAIN	0.1949**	2.15
CASSAVA	0.4972***	2.49
VBEANS	0.4176***	3.08
LIVEST	0.0256	0.3
HHSIZE	0.0194*	1.81
AGE	-0.0103*	-1.69
PCREDIT [a]	0.8652**	2.19
TWIMEA	-1.0349***	-5.51
WORASO	-0.1760	-0.98
AWOROPAT	-0.2869	-1.39
AYEREDE	-0.1461	-0.82
DROMA	-0.0331	-0.15
Adjusted R^2	0.259	
χ^2 *-statistic* for Overidentification (*p*-value)	0.382 (0.49)	
Number of observations	560	

Note: [a] Predicted values of credit used in the estimation. Overidentification test statistic for instruments given in the table.
*** Denotes significant at 1%, ** denotes significant at 5%,* denotes significant at 10%.

Appendix A. Probit Estimates of Determinants of Access to Credit

VARIABLE	COEFFICIENT	t-VALUE
CONSTANT	0.73937***	6.45
OWNER	0.01876**	2.27
FIXRENT	-0.00263	-0.04
SHARECROP	-0.00449	-1.04
FSIZE	0.00075	1.40
PLTDIST	-0.20254	-1.53
PLOTFERT	0.00092	0.06
HHSIZE	0.01655**	2.32
EDUCN	0.02423***	4.86
AGE	-0.00159	-0.90
SEX	0.03017	1.42
ETHNIC	0.01075**	2.57
EXTEN	0.05412	1.13
LEGUME	-0.04979	-1.16
TWIMEA	-0.22047***	-2.79
WORASO	-0.14682**	-2.02
AWOROPAT	0.20183***	2.36
AYEREDE	0.02705	0.37
DROMA	-0.12735	-1.37
Log-likelihood ratio	126.05	
Pseudo R^2	0.386	
Number of observations	560	

Note: *** Denotes significant at 1%, ** denotes significant at 5%, * denotes significant at 10%.

Notes

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[1] They have argued that farmers without secured rights engage in slash and burn practices to save time and cash, cut many trees with the view that land tends to be less productive under shady conditions, and also stump to make way for construction of mounds and ridges.

[2] Since the time perspective of owner-operated is independent of type of property right, we simply use the term owner in the theoretical section of the article to refer to both types of owners.

[3] Inherent to sharecropping is the question of sharing the risk between the landlord and the farmer. However, as we concentrate on the issue of different tenure regimes we use expected values and do not analyze the variation in crop yields.

[4] Since the cross derivatives of f are zero or constant we can graph pf_{x_M} independently from the tenure regime although the values of the argument of f vary with the tenure regime.

[5] As pointed out by Greene (2008), the magnitude of the variance of the disturbance term cannot be identified for each probit equation, as such the variance has normally been assumed as 1.

[6] For example, Marenya and Barrett (2007) employed single probit models for the investment options in their study on Western Kenya.

[7] The non-linearity of the probit model will result in estimates of standard errors that are downward-biased and coefficients that are not normally distributed (Wooldridge, 2002).

[8] Rivers and Vuong (1988) point out that the usual probit standard errors and test statistics are not strictly valid if the null hypothesis of exogeneity of the variable is rejected. In such a case, they suggest the use of an M-estimator to derive the asymptotic variance of the two-step estimator.

[9] The exogeneity test is similar to a Hausman (1978) test for exogeneity in that the parameter δ_h is an estimate of the difference between the parameter γ_h and the

corresponding probit estimate of γ_h in which tenure rights enter exogenously, e.g., γ_h in equation (18) without the $\hat{V}\delta_h$ term (DeSimone, 2002).

[10] Brasselle et al. (2002) also employed the 2SMCL in their study on Burkina Faso, while DeSimone (2002) employed the framework in his study on drug use and employment in the United States. Besley (1995) employed the linear probability model to estimate the investment specification in his study.

[11] Davidson and Mackinnon (1993) explain that this statistic tests the joint hypothesis that the excluded instruments are not appropriately excluded and are uncorrelated with the error term in the investment specification.

[12] A Jacque-Bera test of conditional normality of the residuals in the multivariate probit model could not reject the hypothesis that the residuals are normally distributed. The results are not presented in the interest of brevity, but are available upon request from the authors.

[13] The magnitude of the coefficients and the marginal effects support this assertion.

[14] The joint test of the null hypothesis that all district effects are equal using a likelihood ratio test gives a sample chi-squared value of 75.65 and a critical value at the 1% level of 15.1.

[15] As the results in Appendix A shows, some of the variables in the credit model were not included in the productivity model, thus leading to identification of the productivity model.

[16] Goldstein and Udry (2008) show in their recent study in the Akwapim district in Ghana how a great deal of potential output is lost because land tenure is insecure.