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CENTER DISCUSSION PAPER NO. 819

SKILLS, PARTNERSHIP AND TENANCY IN SRI LANKAN RICE FARMS

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ABSTRACT

This paper examines whether sharecroppers and fixed-rent tenants in the rice farms of South Asia are distinguished by their farming skills. The idea that fixed-rent contracts are typically given to relatively skilled tenants dates back to the agricultural (tenancy) ladder hypothesis of Spillman [1919]. The screening models [e.g. Hallagan 1978] that have attempted to formalize this idea assume that landlords do not observe the tenants' skill levels. This assumption is restrictive, and has found little support in empirical studies. The principal-agent model proposed in this paper focuses on the differences between time-intensive and skill-intensive labor tasks. I show that tenancy contracts are designed to match the provision of these tasks with the owners of time and skill inputs. Sharecropping, in this model, provides an incentive scheme that allows for the specialization between a time-abundant tenant and a skill-abundant landlord.

The second part of the paper empirically explores this result with household-level data from Sri Lanka. A two-stage model that distinguishes the choice of contract from the extent of land leased is used. The results clearly show that relatively skilled farmers are more likely to become fixed-rent tenants. I also find that, conditional on contract choice, farming skills do not affect the extent of land leased. A substantial part of the empirical analysis is devoted to the measurement of farming skills. I interpret farming skills as the contribution of observed farmer characteristics to the technical efficiency of the farm. This measure recognizes that many dimensions of skills are observed, and the use of weights computed from a production function to construct the skill index is theoretically more appealing than the ad hoc selection of proxy variables.

KEYWORDS: Land Tenancy, Farming Skills, Agricultural Labor, Sri Lanka

JEL CLASSIFICATION: O13, O17, D23, Q12, Q15

1 Introduction

The prevalence and persistence of land tenancy contracts have intrigued economists from the days of Adam Smith [1776] and Alfred Marshall [1890]. Although a large and fascinating literature has since evolved on this topic, many important questions on the existence of land tenancy contracts remain unresolved.[1] The goal of this paper is to provide a theoretical and empirical answer to one such question, the role of farming skills in the choice between fixed-rent and share-rent contracts.

The idea that skilled farmers obtain fixed-rent contracts dates back to Spillman [1919] who argued that farmers climb an "agricultural ladder" from agricultural labor to share-tenancy and then to fixed-rent tenancy through the gradual acquisition of skills. The ladder hypothesis has important policy implications that are especially relevant to countries, like Sri Lanka, that have attempted to discourage sharecropping through legislation. For example, the model developed in this paper shows that a time scarce landlord will prefer a fixed-rent contract provided that the tenant is sufficiently skilled. Therefore, narrowing the skill gap between landlords and tenants is the key to changing the tenancy mix in favor of fixed-rent farming. Secondly, removing the sharecropping option from the tenancy ladder through legislation leaves agricultural labor as the only option for unskilled tenants. Sharecropping provides a vital link by which unskilled tenants acquire the necessary management skills in partnership with landlords. The empirical estimates show that yields obtained by unskilled sharecroppers if they were to fixed-rent are too low to be feasible.

Over the years, the tenancy ladder has remained largely a "verbal hypothesis". [Otsuka and Hayami 1993]. The screening model proposed by Hallagan [1978] has attempted to formalize this idea using an adverse selection argument. The critical assumption of this model is that landlords do not observe the entrepreneurial skills of potential tenants. He argues that landlords can choose the contract parameters (share and fixed rents) to induce utility maximizing tenants of different abilities to self-select in

[1] See Hayami and Otsuka [1993] for an excellent survey of the tenancy literature.

to different types of contracts. Tenants with highest skill levels choose fixed-rent contracts, those with medium-skills self-select into sharecropping and the least skilled ones remain as agricultural laborers. However, the screening model is of limited use because the adverse selection argument falls apart in village economies where social networks are especially strong and information on tenant attributes is easily available.[2] This model is also theoretically flawed because it fails to address the landlord's optimization problem.[3]

More recent studies of land leasing have emphasized that moral hazard is a greater problem than adverse selection in village economies. The reasons for the severe moral hazard (or agency) problems are twofold: 1) many farm tasks are characterized by long time lags between inputs and the outcome and 2) a variety of random shocks (weather etc.) can make output uncertain and the contribution of workers to output difficult to measure.[4] An obvious solution to the moral hazard problem, especially in a modern industrial context, is the direct supervision of workers. However, direct supervision is a directly unproductive activity and can incur heavy costs especially for tasks with the large time lags and greater exposure to production shocks.[5] Some examples of such tasks are farm management and decision-making, application of chemicals and fertilizer, irrigation control, seed preparation and care and the supervision of

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[2] Bardhan [1984], Bell [1988] and Lanjouw [1999] find that information on the attributes of farmers is widely available in village communities.

[3] See Allen [1982] for a discussion of this problem. Allen [1985] attempts to salvage the screening model by looking at the optimization behavior of both parties under the assumption that contracts are designed to prevent default in rent payments. However, he succeeds only in showing that both parties are indifferent between share and fixed rents for certain skill levels. In addition, the advanced payment of a fixed-rent has been shown to be a widely practiced first-best solution for the default problem [Otsuka and Hayami 1993].

[4] See Lanjouw [1999] for empirical evidence on the existence of moral hazard problems.

[5] For an empirical analysis of farm supervision activity, see Evenson, Kimhi and DeSilva [2000]

short-term workers. [6] Tenancy can be used to allocate these imperfectly marketed labor inputs. Thus, in environments with imperfect factor markets, land tenancy plays a significant economic role by facilitating the efficient allocation of farm inputs.

The differences in the difficulty of supervision across farm tasks are clearly manifested in how these tasks are allocated in a farm's organization. The easily supervised tasks (harvesting, threshing, weeding etc.) are typically delegated to hired short-term workers or teams of workers who are paid a fixed or piece-rate wage. The more spatially and temporally spread out tasks are, on the other hand, often performed by the owner's family or tenants.[7] The goal of this paper is to understand the mechanism by which some or all of these tasks may be delegated to a tenant.

The motivation for this work comes from several interesting empirical observations made in quite different historical and geographical contexts. The earliest articulation of tenancy as a partnership between a landlord and a tenant comes from a series of papers by Reid [1973, 1975, 1976, 1979] on the emergence of sharecropping as a common form of tenancy in the Post-Bellum American South. He argued that freed slaves possessed large amounts of unskilled labor but lacked the managerial expertise that was required to single-handedly carry out cotton cultivation. The former slaves who lacked management or decision making abilities appear to have formed partnerships with white landlords who, due to their significantly greater experience and resources, possessed these qualities in abundance. Bell and Srinivasan [1985] find similar evidence in the entirely different setting of the contemporary Indian states of Punjab, Bihar and Andhra Pradesh. Their survey questionnaire asked explicit questions about the role landlords and tenants play in making key decisions and performing managerial tasks. The survey

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[6] See Bell and Zusman [1976], Bliss and Stern [1982], Pant [1983] and Eswaran and Kotwal [1985a]. Some other tasks, such as harvesting and threshing, are quite amenable to direct supervision. These tasks have outcomes that are immediately and directly observed during a short time frame so that direct monitoring is feasible.

[7] In some areas, especially in India, these tasks are sometimes given to permanent hired workers. It has been argued, however, that these permanent workers face very similar incentives to that of family members and are considered a *de facto* part of the household [Eswaran and Kotwal 1985b].

results show clearly that landlords play a significant role in providing these tasks in sharecropped lands and a minimal role in the fixed-rented farms. Roumasset [1995] reports further evidence of this division of managerial tasks by type of contract. Under Roumasset's classification, the landlord carries out land and asset management as well as most production decisions, whereas the tenant provides the control of labor and some of the more routine production decisions in sharecropped lands. This mostly anecdotal evidence tells us that sharecropping allows for a skill-abundant landlord and a time-abundant tenant the right incentive schemes to specialize in providing the labor tasks in which they possess a comparative advantage.

Eswaran and Kotwal [1985a], in their seminal theoretical work, focus on two types of skilled labor inputs, management and supervision. They argue that tenancy contracts are designed to offer self-monitoring incentives to the owners of these inputs by tying their incomes to farm output. In this setting, owner-cultivation is chosen if both inputs are provided by the landlord, and a fixed-rent contract is chosen if they are provided entirely by the tenant. Sharecropping provides a solution to the double-incentive problem that arises when both parties provide unenforceable inputs. This is of course a second best solution because of the usual Marshallian inefficiency costs associated with sharing rents. [8]

The Eswaran-Kotwal formulation takes the absolute advantage of landlords in management and tenants in supervision as given. The assumption that tenants are somehow endowed with supervisory skills is questionable [Hayami and Otsuka 1993]. To begin with, tenants in share arrangements appear to provide a much broader range of tasks than just supervision. Even if supervision of casual workers is important, it is likely to require very little skill and a large amount of time. Hayami and Otsuka [1993]

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[8] Shaban [1987] supports this argument with empirical evidence that yields (controlling for other observed factors) are lower in sharecropped lands. We do not contest this view that sharecropping is less efficient than fixed-rent farming. Our aim is to determine the conditions under which share-tenancy arises in spite of the apparent inefficiencies.

propose that we re-interpret the second input as labor. In this case, a clearer justification must be given as to why tenant may hold an absolute or comparative advantage in providing labor.

In the next section of this paper, we formalize this more general idea by assuming that landlords are time constrained and tenancy is really a solution to a time allocation problem. The two key inputs are skills and time, and they are combined in different proportions to perform each farm activity. We introduce three new features to the standard principal-agent model: 1) tenants are not assumed to have an absolute advantage in any type of skill; 2) landlords are assumed to have time constraints; and 3) landlords are allowed to retain parts of their holding for owner-farming (i.e. there may not be a single optimal contract for the entire holding). These generalizations allow us to formulate empirically testable propositions that accurately represent the environment that is studied, and provide a sound theoretical basis for the empirical analysis.

The second section of this paper develops an empirical test of farming skill effects on contract choice. A significant obstacle to empirical analysis is the difficulty of measuring farming skills. A few studies [Skoufias 1991, 1995, Lanjouw 1999] have established that skilled farmers lease-in larger extents of land, but have not examined the interesting issue of contract choice. Unlike in the previous studies, an index of farming skills is constructed from the observed production data using a stochastic production frontier approach. This method does not require panel data or rely on the restrictive assumption that skills are time invariant.

The third section describes the data and formulates testable propositions. The fourth section discusses the results, and the fifth section concludes with a summary of the main results and policy implications.

2: The Model

In this section, we outline a principal-agent model that explains how owner-farming, sharecropping and fixed-rent tenancy allocate farming skills and time. We treat skills and time as separate inputs because there are large variations in their relative distributions across households. In addition, the many different farm labor tasks require different complementary combinations of skills and time. For simplicity, we divide these tasks in to two types according to their relative time and skill intensities. The first type (M1) includes skill-intensive tasks that involve management and decision making elements (crop and input choices, timing decisions, land and asset management, technological change etc.). The second type (M2) consists of time-intensive unskilled activities such as the application of water, pesticides and fertilizer, preparation of seeds, protection of assets, inputs and crops, animal care and the supervision of casual labor.[9] The provision of both M1 and M2 is not enforceable with fixed payments because their contribution to output is not easily and immediately observed. The difficulties in identifying the inputs shares has been attributed to the spatial, temporal and uncertain nature of agricultural production. The M1 input differs from M2 because it depends heavily on the skills of the provider and relatively less on the time spent providing it.

Suppose the agricultural production function is

$$Q = qF[M1, M2, H] \qquad [1]$$

where F is increasing and twice differentiable in its arguments, and H is land. The multiplicative uncertainty term, θ, with $E[\theta]=1$, makes the enforcement difficult but plays no other role due to the risk

[9] We ignore casual labor tasks such as harvesting, threshing, weeding etc. which are easily monitored and enforced with fixed wage contracts.

neutrality assumption. The labor tasks can be expressed in the following general form;

$$Mi = M(S, Ti; x) \quad \forall i = 1,2 \qquad [2]$$

Mi is an aggregate of the skill level (S) and the time spent (Ti). M is assumed linear homogeneous, increasing and concave in S and Ti. Parameter x, (0 < x < 1) describes the relative intensity of skill in Mi and S is exogenously given to each individual. The tasks M1 and M2 are distinguished by appropriate restrictions on the parameter x. Specifically,

$$M1 = M(S, T1; x > 0) = S^{x} T1^{1-x} \text{ and } M2 = M(S, T2; x = 0) = T2 \qquad [3]$$

The production function can be simplified by substituting the above expressions for M1 and M2,

$$Q = qF[T1, T2, H; S] \qquad [4]$$

where F is increasing and concave in all its arguments, and linear homogeneous in T1, T2 and H for a given level of S.[10] The three types of contracts are identified by the following income schedule of the tenants:

$$Y = a\,Q + b\,H$$ [11]

1) Owner-Operator/Fixed-Wage Labor $\alpha = 0$, $\beta > 0$

2) Share Tenancy $0 < \alpha < 1$ [5]

3) Fixed Rental Tenancy $\alpha = 1$ and $\beta < 0$

We assume there is one landlord who owns H units of land and an infinite supply of landless workers (potential tenants). The landlord self-cultivates a part of the land, H_o, and leases out H_s units of land to sharecroppers and the remaining H_f units to fixed-rent tenants. Both landlords and tenants face

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[10] This is consistent with the view that there are increasing returns to scale when skills are included as an argument in the production function [Bliss and Stern 1982].

[11] According to this definition, both share and fixed rent tenants make a fixed payment (which may be negative) per unit of land leased to the landlord. This is somewhat different to the specification of a fixed rent independent of the farm size introduced by Stiglitz [1974]. However, since both the fixed rent (β_s ,β_f) and the parcel size (H_s ,H_f) are the landlord's choice variables, this does not change our conclusions in any way.

an elastic demand for their labor in the non-farm labor market. Therefore, they can supply as much labor as they want at an exogenously determined market wage that we assume to be v for tenants and u for landlords.

Fixed-Rent Tenant's Problem

Each fixed rent tenant faces the following optimization problem [12];

$$\max_{t1_f, t2_f} F[t1_f, t2_f, h_f; s] + (1 - t1_f - t2_f)v - b_f h_f \qquad [6]$$

The first term gives the tenant's income from cultivating the h_f units of land.[13] The second term shows his or her outside earnings where v is the market wage and the time endowment is unity. The third term is the fixed payment to the landlord where the rent (β_f) is determined by the landlord. We assume that the tenants' time endowment is large enough relative to his or her time input requirements so that the time constraint is never binding. Since F(.) is linear homogeneous, equation [6] can be re-written as follows;

$$\max_{z1_f, z2_f} h_f \{ f(z1_f, z2_f; s) - (z1_f + z2_f)v - b_f \} + v \qquad [7]$$

where $zi_l = \frac{ti_l}{h_l}, \forall i = 1,2$ and f (.) is increasing and concave in both z1 and z2.

Let

$$f(z1_f, z2_f; s) - (z1_f + z2_f)v = r_f \qquad [8]$$

Then the optimal time inputs per unit of land are,

$$zi_f^* = \arg\max \ r_f, \quad \forall i = 1,2 \qquad [9]$$

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[12] For clarity, all terms associated with tenants are shown in lower case and all terms associated with the landlord are in upper case. The functions are otherwise identical for both landlords and tenants.

[13] Output price is normalized to one, and income maximization is considered equivalent to utility maximization because the allocation of the fixed time endowment across types of work is assumed independent of the overall labor-leisure choice.

Now, the tenant's income reduces to

$$h_f [r_f^* - b_f] + v \qquad [10]$$

where $r_f^* = r_f(z1_f^*)$. It is clear from [10] that the tenant will lease-in land if $r_f^* \geq b_f$. Therefore the choice to lease-in land depends on the landlord's choice of fixed rent, b_f. Since the technology is constant returns to scale, there is no optimal farm size. The maximum amount of land the tenant can cultivate using the optimal levels of time inputs is;

$$h_f^* = \frac{1}{z1_f^* + z2_f^*}, \quad ti_f^* = zi_f^* h_f^* \ \forall i = 1,2 \ \text{ and } \ t1_f^* + t2_f^* = 1 \qquad [11]$$

The optimal time inputs and, therefore, the maximum farm size are functions of the tenants' skill level (s) and outside option (v).

The Share Tenant's Problem

Consider a share tenancy arrangement where the landlord and the tenant provide M1 and M2 respectively.[14] The share tenant's problem is

$$\max_{t2} \ aF[T1_s, t2_s, h_s; S] + (1 - t2_s)v - b_s \ h_s \qquad [12]$$

We incorporate the observation made in the empirical literature that there are some fixed payments even in the case of sharecropping [Otsuka and Hayami 1993]. This limits the role of the share to the enforcement of work effort, because the tenant's reservation income constraint can now be met by adjusting fixed payments.

Notice that the production in sharecropped land takes place at the landlord's skill level. The tenant provides only the time for M2 tasks. As in the case of the fixed-rent tenant, the share-tenant's

[14] We assume that both parties cannot provide the same input due to prohibitively high coordination costs.It is quite possible that the tenant specializes in M1 if his or her skill to time ratio is higher than the landlords. This problem would be, analytically, a mirror-image of the case considered here.

problem can be restated in terms of time inputs per unit of land.

$$\max_{z2_s} \; h_l \{a^* f(Z1_s^*, z2_s; S) - z2_s v - b_s^*\} + v \qquad [13]$$

where the tenant takes the landlord's optimal choices of a^*, b^*_s and $Z1^*_s$ as given. The assumption here is that each tenant and the landlord engage in a one-shot non-cooperative Nash game where each party maximizes his or her income subject to the optimal choices of the other.

Let

$$a^* f(Z1_s^*, z2_s; S) - z2_s v = r_s(a^*, Z1_s^*) \qquad [14]$$

The tenant's optimal choice of $z2_s$ is

$$z2_s^* = \arg\max \; r_s(a^*, Z1_s^*) \qquad [15]$$

This is the reaction function of the tenant that is solved simultaneously with the landlord's choice of $Z1_s$ to obtain the Nash equilibrium levels of time inputs. Once the time inputs are chosen, the tenant's income is reduced to

$$h_s[r_s^* \; (a^*, Z1_s^*) - b_s] + v \qquad [16]$$

where $r_s* = r_s (Z2_s*)$. The share tenant will lease-in land if $r_s^* \geq b_s$. For those who lease-in, the maximum amount of land cultivable with the optimal levels of time inputs is

$$h_s^* = \frac{1}{z2_s^*} \qquad [17]$$

The Landlord's Problem:

The landlord maximizes his or her income subject to a time constraint and the reservation incomes of tenants. The choice variables of the landlord are the time inputs in owner-farmed and sharecropped land ($T1_o$, $T2_o$,$T1_s$), the amount of land under each type of contract (H_s and H_f) and the contract parameters (α, β_s and β_f). Without loss of generality, we focus on the landlord's choice of H_s and H_f without consideration to how this land is allocated among tenants. As long as tenants' time constraints (equations [11] and [17]) are not met, the tenants are indifferent to the size of plot they obtain. Therefore, with a large enough number of tenants, the landlord is also indifferent to how the land is distributed among tenants of each type once the choice of H_s and H_f is made.[15] The optimization problem is,

$$\max_{T1_o,T2_o,T1_s,H_s,H_f,a,b_s,b_f} L = F(T1_o,T2_o,H_o;S) + [(1-a)F(T1_s,t2_s,H_s;S) + b_s H_s]$$

$$+ b_f H_f + (1 - T1_o - T2_o - T1_s)u + \Lambda[1 - T1_o - T2_o - T1_s] + \quad [18]$$

$$\Lambda_s[aF(T1_s,t2_s,H_s;S) - t2_s v - b_s H_s] + \Lambda_f[F[t1_f,t2_f,H_f;s] - (t1_f + t2_f)v - b_f H_f]$$

where $H = H_o + H_s + H_f$. The first four terms are the landlord's income from owner-farming, sharecropping, fixed-rent leasing and non-farm employment. The fifth term is the landlord's time allocation constraint, and the next two terms are the reservation income constraints of agents. The landlord takes tenants' choices per-unit labor time inputs ($z2_s^*$, $z1_f^*$, $z2_f^*$) as given.

The first order conditions with respect to b_f, b_s and α are

$$\begin{aligned} b_f: &\quad H_f[\Lambda_f - 1] = 0 \\ b_s: &\quad H_s[\Lambda_s - 1] = 0 \\ a:: &\quad F(T1_s,t2_s,H_s;S)[\Lambda_s - 1] = 0 \end{aligned} \quad [19]$$

From the first two first order conditions, we see that $\Lambda_f = 1$ for fixed-rent farming to exist ($H_f \geq 0$) and $\Lambda_s = 1$ for sharecropping to exist ($H_s \geq 0$). The first order condition with respect to the share-rent also tells us that $\Lambda_s = 1$ if production takes place in the sharecropped land (F>0). Since the multipliers are non-

[15] This indeterminacy arises from our assumptions of a production function that is linear homogeneous in T1, T2 and H, and a non-binding time constraint for tenants. When these assumptions are relaxed, the landlord may choose a small enough farm size for each tenant in order to maximize their time inputs. We abstract from this because our focus is on the allocation of contracts.

zero, the reservation income constraint for each type of tenant must be binding if that type of contract exists. The multiplier values of one tell us that if the reservation income constraints are relaxed by a unit, the landlord can adjust the contract parameters to increase his or her income by the same amount.

Because the constraints must bind in order for a contract to exist, the fixed payments of the tenants are,

$$b_f = f(z1_f^*, z2_f^*; s) - (z1_f^* + z2_f^*)v = r_f$$

$$b_s = af(Z1_s^*, z2_s^*; S) - z2_s^* v = r_s(a^*, Z1_s^*) \qquad [20]$$

From [10] and [16], we see that the rents in [20] are consistent with the participation conditions of the tenants. In fact, since the reservation constraint hold with equality, tenants are indifferent to the extent of land leased for these fixed payments under the assumption that the equalities [11] and [17] are not met. Using these results, the landlord's problem reduces to the following form:

$$\max_{Z1_o, Z2_o, Z1_s, H_s, H_l, a} H_o[f(Z1_o, Z2_o; S) - (Z1_o + Z2_o)w] + H_s[f(Z1_s, z2_s^*; S) - z2_s^* v - Z1_s w] + H_f[f(z1_f^*, z2_f^*; s) - (z1_f^* + z2_f^*)v] + w \qquad [21]$$

where $w = u + \Lambda$ and Λ is the Lagrange multiplier of the time constraint (marginal value of increasing the time endowment).

By appropriately reorganizing the terms in expression [21], the landlord's problem can be interpreted as maximizing the joint income of both parties minus the opportunity income of tenants.

Let

$$[f(Z1_o, Z2_o; S) - (Z1_o + Z2_o)w] = R_o$$

$$[f(Z1_s, z2_s^*; S) - z2_s^* v - Z1_s w] = R_s \qquad [22]$$

The landlord's time allocation problem is defined in [22]. The optimal time inputs per unit of land, under the usual assumptions of concavity of R_o and R_s are,

$$Z_o^* = Z1_o^* + Z2_o^* = \arg\max_{Z1_o} R_o + \arg\max_{Z2_o} R_o \quad [23]$$

$$Z_s^* = Z1_s^*(z2_s^*) = \arg\max_{Z1_s} R_s$$

However, the two problems are separable only if the landlord's time constraint is not binding. That is, if L =0, the exogenous market wage u acts as a separating hyper-plane between the landlord's time utilization problems in owner-operated land and sharecropped land, and the three first order conditions are sufficient to fully identify the time input choice solution. Equation for Z^*_s in [23] is the landlord's reaction function in the Nash game over the provision of time inputs in sharecropped land. Assuming that a unique solution exists, the solution to this game ($Z1^*_s(\alpha)$, $z2^*_s(\alpha)$) is found by solving the two equations [15] and [23] simultaneously. The landlord's time input choices (Z^*_o, Z^*_s) in the absence of time constraints provide us with a benchmark "efficient" solution.

If L >0, the problem is analytically more interesting because there is no exogenous market wage to separate owner-farming from share-cropping. The marginal value of the landlord's time is now given by a "shadow wage" w which is the sum of the market wage u and the multiplier Λ which measures the "magnitude" or the "severity" of the time constraint. Since w does not characterize an exogenous separating hyper-plane, the landlord's time constraint is necessary to identify the time input choice solutions. The landlord's time constraint is:

$$Z_o H_o + Z1_s H_s = 1 \quad [24]$$

After solving the Nash game with the share-tenants, the landlord's optimal time inputs choices are obtained as functions of H_s and H_f.

$$Z_o(H_s, H_f, a) = \arg\max_{Z1_0} R_o + \arg\max_{Z2_0} R_o$$

$$Z2_s(H_s, H_f, a) = \arg\max_{Z1_s} R_s \quad [25]$$

Once the optimal input levels are determined, the landlord chooses how much land is leased out to fixed-rent and share-rent tenants. When H_s and H_f are changed, the landlord's net income changes if the average products of each type of tenancy are different. In addition, equations [25] show that the re-allocation itself could cause the average products under each contract to change by changing the intensities of landlord's time inputs in owner-farmed and sharecropped land. The equations for landlord's choice between each pair of contract can be derived by taking the first order conditions of equation [21] with respect to H_s and H_f with appropriate restrictions on land allocation constraint (given in [18]). Land is allocated from owner-farming to sharecropping (fixed-rents held constant) if ,

$$f_s\ (Z1_s, z2_s; S) - v.z2_s + w(Z_o - Z1_s) > f_0\ (Z_o; S) \qquad [26]$$

From owner-farming to fixed-rent leasing (share-rents held constant) if,

$$f_f^*\ (z_f^*;\ s) - v z_f^* + w Z_o > f_0\ (Z_o; S) \qquad [27]$$

and from share-cropping to fixed-rent farming (owner-farming held constant) if,

$$f_f^*(z_f^*; s) - v z_f^* + w Z1_s > f_s\ (Z1_s, z2_s; S) - v.z2_s \qquad [28]$$

where $w = u + \Lambda = \dfrac{\partial f_o}{\partial Z_o} = \dfrac{\partial f_s}{\partial Z_s}$ [29]

These choice equations tell us that the gains from re-allocation include the value of the labor that is freed up due to the re-allocation in addition to the net gain in income when the parcel is allocated between two contracts with different average products. The left hand and right hand sides of equations [26]-[28] can be interpreted as the marginal revenue and marginal cost of the re-allocation respectively. For the re-allocation from owner-farming to sharecropping [26], the first two terms of marginal benefit represent the average product of sharecropped land net of the opportunity cost of the tenant's time evaluated at the market wage. The third terms depicts the value of landlord's time freed due to the re-allocation evaluated at the marginal product of the landlord's time. The marginal cost, on the other hand, is the average product under owner-farming. Figure 1 illustrates the marginal revenue and cost as a function of the proportion of sharecropped land (H_s/H). The slopes of these functions are:

marginal benefit (MR): $$-Z1_s^* \frac{\partial w}{\partial H_s} > 0$$ [30]

marginal cost (MC): $$-Z1_o^* \frac{\partial w}{\partial H_s} > 0$$

since $\frac{\partial w}{\partial H_s} < 0$.

The average products and the shadow wage are sensitive to the allocation of land across contracts. When the landlord allocates H_s units of land to sharecroppers, he or she must equate the marginal products of time allocated to owner-farming (H_o) and sharecropping (H_s). The labor allocation condition implies that when labor is freed up due to land re-allocation, most of it must be assigned to owner-farming. Therefore, as the slope equations [30] indicate, the marginal cost increases at the faster rate than the marginal revenue because most of the re-allocated time is assigned to owner-farming, and owner-farming thus gains relatively more from the increase in H_s. If MR=MC for some H_s, mixed-tenancy arises with some of the land share-cropped and the remainder, owner-farmed. The sufficient condition for the existence of sharecropping is,

MR>MC when $H_s=0$ [31]

and the sufficient condition for mixed tenancy is [31] and

MR<MC for large enough H_s [32]

Using equations [27] and [28], the choice between owner-farming and fixed-rent contracts and the choice between fixed-rents and share-rents can be analyzed in a similar way. An important difference is that an increase in fixed-rent farming has a positive external effect on both owner-farmed and sharecropped land. When the marginal unit of land is fixed-rented, both the time inputs Z_o and Z_s increase and the shadow wage (w) converges to the market wage, u. This results in a relatively steeper slope for the marginal cost function compared to the case illustrated in figure 1. However, the optimal time input in the fixed-rented land, z_f is not affected by the re-allocation. By easing the landlord's time constraint, fixed rent contracts facilitate the replacement of inefficient (in the Marshallian sense) sharecropping with first-best owner-farming. A fixed rent contract will be chosen if the loss in average product due to skill deficiency is outweighed by the gains due to higher time inputs in owner-farming and sharecropping.

The existence of mixed-tenancy depends on condition [32]. When H_s increases, the marginal product of landlord's time converges to the market wage, u. For large enough H, the landlord may be able to achieve the optimal levels of Z_o^* and Z_s^* for some H_s. In this case, the landlord's time allocation per unit land and thus the average product under each arrangement is independent of land allocation choices (H_s and H_f). As a result, he can freely re-allocate land between owner-farming, sharecropping and fixed-lease renting without changing the time inputs Z_o^* and Z_s^*, and the optimal time input choices are separated by the exogenous market wage, u. The straight-line segments in the MR and MC functions in figure 1 depict this scenario. The condition [32] is then determined by the relative magnitudes of the following optimal average product functions:

$$f_o^* = f_o\left(Z_o^*(u,S)\right) \ , \quad f_s^* = f_s\left(Z_s^*(u,v,a,S)\right), \quad f_f^* = f_f\left(z_f^*(v,s)\right) \qquad [33]$$

Since the landlord's time allocation is separable and all three average revenue functions are independent of land allocation choices H_s and H_f, equations [26]-[28] reduce to:

$$f_s^* - v.z2_s^* + u(Z_o^* - Z1_s^*) > f_0^* \qquad [34]$$

$$f_f^* - vz_f^* + uZ_o^* > f_0^* \qquad [35]$$

$$f_f^* - vz_f^* + uZ1_s^* > f_s^* - v.z2_s^* \qquad [36]$$

The choice between owner-farming and sharecropping now depends only on the relative market wage and the output share. Specifically, owner farming is preferred to sharecropping if the opportunity cost of using the landlord's time for unskilled labor is smaller than enforcement costs associated with sharecropping. Owner farming is preferred to fixed rent farming if the opportunity cost of using landlord's time is smaller than the gains from using landlord's farming skills. In addition, if skills are relatively more important to production than time, as represented by a large x in [2], the incidence of owner-farming will be higher. Finally, Sharecropping is preferred to fixed-rent farming if the landlord's skills are relatively high, Marshallian inefficiency losses are low, and the opportunity cost using landlord's labor is small. Here again, the incidence of sharecropping increases when skills becomes relatively more important than time.

The basic result of the resource adjustment model is summarized in Figures 2 and 3. Figure 2 illustrates the case where the landlord owns more land (h_l) than the tenant (h_t) but has identical endowments of both time and skill. It is clear that a Pareto superior outcome can be achieved by re-allocating h^*-h_t units of land from the landlord to the tenant under a fixed-rent contract. Since the provider of both time and skill is assigned the entire residual under both owner-farming and fixed-rent farming, the marginal product functions are identical mirror images in figure 2. The shaded area (A) shows the gains from contracting. The gains are large when the two parties differ only in terms of their land endowment.

However, tenants are likely to have lower skill levels than landlords in most rural economies.[16] If the tenants are relatively unskilled, as shown in figure 3, the gains from fixed-rent contracting (area A) are much smaller. In this case, sharecropping provides an alternative mechanism where the landlord and tenant specialize in the inputs they are better endowed with.

As shown in figure 3, the marginal product function for sharecropping is similar to that of owner-farming because the landlord compensates for the low skill level of the tenant. However, sharecropping introduces two new costs to the equation: first, the standard Marshallian inefficiency arises because the residual is shared by both parties, and second, the landlord must re-allocate some time away from his or her own farm to provide skilled inputs in the sharecropped land. Such a re-allocation of inputs away from the owner-farmed land when the landlord engages in sharecropping was observed in Indian state of

[16] We do not claim that this is necessarily the case. For example, relatively more skilled tenants are observed in the case of absentee landlords who have no experience in farming and in the case of landlords who are impoverished due to the exceedingly small size of their inherited holding.

Punjab by Bell, Raha and Srinivasan [1995]. They call this a "dilution effect". The decision to sharecrop lies primarily on the trade-off between the gains from specialization in the sharecropped land net of the enforcement costs (area B) and the loss of landlord's time in the owner-farmed land (area C). The gains from sharecropping will be large if the differences in skills are large and the marginal cost of re-allocating time is small. Sharecropping may arise when the tenants have relatively low skills, and the landlord is able to provide skilled inputs with minimal effects on his or her own farm (minimum dilution effects).

Comparative Statics: The Effect of Skills and Outside Options

As indicated earlier, the effects of relative management skills and the outside labor market options on contract choice are different for small and large farms.[17] The owner-farming-sharecropping trade-off is independent of the relative skills of the landlord for small enough farms. In both cases, owner-farming is chosen when the outside option of the landlord is relatively low. Fixed-rent contracts are chosen when tenants are relatively skilled and the landlord's outside options are relatively high. As the relative skill of the landlord increases, the outside option must rise correspondingly larger for a fixed-rent contract to arise. Absentee-landlords are an example of relatively unskilled landlords with high outside options. Sharecropping is preferred when the landlord's outside options are high enough to make owner-farming (the provision of both M1 and M2) unprofitable, but relative management skills of the landlord are sufficiently high to make sharecropping preferable to fixed-rentals. Therefore sharecropping is observed when the landlords are skilled at farming but do not have enough time, given their outside options, to engage in self-cultivation.

The analysis of large farms is somewhat different. In the large farm, since the landlord's labor

[17] The absence or presence of a binding labor time constraint for the landlord identifies small and large farms. Technically, farms sizes are expressed relative to family labor endowments, which for purposes of this paper are assumed to be identical.

time constraint is binding, the landlord must allocate his or her time so that the income from the entire holding, not an individual parcel, is maximized. For example, he or she must choose between owner-farming a small parcel and fixed-leasing the remaining large portion of the holding, or specializing in share-cropping the entire holding. The first choice avoids enforcement costs but may involve skill costs if the fixed-rent tenants are inept at management, and vice versa. Therefore, for large farms, the choice is two-fold: 1) owner-farming a small portion of the holding and fixed-leasing the remaining large portion, and 2) share-cropping a large portion of the holding and fixed-leasing the remaining (if any) small portion. The first is preferred if the tenant is relatively skilled (so fixed-leasing is not inefficient), and the second choice is preferred if the tenant is relatively unskilled. The trade-off between share-rents and fixed-rents is represented by net gains from the skills used, the re-allocation of landlord's time, and the enforcement costs in sharecropping. The greater the time constraint, and higher the marginal value of landlord's time, fixed-rent contracts are preferred.

If the landlord's outside option increases, the incidence of fixed-rent contracts increase. On the other hand, increasing outside options of the landlord makes sharecropping more attractive than owner-farming. Therefore, an increase in landlord's outside options has a positive effect on both fixed-rent contracts and share-cropping at the expense of owner-farming. Unlike in the small farm case, no single contract is necessarily optimal for the entire holding. The optimal solution, for large enough farms, may be a combination of all three types of contracts.

3. The Empirical Specification

The underlying framework of our analysis is the simple leasing model of Bliss and Stern [1982]. Suppose that farmer i owns F_i units of family labor, X_i units of bullocks, and H_i units of land. Then, if the markets for labor, and bullocks are imperfect, the desired cultivated area (C_i) is

$$C_i = f(F_i, X_i, Z_i) \qquad [37]$$

where Z_i is a vector of all other characteristics of the farmer. Then, the notional demand for land (Y^*_i) in the land leasing market is;

$$Y_i^* = C_i - H_i = f(F_i, X_i, Z_i) - H_i \qquad [38]$$

The difference between the actual and notional demands for land depends on the transaction costs in the land leasing market. Suppose the actual net amount of land leased-in is Y_i. Then

$$Y_i = h(Y_i^*) = h(f(F_i, X_i, Z_i) - H_i) \qquad [39]$$

where h(.) is the transformation function in the leasing market.

The Choice of Contract

The main hypothesis of this paper is that relatively skilled tenants obtain fixed-rent contracts while those endowed with family labor get share contracts. The theoretical analysis showed that the level of managerial skill required to enter in to a sharecropping contract is less than that for a fixed-rent contract because the landlord typically provides some of the skill-intensive managerial inputs in sharecropped farms. The empirical model presented in this section identifies some key differences between the two contracts as resource adjustment mechanisms.

We focus on the leasing behavior of tenants because data constraints prevent us from estimating a more general model that includes the landlords. The simplest method of estimating the determinants of sharecropping and fixed rent leasing is to carry out separate leasing or contract choice estimates for each type of contract. The starting point of our analysis is probit and tobit models for the following underlying equations based on the model outlined in [37]-[39]:

$$\begin{aligned} S_i^* &= b_o + b_1 F_i + b_2 H_i + b_3 X_i + b_4 Z_i + e_i \\ F_i^* &= d_o + d_1 F_i + d_2 H_i + d_3 X_i + d_4 Z_i + j_i \end{aligned} \qquad [40]$$

where ε_i and φ_i are distributed N (0, σ_ε^2) and N (0, σ_φ^2) and S_i^* and F_i^* are the underlying variable for sharecropping and fixed-rent leasing, F_i, is the endowment of family labor, H_i is the amount of land owned, X_i are the other owned farm inputs, and Z_i is a vector of farmer characteristics that includes skill.

A well-documented flaw of the single equation tobit model is its inability to distinguish the two distinct, albeit related, events of leasing-in and choice of contract. For example, we expect farmers who own little land to lease-in relatively more land under either contract. However, among the tenants, those with more assets, including land, may prefer fixed-rent contracts. A multi-stage generalization of this model is needed to separate the three different stages of the decision making process; 1) the choice to lease-in, 2) the choice of contract, and 3) the extent of land leased-in.

Two alternative methods are used to model the first two stages. In the first method, a multinomial logit model is used to combine the first two choices in to a single decision between three alternatives. In the second method, the two stages are modeled as sequential probit equations with the contract choice observed only when the choice to lease-in is made. The extent of land leased-in is modeled in the next section as a linear regression for each type of tenant with appropriate corrections for sample selection computed from the choice equations.

Multinomial Logit Model of Contract Choice

A standard multinomial logit specification is used with the choice variable Y where:

Y = 0 if land is not leased-in

1 if land is leased-in under a share-contract

2 if land is leased-in under a fixed-rent contract

and

$$\text{Prob}(Y = j) = \frac{e^{b'_j x_i}}{1 + \sum_{k=1}^{2} e^{b'_k x_i}} \quad \text{for } j = 0,1,2 \quad \text{and } b_0 = 0 \qquad [41]$$

The coefficients estimates, β_j, can then be interpreted as the marginal effect of x_i on the relative log odds ratio between the choice j and choice 0.

Bivariate Probit Model of Contract Choice

The bivariate probit model jointly estimates probit equations for the leasing and contract choices with correlated error terms. The specification of this standard model is

$$\begin{aligned} &L^* = b_1' x + e_1, \qquad L = 1 \text{ if } L^* > 0, \text{ 0 otherwise} \\ &S^* = b_2' x + e_2, \qquad \text{S} = 1 \text{ if } S^* > 0, \text{ 0 otherwise} \\ &e_1, e_2 \sim N(0,0,s_1, s_2, r) \end{aligned} \qquad [42]$$

where L^* and S^* are the underlying choice variables for the extent of land leased-in and the extent of land sharecropped, L and S are the observed choices and x is a vector of explanatory variables that includes F, X, H and Z. The functional form is used to identify the model with the same set of explanatory variables in both equations because it is difficult to find identifying variables for either equation.

Since we do not observe the contract choice for the farmers who choose to self-cultivate, the standard model must be modified to incorporate the fact that the contract choice (S) exists only if the leasing choice (L) is positive. This gives rise to a bivariate probit model with three types of probabilities:

$$\begin{aligned} &\text{Prob}(L = 1, S = 0) = \Phi_2(- b_2' x_2, b_1' x_1, -r) \\ &\text{Prob}(L = 1, S = 1) = \Phi_2(b_2' x_2, b_1' x_1, r) \\ &\text{Prob}(L = 0) = (1)\ - \Phi(b_1' x_1), \quad (2)\ 1 - \Phi(b_1' x_1) \end{aligned} \qquad [43]$$

The first specification, proposed by Wynand and van Praag (1981), treats S as a truncated variable at L=0. The second variant, due to Meng and Schmidt (1985), defines S as a zero-censored variable when L=0. The obvious difference is that the latter method treats the choice to reject leasing-in as an indicator of a simultaneous decision to reject sharecropping. As a result, owner-farming and fixed-rent farming are pooled as a common alternative to sharecropping.

The Land Extent Equations

We also carry out least squares regressions for the extent of land leased by each type of tenant to determine whether this adjustment process occurs within each group. If the evidence of adjustment is weak within groups, we can conclude that the adjustment process is carried out primarily in the first stage where contracts are assigned to the tenants, and not by the size of the farm allocated to each tenant. This result would confirm the claim of the theoretical model that type of contract, and not the individual farm size, is the key choice variable in the leasing model. Since tenants of either type are a subset of our sample, selectivity correction terms are included to obtain consistent estimates. We follow a two-step method analogous to that of Heckman [1976] where the predicted probability of the subset is estimated in the first stage, and a selectivity correction term based on this predicted probability is included in the second stage linear regression to obtain consistent estimates of the parameters. The only difference from Heckman's original method is the use of multinomial and bivariate probit equations for selection. The leasing equation for observations with Y=j is,

$$H_j = b' x + q_j l_j + h_j \qquad [44]$$

The selectivity terms, $\lambda_{j,}$ are constructed from the predicted probability of choice j computed from the choice equations. If the multinomial logit model is used as the selection equation, the selectivity term, λ_j, is calculated using the predicted probability for Y=j (equation [41]).

$$l_j = \frac{f(H_j)}{\Phi(H_j)}, \quad \text{where} \quad H_j = \Phi^{-1}(P_j) \qquad [45]$$

and ϕ and Φ are the standard normal PDF and CDF[18]. If the bivariate probit model is used for selection, the selectivity term is calculated in the same way using the appropriate predicted probability from [43].

The Index of Farming Skills

The biggest obstacle to understanding the role of management or entrepreneurial skills in land leasing is the absence of an appropriate measure of skill. Management skill or capacity has several dimensions including "(1) drives and motivations, e.g. farmer's goals and risk attitude; (2) abilities and capabilities, e.g. cognitive and intellectual skills; and (3) biography, e.g. background and experience" [Rougoor et. al. 1998]. While some aspects of skill such as education and age are easily measured, many others such as drive, motivation, entrepreneurship and ability are neither directly observable nor quantifiable.

Farm studies have used two distinct approaches to measure management skills. The first, based on Mundlak [1961], treats management inputs as the time invariant portion of the production function residual. Skoufias [1991] uses this method to estimate a linear land leasing equation using panel data from India. However, the panel data fixed effects estimation is clearly unsuitable in our context because many explanatory variables such as asset ownership have negligible time (within) variation compared to the cross-sectional (between) variation.[19] More fundamentally, by focusing solely on the residual, the panel data methods fail to make use of the observed dimensions of skill such as education and experience.

The second approach is the inclusion of observed variables that are assumed highly correlated with managerial skill. Bliss and Stern, Nabi and Skoufias [1991] include age, education and caste as

[18] This model is proposed in Lee [1983]. This paper also describes the corrected asymptotic covariance matrix for the two-step estimator.

[19] Skoufias himself points out, for example, his land ownership coefficient is biased as a result. A solution to the fixed effects problem is proposed by Lanjouw [1999] who models the error structure explicitly with in a joint maximum likelihood estimation of leasing and production functions.

proxies. Pant [1983] includes the value of farm implements. However, these proxy variables may have an independent effect on land tenancy that cannot be separated out by including them directly in an OLS regression. For example, education may have a positive effect on leasing by improving access to market information or a negative effect by improving non-farm outside options, two effects that are quite independent of the positive skill effect. Therefore, there is no *a priori* basis to identify any of the farmer characteristics as indicators of skill.

In this paper, we combine these two approaches by interpreting farming skill as the contribution of a farmer's observed characteristics to the farm's productive efficiency. Farming skills are defined as a weighted average of the tenant's observed characteristics (such as age, education, household demographics, types of non-farm activity and wealth). Since there is no *a priori* basis to assign values to the weights, they are computed by estimating the predicted contribution of farmer characteristics to farm efficiency. The simplest method is to include a vector of farmer characteristics directly in a production function. We use a conceptually similar method, but give a more appropriate structure to the estimates by using a stochastic production frontier method.

The stochastic production frontier, first proposed by Aigner et. al [1977] and Meeusen and van der Broeck [1977] is a production function with two error terms, a random disturbance term, ε_i, that is independent and identically distributed, and a one-sided non-negative error term, u_i, that is distributed independently of ε_i. [20] The former captures both the effects of unobserved stochastic factors (e.g.weather shocks) and errors due to mis-specification of the model, and the latter represents "technical inefficiency" of the farmer or, more precisely, the ratio of the observed to maximum feasible output, where maximum feasible output is determined by the stochastic production frontier [Lovell 1993]. This structural model is more appropriate for our purposes because it explicitly recognizes the non-linearity of

[20] See Greene [1993b] for an extensive survey of this literature

the production function and separates the technical efficiency (one-sided) component of the residual from other unobserved stochastic (two-sided) effects.

The production frontier, where Q is the output, and Z is a vector of observed inputs, such as land, labor, fertilizer, seeds, machinery and draft animals is defined as follows:

$$Q_i = f(Z_i; b)\exp(e_i - u_i)$$
$$where \quad u_i = |U_i| \quad and \quad U_i \sim N(0, s_u^2) \qquad [46]$$
$$and \quad e_i \sim N(0, s_e^2)$$

We assume that the two error terms are distributed normal and half-normal respectively. If u_i =0, production is at the stochastic frontier. Then, from [46], the technical efficiency (TE_i) of farmer i is,

$$TE_i = \frac{Q_i}{[f(Z_i; b)\exp(e)]} = \exp\ (-u_i) \qquad [47]$$

The concept of technical efficiency can be illustrated using a simple isoquant diagram with land and labor as the two inputs [figure 4]. The isoquant q defines the frontier, or the set of efficient choices of inputs for a given output level. Points such as A and B represent actual observed input choices for the output level q. Assuming that the observed land-labor ratio is efficient, i.e. there is no allocative inefficiency, technical efficiency of the farm is given by the distance between the observed point and the frontier along the ray that represents the actual input ratio. Point B represents a technically efficient farm because the distance to the frontier is zero.

This estimate of technical efficiency (TE) is independent of stochastic errors and measures the degree to which a farmer comes close to achieving the best possible outcome conditional on his or her input choices and the production technology.[21] Technical efficiency in farms may be determined by the

[21] Although it is straightforward to estimate the stochastic frontier model using maximum likelihood methods, the derivation of a technical efficiency measure (TE_i) for each farmer is difficult because the two components of the error term cannot be easily decomposed. We use the functional form proposed by Jondrow et. al [1982] and generally accepted in the literature for the conditional distribution of the one-sided error term to express the conditional mean of the one-sided error term:

characteristics of the farmer, the land, the climate and, in the case of share-tenancy, the landlord.[22] For example, landlords may compensate for the low skills of the less able tenants by providing some or all of the skilled inputs in a sharecropping arrangement. Therefore, two farms can have the same technical efficiency even though the tenants' skill levels are quite different. An accurate measure of farming skills must isolate the farmer's contribution to technical efficiency. The one-sided error term, u, can be expressed as follows:

$$u_i = -\log TE_i = a_1 F_i + (a_s d_s + a_f d_f) L_i + a_3 H_i + e_i \qquad [48]$$

where F is a vector of farmer characteristics, L is a vector of landlord's characteristics and H is a vector of geo-climatic variables that include soil quality, gradients, irrigation, rainfall, humidity and temperature. d_s and d_f are dummy variables for share and fixed-rent tenancy and e_i is a random i.i.d. error term which is uncorrelated with the included variables.

Farmer skills can be defined as the farmer's contribution to technical efficiency, or a_1F_i in equation [48]. In order to fully capture the many dimensions of skill, the vector F_i includes not only variables such as education and age, but other farmer characteristics that are likely to be correlated with unobserved aspects of skill such as motivation and ambition. Ownership of non-farm assets and types of non-farm activity are included as potential indicators of such attributes. Since the weights of each factor are econometrically derived, the best approach is to include as large a set of farmer characteristics as possible in the efficiency equation. A consistent estimate of skill can be obtained only if the parameter a_1 is consistently estimated. Unfortunately, since our data set does not match tenants with landlords, landlord's characteristics cannot be included in equation [48]. Because tenants and landlords are matched in a systematic non-random manner, the estimate of a_1 will thus be biased. We avoid this problem by estimating the frontier only for the self-cultivators to obtain the coefficient estimates and then using these

[22] Some studies have interpreted the technical efficiency term as a measure of skills. Kirkley et al. [1998], for example, argue that differences in technical efficiency account for differences in skills between fishing boat captains who use

estimates to compute predicted values for the entire sample. Therefore, definition of farming skills is modified to mean the contribution of farmer attributes to technical efficiency if the farmer were a self-cultivator.

We include district-level dummy variables to account for broad regional agro-climatic characteristics. Since only irrigation variables are available as farm level measures of land quality, farm-level variation in land quality that is not correlated with irrigation may be left out. It can be argued that some of this residual land quality reflects high skill levels of the farmer, such as the skillful management of soil quality, and legitimately belong in the predicted skill index. If the remaining unobserved land quality is correlated with observed farmer characteristics, the predicted skill estimates are biased. The implications of this problem are discussed in detail in under specification problems.

The last stage in constructing the skill index requires the estimation of equation [48] for the self-cultivators. Prediction efficiency equations are commonly estimated by regressing the technical efficiency estimates obtained from the stochastic frontier estimation on a set of explanatory variables [Pitt and Lee 1981, Kalirajan 1981, Kirkley et al 1998]. Several recent studies [Kumbhakar et. al 1991, Reifschneider and Stevenson 1991, Huang and Liu 1994, Battese and Coelli 1995] have pointed out that such a two-step method is fundamentally incorrect because the dependent variable in the second step is assumed one-sided, non-positive and identically distributed in the first step. A more appropriate method is to estimate the parameters of equation [48] jointly with those of the stochastic frontier using maximum likelihood methods using consistent distributional assumptions on the error structure. We use the version of this method proposed in Battese and Coelli [1995].

The frontier-based skill index has its share of problems that include 1) strong distributional assumptions on the error structure, 2) inconsistency of the technical efficiency estimator, and 3) endogeneity problems. The distributional assumptions are common to most maximum likelihood methods.

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similar boats and share the same waters. Although there is some merit to such an inference in a controlled setting

However, it is possible to use a variety of distributions, such as half-normal, truncated normal and exponential to model the one-sided error term [Greene 1993b].[23] In addition, the estimates from the frontier model can be compared to linear production function estimates to test whether our index is particularly sensitive to the distributional assumptions. The inconsistency of the efficiency estimator is more difficult to circumvent in cross-sectional models.[24] Fortunately, the estimator is unbiased and the inconsistency is caused by the fact that the variance is independent of the sample size. The endogeneity issues are dealt with in detail in the following two subsections.

Specification Issues I: Endogenous Inputs in the Production Frontier

The direct estimation of production functions has been criticized because inputs are typically jointly determined with the output [Mundlak 1961]. In the production frontier, the parameters as well as technical efficiency may be inconsistently estimated if technically efficiency is correlated with inputs [Kumbhakar 1987, Kalirajan 1990, Kumbhakar et. al 1991].

The literature has responded to this issue in two ways. Many studies have invoked the well-known arguments of Zellner et. al [1966] to assume that input choices are exogenous in an stochastic agricultural production environment.[25] However, as Kumbhakar [1987] points out, this assumption holds only if technical efficiency is unknown to the farmer. A solution to the endogeneity problem is the joint estimation of the frontier and its first order conditions in a profit maximizing framework [Kumbhakar 1987,

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like this fishery, several other factors can affect technical efficiency in a larger, more diverse data set.

[23] Semi-parametric methods that are independent of functional assumptions have not yet been developed.

[24] Battese and Coelli [1988] develops a consistent estimator for panel data.

[25] Two recent examples are Battese and Coelli [1995] and Kirkley et. al. [1998]. Greene [1993] surveys some of the earlier papers.

Kalirajan 1990, Kumbhakar et. al 1991] [26]. This specification has sound micro-economic foundations, and treats both inputs and outputs as endogenous variables. The profit maximization method is obtained by adding allocation equations for each endogenous input j to the stochastic frontier defined in equation [48]. For inputs such as fertilizer and pesticides that are obtained in competitive markets with exogenous prices, the allocation equations are just the first order conditions of profit maximization:

$$w_j = p.MP_j \exp(v_j) \qquad [49]$$

where j indexes inputs, w_j is the exogenous input price, p is the output price, and MP_j is the marginal product of input j. The random variable v_j is a two-sided error term that measures allocative inefficiency, or the degree to which the farmer fails to satisfy the first order condition. This error term can be interpreted as noise in the price signal that may be a result of imperfect information or measurement error, or as errors in optimization. It is also assumed that input and output prices are exogenously given, and that the technical efficiency is known to the farmer. The technical efficiency term enters the first order condition through the marginal product (MP_j) term.

This method can be used only if reliable price data are available and is limited to inputs that are traded in a competitive market (with exogenous prices). In this paper, we estimate the frontier with fertilizer as an endogenous input. The lack of suitable price data prevents us from estimating a complete set of first order conditions. First order condition of this type cannot be formulated for inputs such as land, animals and even labor, which are not traded in competitive markets at exogenously determined prices. As a result, we assume the exogeneity of these inputs.

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[26] Several other studies have used a cost minimization framework where input levels are treated as endogenously determined for given prices and technologies [Schmidt and Lovell 1979, Greene 1980, Kumbhakar 1997]. While the behavioral assumption of cost minimization has a clear economic interpretation, the assumption of an exogenous output level is clearly inappropriate except in the case of certain regulated environments. In addition, since price data show very little variation (compared to input levels) in most household-level surveys, cost functions are difficult to estimate. Finally, technical complications arise in the definition of allocative efficiency as a one-sided error in the cost function and a two-sided term in the share equations [Bauer 1990]

Fortunately, the potential endogeneity of land in the production function does not affect the power of our tests in the leasing model because the skill variable is unbiased by definition under the null hypothesis that farming skills do not affect land leasing decisions. It must be emphasized however that, if the null hypothesis is rejected, the coefficient of the skill variable in the leasing equation cannot be reliably interpreted as the magnitude of the effect of skill on leasing since the land input is in fact correlated with skills.

Specification Issues II: Endogeneity in the Leasing Equation

Another potential problem in our specification is the possible correlation of farming skills and the error term in the leasing equation. The stochastic two-sided error term removes some of these effects, such as weather shocks, from the technical efficiency estimates. More factors are removed in the second stage when the predicted values are obtained. But some unobserved factors that affect the leasing choice may remain in the skill index if they are correlated with observed farmer characteristics. If, for instance, the skill index includes some elements of unobserved land quality, the coefficient on technical efficiency in the leasing model will be biased. We include irrigation and district dummy variables to control for some of the land quality differences. Any remaining unobserved land quality effects may be picked up by the skill variables and reduce the power of our tests.

We resort to theoretical arguments to assert that potential endogeneity problems in the skill variable do not affect our conclusions on contract choice. The null hypothesis that skills do not affect the choice of contract will be incorrectly rejected if the effect of both skill and unobserved land quality have the same sign. Fortunately, the theoretical literature on the relation between land quality and contract choice comes to a different conclusion, that sharecropping is used as a mechanism to minimize "land mining" or "land quality abuse" by tenants [Murrell 1983, Datta et al 1986, Ray 1998, DeWeaver and Roumasset 1999]. In these land mining models, fixed-rent contracts are offered only under conditions where the scope for land mining is limited. Examples of such conditions include cases where landlord is able to directly monitor land abuse, where the land is resistant to mining, and most importantly, when the land quality is poor. Therefore, the relationship between land quality and the choice of fixed rent tenancy is in the opposite direction from that of the relationship between farmer skill and the choice of fixed rents.

4. The Data

The data used for the empirical analysis are taken from the Household Survey of the Agricultural Sector (HSAS) conducted by the Department of Census and Statistics of Sri Lanka in 1988-89[27]. This survey collected detailed production information from 15,981 agricultural households in seven of Sri Lanka's nine provinces.[28] In this paper, the subset of 8428 households that engage in rice cultivation as self-cultivators, landlords or tenants are included. Since the survey was conducted in most parts of the island, considerable spatial variation is found in terms of agro-climatic conditions and agrarian institutions. About 45% of the households are located in the "dry zone" which contains the semi arid lowlands of north western, north central, eastern and south eastern parts of the island. The dry zone is relatively sparsely populated and less urbanized than the rest of the country, and contains a large part of Sri Lanka's non-plantation agricultural activity. About 34% of the households are in the central hills that range from elevations of 1000 to 8000 ft above sea level. The central hills are more densely populated than the dry zone, and are home to the large-scale tea plantations. The wet zone lowlands of western and southern Sri Lanka contain 21% of the sample households. The wet zone does not have much large-scale agricultural activity with the exception of coconut in the coastal areas and rubber plantations in the interior. Rice cultivation in this region is confined largely to small scale, owner operated, subsistence farms.

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[27] For detailed information on survey methodology of the HSAS, see Dept. Of Census and Statistics, Sri Lanka [1993]

[28] The Northern and Eastern Provinces were not covered due to the civil war in that part of the country. In addition, only about 50% of the selected households were surveyed in the Matara district in the Southern Province due to civil disturbances. Overall, the response rate in the seven surveyed provinces was 88.6%.

The summary statistics of the variables used are reported in Table 1 for the entire sample as well as by type of farmer, i.e. self-cultivators, fixed-rent tenants, sharecroppers etc. Both the land extent and the land-to-family labor ratio converge with land leasing [figures 5 and 6]. Interestingly, the average farm size of fixed-rent tenants is considerably larger than that of sharecroppers and self-cultivators. Fixed-rent tenants are also strikingly similar to landlords in terms of the education of the household head, non-agricultural earnings, and the market-orientation of production. The distinguishing characteristic between landlords, on the one hand, and tenants, on the other, lies in the demographic characteristics. A significantly larger proportion of tenant households is headed by a male, and has a somewhat larger proportion of adult males than landlord households. Both types of tenant households have similar demographics, and landlords stand out primarily due to their larger proportion of elders.

The preliminary look at the data reveals the following testable propositions: 1) land leasing is used to equate land-to-family labor ratios across households; 2) the adjustment through the land leasing market is imperfect and different for landlords and tenants; 3) land scarce households that are otherwise endowed with resources similar to the landlords lease-in large amounts of land as fixed-rent tenants; 4) land-scarce households that do not have the resource characteristics of the landlords lease-in smaller extents of land as sharecroppers, and finally; 5) low levels of managerial and entrepreneurial skills distinguishes sharecroppers from landlords and fixed-rent tenants.

5. Results

Estimation of the Skill Index

Table 2 reports the results of stochastic production frontier and technical efficiency equations that are used to construct the skill index. As explained earlier, these estimates are carried out only for the self-cultivators in order to obtain consistent predicted skill values. The first column reports the joint maximum likelihood estimates of the frontier and the efficiency equations.[29] The production function shows slight increasing returns to scale with the Cobb Douglas coefficients adding to 1.06. As expected, land and labor have the largest elasticities in the production function. The coefficient for bullocks is negative and insignificant, probably because the functional forms does not take into account the fact that bullocks are an inferior substitute for tractors. The maximum likelihood estimates of the predicted efficiency equation show that the productive efficiency of farmers is significantly influenced by several characteristics of the households. For example, households that own more paddy land and assets (bullocks, cattle, tractors, vehicles and farm implements) are more efficient. Households whose primary occupation is agriculture, have younger and male heads and have a large proportion of educated members also have greater productive efficiency. While engaging in non-agricultural activity as a primary activity has a negative efficiency effect, the type of non-agricultural activity has a positive efficiency effect if household members work for the government or are self-employed. Government employment probably reflects a selection effect or gains from better access to information, credit, markets and extension services. Self-employment may indicate entrepreneurship. Two effects that are somewhat difficult to interpret are the negative effects of the education of the head (over most sample values) and the proportion of male adults in the households.[30] The education effect may reflect a lesser commitment to agricultural activity due to greater outside options.

The second column presents the results of the three equation system where fertilizer is treated as an endogenous input. These estimates are also qualitatively similar to those when all inputs are treated as exogenous. The skill indices are also very similar with a partial correlation coefficient of 0.94. The third

[29] 17 district dummy variables are included in both the production frontier and the efficiency equation. These dummy variables are jointly significant at the 5% level.

[30] Since the quadratic term for education is positive, the overall education effect becomes positive for households with a head who has more than 10.87 years of schooling (using the one step ML estimates). It must be noted, however, that most households face a negative education effect because 92.2% of sample education values are less than 10.87 years and the sample mean is only 5.4 years.

column reports the results when each equation is separately estimated. It is clear from the standard errors that the maximum likelihood estimates of the predicted efficiency equation are more efficient. The fourth column reports linear production function where farmer characteristics are directly included as arguments in a OLS regression. Here again, the standard errors are considerably larger suggesting that the non-linear specification provides a better fit of the data. The linear and non-linear skill indices have a positive partial correlation coefficient of 0.74.

The linear index will be used as a test of the normality assumptions of the frontier-based index. In addition, we also use a fourth skill index where asset ownership variables are excluded as determinants of skill levels. This allows us to address the potential criticism that our measure may in fact measure risk-aversion because asset ownership is really a proxy for income and therefore the degree of risk-aversion. Figure 7 represents the estimated frontier based skill indices (with and without asset ownership) for all types of farmers. The low skill level of share tenants stands out in both indices, especially compared to fixed-rent tenants who appear to be more skilled than even owner farmers and landlords. The extraordinarily high skill level of fixed-rent tenants decreases when asset ownership is excluded, but the large gap between fixed and share tenants remains.

Probit and Tobit Models

The determinants of share and fixed-rent tenancy can be estimated with separate probit or tobit equations for each type of tenancy. The age of the household head, the type of non-agricultural activity conditional on the degree of non-agricultural activity, the proportion of family members with a primary education and ownership of non-farm input assets (cattle and vehicles) are excluded as identifying variables of the skill index because they do not have a direct effect on land leasing. The results of these estimates are given in Table 3. The probit estimates, given in the first two columns, show that farming skills have a positive effect on choosing fixed-rent contracts but not on sharecropping. In addition, households that own less paddy land, own more bullocks and have a male head of household are more likely to be sharecroppers. The probability of fixed rent tenancy is also positively related to the ownership of machines and the presence of male adults. The tobit estimates in the third and fourth columns show similar results.

The different effects of bullock and machine ownership confirm that each contract is used to adjust different inputs.[31] Apart from these differences, the results for share-rents and fixed-rents are qualitatively similar. As expected, the ownership of land has a significantly negative effect on both types of leasing. This confirms that households lease-in land in order to achieve the optimal operational scale consistent with its characteristics. The ownership of highland lands, which are used mainly for the cultivation of non-seasonal crops, vegetables and dry grains, also has a negative but considerably smaller effect on leasing. This can be explained by the fact that highland cultivation is an imperfect substitute for rice cultivation in utilizing some unmarketable resources of the household, especially labor and management, but not others that are specific to the wetlands (e.g. bullocks). In addition, due to the greater intensity of input use in rice farming, the elasticity of substitution of inputs between highlands and paddy lands is likely to be less than unity. The labor endowment of the household, measured by its size, has a positive effect on both types of leasing indicating the household labor is an unmarketable resource. However, the gender composition of the labor endowment has different effects on each type of contract. Among other household characteristics, education of the head, the proportion of students and engagement

[31] A potential criticism is that family size and the ownership of assets may be endogenous, i.e. those who lease-in land purchase more inputs. In the absence of convincing instruments, we rely on the empirical observation that many of these inputs, especially family labor and farm animals, are largely exogenous in the leasing model. Although the choice of family size is theoretically endogenous in the household's decision making process [Evenson and Roumasset 1986, DeSilva 1998], the large gestation period and other considerations associated with fertility (both economic and social) would make the adjustment of family size by and large exogenous to the land leasing process. Similarly, it has been documented that bullocks are usually transferred within families and seldom sold. The endogeneity of farm machinery is a more likely problem. Here, we rely on the argument that the purchase of large assets (e.g. tractors, vehicles) is unlikely to depend on leasing choices because the extent of land leasing-in is quite small (on average 0.35 acres, or about 30% of the average ownership holding). Therefore, we include only relatively large and lumpy assets as exogenous regressors, leaving out small farm implements such as mammoties, sickles and water pumps which are much more likely to be endogenous.

in fisheries and livestock activity have similar and significant effects on both types of leasing. The proportion of students has a negative effect because it leads to less disposable family labor if the schooling choice is assumed exogenous to the leasing decisions. Interestingly, the engagement of the household in fisheries and livestock activities has a positive impact on land leasing. This may be because such households are more enterprising, or because the presence of interests outside of cultivation in the village makes it profitable for these households to remain as farmers and not seek outside employment. The positive education effect may reflect lower transactions costs (lower information and negotiation costs) they face in the leasing market.

Multinomial Logit Sample Selection Model

The multinomial logit selection model is reported in Table 4. The first stage is a contract choice equation with the three choices, 0) self-cultivation, 1) share-rent and 2) fixed-rent. The second stage has leasing equations for share and fixed-rent tenants corrected for sample selection. The last sub-column for each type of tenancy report the marginal contribution of each variable to the odds ratio between that type and owner-farming. These odds ratios help us interpret the logit coefficients in a meaningful way. For example, an increase in paddy land ownership makes the farmer 0.109 times as likely to be a share-tenant and not a self-cultivator. Similarly, a unit increase in skills increases the likelihood of share-tenancy by 4.2%, but this effect is not significant. But an increase in skills has a positive and significant effect of 25% on the probability of fixed-rent tenancy.

Since it is more useful to directly compare the relative probabilities of share and fixed-rent tenancies, the last column computes the marginal effects on the probability of fixed-rents relative to share contracts. These estimates show that an increase in skills makes it 19.9% more likely that a tenant chooses a fixed-rent contract. Other variables that make the likelihood of fixed-rent tenancy greater are paddy land ownership (408%), proportion of male adults (84%), and ownership of tractors (52%).

Variables that increase the likelihood of share tenancy (relative to fixed-rent) are highland ownership (18%), proportion of female adults (201%), bullock ownership (10%) and the proportion of students (45%).

The second stage (leasing) equations show that farming skills do not affect the extent of land leased conditional on contract choice. The results also show that tenants who own more land are able to lease-in more. This contradicts the land adjustment hypothesis within the group of tenants. In addition, primarily agricultural households lease-in larger parcels while those with a more educated head of households and those who engage in livestock or fishery activity lease-in smaller parcels. These effects are consistent with opportunity cost arguments. Finally, tractor ownership has a positive effect on the extent of leasing at least for share tenants. Table 5 re-estimates the multinomial logit model with two alternative skill indices: 1) using the linear production function, and 2) using the frontier without asset ownership variables. These estimates can be used as a simple test of whether the strong distributional assumptions of the frontier method and potential correlation with risk aversion affect our conclusions. In both these alternative models, the coefficient of the skill index is still strongly positive for fixed-rent contracts and insignificant for share-rents. In fact, with a linear index, the t-statistics are even larger than when the frontier-based index is used. Other coefficient estimates are also not qualitatively affected. This simple test gives us confidence that our conclusion does not depend crucially on the structural assumptions of the frontier model.

Bivariate Probit Models

Table 6 reports the results of the bivariate probit model with truncated sample. The probit for leasing-in shows a large skill effect and strong evidence in support of land and input adjustment.[32] The

[32] If all leasing in is classified as share or fixed rent contracts , the first stage equation should have the same estimates and standard errors regardless of whether the second stage is for share-rent or fixed-rent. However, our sample

second probit equation, for contract choice conditional on leasing-in, reveals difference between the two types of contracts similar to those found in the multinomial logit model. In addition, our hypothesis that tenants with greater skill enter fixed-rent contracts is supported although with less than 95% confidence. Among tenants, those who own relatively more paddy land obtain fixed-rent contracts, while those who own a relatively large number of bullocks and have a male head of household get share contracts. The land extent equations show that households that have more family labor and own more tractors, and those that are primary agricultural lease-in more land as sharecroppers. On the contrary, there appears to be very little adjustment of inputs among fixed-rent tenants. In fact, the fixed-rent tenants that own more paddy land lease-in larger extents. However, all models of contract choice agree that higher skill levels increase the probability of entering a fixed-rent contract relative to share-tenancy as well as self-cultivation. Table 7 reports the bivariate probit variant with a censored sample.[33] Here again, the strong skill effect in the probability of obtaining a fixed-rent contract is observed.

A Comparison of Contract Types

The theoretical model argued that sharecropping is a second-best efficient solution to a double incentive problem that arises when the tenants are relatively unskilled. In the empirical analysis so far, we established that only the relatively skilled tenants obtain fixed rent contracts. In this section, we use the stochastic frontier estimates [Table 2] to directly establish the efficiency effects of different contract types.

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included some observations where both share and fixed rent is 0 although hire is equal to 1. This causes the slight difference in first stage estimates and standard errors when both equations are jointly estimated.

[33] Only the contract choice equations are reported for the sake of brevity.

The significantly lower yields in sharecropped lands have troubled economists for a long time.[34] Our data also show a large yield deficit in sharecropping relative to both owner-farming and fixed-rent farming [Table 8]. The mean yield in sharecropped land is only 85% of the mean yield in fixed-rent land and 86.8% of the mean yield in owner-farmed land.

Frontier estimates show that a considerable part (58%) of the yield differences between share and fixed-rent farming is explained by technical efficiency differences which includes skill and shirking costs. The higher yields in fixed-rent farms appear to come from the higher skill levels and the higher technical efficiency. Increasing the technical efficiency of sharecropped lands to 0.5789 increases the yield only to 1943.14 kg/acre. The remaining difference between share and fixed-rent yields come from the large differences in input intensities. Although sharecropped farms use labor 39.2% more intensively, they use considerably less chemicals (71.9%) and machines (35.8%) than in fixed-rent farms. These are both modern technological improvements that are likely to have large yield effects. It is quite understandable that share-tenants may not have the financial resources to invest in these modern technologies, and that neither the tenants nor the landlords face the right incentives to provide optimal amounts. This suggests a dynamic story where the incentive problems associated with sharecropping leads to a systematic under-investment in yield-increasing modern technologies such as pesticides and tractors.

Interestingly, the technical efficiency in sharecropping is slightly higher than in owner-farmed land. This may be because skilled landlords provide management inputs in sharecropped lands, whereas owner-farmers are likely to have lower skill levels. Although our results support the general consensus that sharecropping is inefficient, we find that this inefficiency comes from sub-optimal input use rather than lower technical efficiency. This supports the idea proposed in the theoretical model that landlords and tenants form a partnership to compensate for the lower technical efficiency of unskilled tenants.

[34] See Hayami and Otsuka [1993] for an excellent survey of the voluminous empirical research on this topic. Shaban's [1987] study of India is probably the best known work in this literature.

Another important implication of the theoretical work was that sharecropping is the best option for unskilled tenants, i.e. they would perform much worse under a fixed-rent arrangement. We see in Table 1 that share tenants have the lowest skill levels among the three groups. Specifically, they are 7.9% less skilled than the fixed-rent farmers. We can use this information to compute the technical efficiency that share-tenants can obtain if they became fixed-rent farmers using the following equation:

$$TE_{new} = TE_{old} e^{bSf} \qquad [50]$$

where b is the percentage difference in skill levels and Sf is the skill level of fixed-rent tenants. With TE_{old} =0.5789, b= -0.079 and Sf=5.168, we find that the technical efficiency at the new skill level is 0.3848. With this level of technical efficiency, the yield of the now fixed-rented land would be 1446.31 kg/acre. This confirms our central point that, sharecropping provides the best possible arrangement when the tenants are relatively unskilled. Although sharecroppers get 15% lower yields than fixed-renters, these sharecroppers would get 33.5% lower yields if they engaged in fixed-rent farming. This is because the technical efficiency will drop to 0.3848 if the same tenants obtained fixed-rent contracts. The partnership with a skilled landlords appears to improve the performance of unskilled share tenants, although not up to the level of fixed-rent farmers due to sub-optimal input use and some deficiencies in technical efficiency which may both be a result of Marshallian type incentive problems.

6. Conclusions

This paper shows that share-rent and fixed-rent contracts play quite different roles in the farmers' allocation problem. The principal-agent model presented shows that tenancy contracts are designed to match the provision of skilled and unskilled labor tasks with the owners of time and skill inputs. Share contracts appear to provide an incentive scheme to pool the unskilled labor of tenants with the land, machinery and management skill of the landlords. In spite of the Marshallian inefficiency, sharecropping is chosen when the skill levels of tenants are low enough making fixed-rent farming even less profitable.

Fixed-rent farming will be preferred when tenants have high enough management skills so that the skill deficit in fixed-rent farming is small relative to the Marshallian inefficiency of sharecropping. This tells us that landlords will not offer share contracts if there is an elastic supply of highly skilled tenants. In a more realistic description of the rural agrarian economy where skills are scarce among tenants, the possibilities for sharecropping arise. This is not inconsistent with Shaban's [1987] finding that observed yields are lower in sharecropped land. Our conclusion is that, while this may be true, the yields in sharecropped land would be even lower if they were fixed-rented.

The empirical results confirm the main hypothesis that farming skill has a significant positive effect on the decision to enter fixed-rent contracts. The choice to sharecrop, on the other hand, is determined largely by the endowments of family labor and bullocks. The main results are summarized in Table 9. We also find that tenants' skills do not affect the extent of land leased within each group of tenant. It is interesting to contrast this result with the conclusion of previous studies [Skoufias 1991, Lanjouw 1999] that there is a positive correlation between skill and farm size. Our results indicate that this correlation occurs through the selection of tenants in to fixed-rent farmers (with large farms) and sharecroppers (with small farms). Therefore, the adjustment of the skill to land ratios is carried out largely through the choice of contract.

We also find evidence to support the argument we made in the theoretical work that sharecropping is a second-best efficient solution when tenants are unskilled because they can form a partnership with a skilled landlord. Our production frontier estimates show that technical efficiency improves from 38.48% to 52.85%, and yields increase from 1446.31 kg/acre to 1849.91 kg/acre when the relatively unskilled tenants switch from fixed-rent farming to sharecropping. These values are still considerably lower than what is observed in other types of farming, but is are a large improvement over what would have happened if sharecropping was not available to the unskilled tenants.

The methodology proposed in this paper can be improved in several ways. Although the results satisfy several robustness tests on distributional assumptions, using techniques that rely less on normality for identification would be more appropriate. In addition, using a complete system of production functions equations (including first order conditions for all endogenous inputs) and jointly estimating the stochastic production frontier and the leasing model to allow for correlation between the errors are likely improve the consistency and efficiency of our results. Finally, a data set that matches landlords with tenants and contains detailed farm level land quality measures can help us better isolate farmer skills from technical efficiency. Since all these improvements require significant advances in computational methodology or considerably more detailed data sets, they are left as useful topics for future research.

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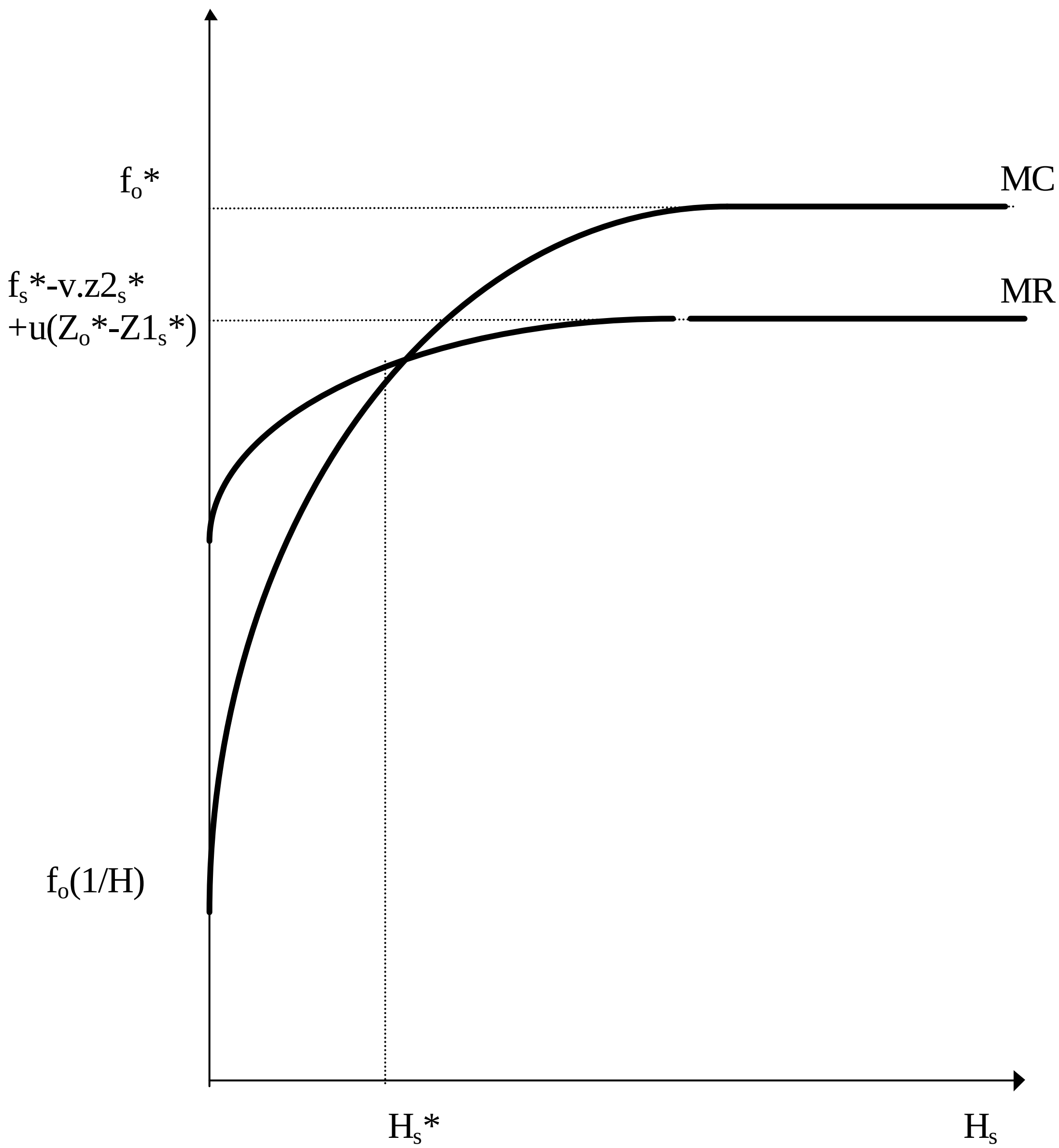

Figure 1: The Allocation between Owner-Farming and Sharecropping

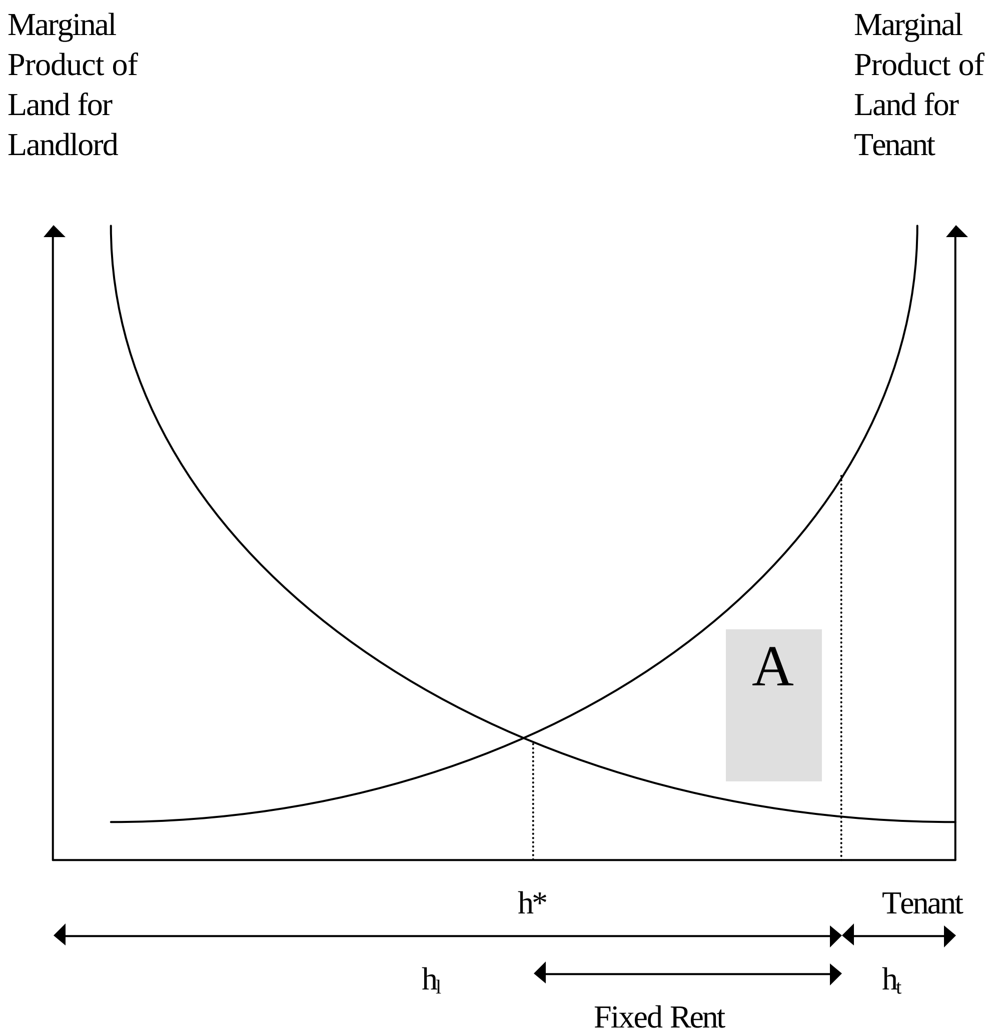

Figure 2: Contract Choice Model with an Equally Skilled Landlord and Tenant

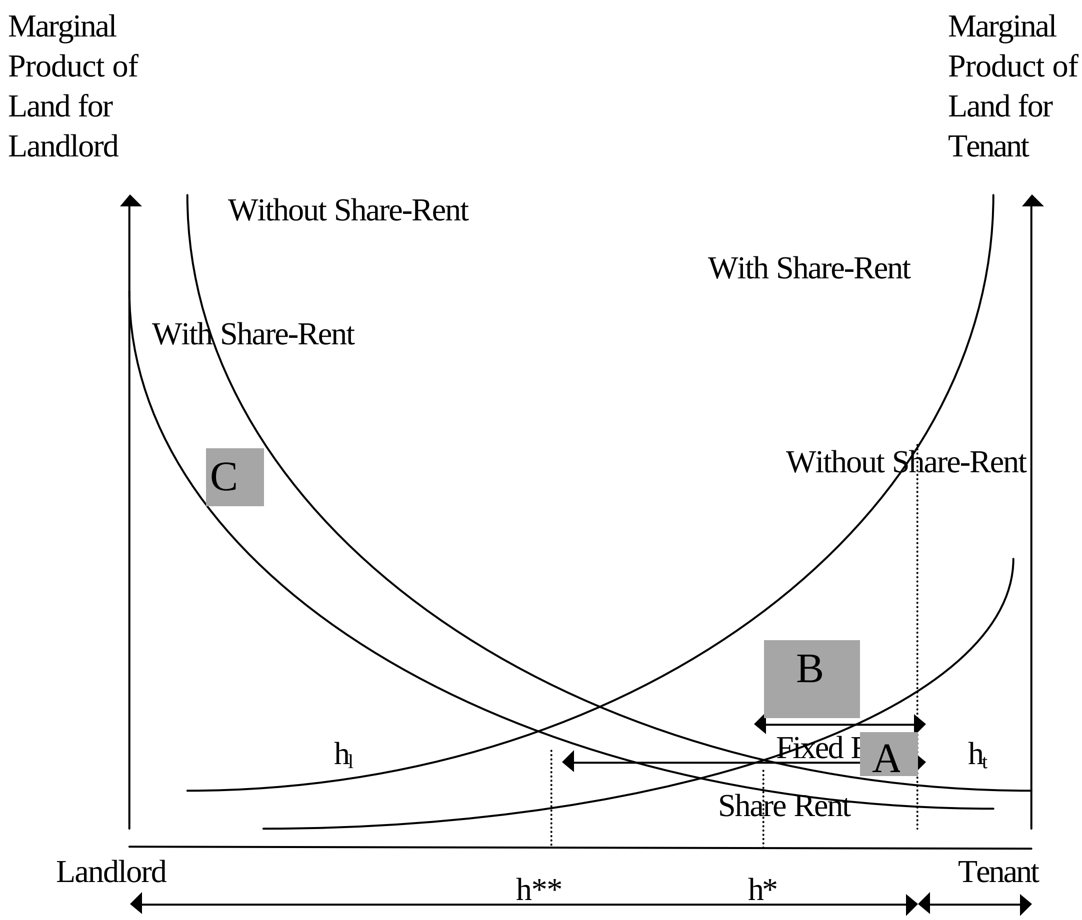

Figure 3: Contract Choice Model with Skilled Landlord and Unskilled Tenant

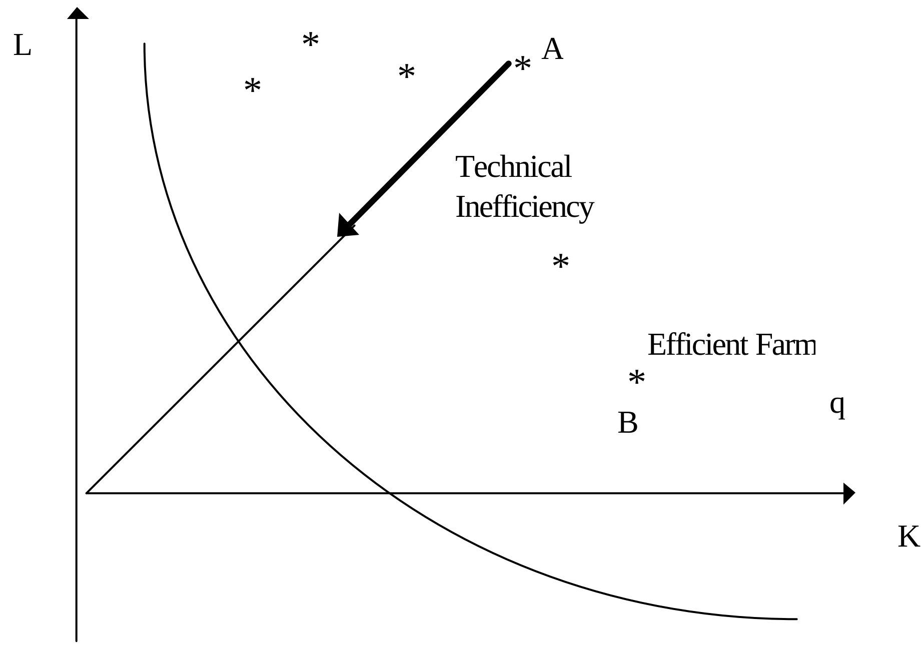

Figure 4: The Stochastic Frontier and the Definition of Technical Efficiency

Table 1: Descriptive Statistics

Variable	Total		Tenants Total		Tenants Share		Tenants Fixed-Lease		Self-Cultivators		Landlords	
Number of Observations	8428		2817		1883		547		4839		887	
	Mean	*St. Dev*	*Mean*	*St. Dev*	*Mean*	*St.Dev*	*Mean*	*St.Dev*	*Mean*	*St.Dev*	*Mean*	*St. Dev*
Paddy Owned	1.042	1.41	0.315	0.76	0.196	0.55	0.610	1.12	1.294	1.42	2.035	1.78
Paddy Leased In	0.358	1.01	1.073	1.52	0.957	1.45	1.4741	1.62	0	0.00	0.095	0.74
Paddy Leased Out	0.153	0.62	0.029	0.26	0.012	0.12	0.061	0.34	0	0.00	1.447	1.36
Area Cultivated	1.245	1.34	1.251	1.37	1.078	1.01	2.029	2.05	1.322	1.35	0.821	1.14
Highland Owned	1.487	2.72	0.959	1.53	0.974	1.67	0.974	1.39	1.606	2.57	2.5701	5.08
Household Size	5.298	1.99	5.384	1.90	5.402	1.91	5.409	1.89	5.327	2.01	4.8785	2.08
% of Male Adults	0.301	0.18	0.308	0.17	0.302	0.17	0.321	0.17	0.305	0.18	0.2591	0.19
% of Female Adults	0.278	0.16	0.275	0.15	0.279	0.15	0.262	0.13	0.280	0.16	0.2785	0.19
Ethnic Group Dummy	0.984	0.13	0.990	0.10	0.992	0.09	0.995	0.07	0.981	0.14	0.9818	0.13
Age of Head	50.321	14.26	48.466	13.77	49.378	13.68	45.193	12.70	50.553	14.13	54.9269	15.22
Education of Head	5.498	3.43	5.267	3.16	5.177	3.12	5.688	3.23	5.537	3.50	5.9993	3.77
Male Head Dummy	0.869	0.34	0.912	0.28	0.919	0.27	0.910	0.28	0.866	0.34	0.7579	0.43
% with Primary Education	0.818	0.20	0.809	0.20	0.813	0.20	0.796	0.20	0.822	0.20	0.8268	0.21
Bullocks Owned	0.354	1.57	0.402	1.33	0.383	1.34	0.397	1.25	0.343	1.75	0.2764	1.16
Tractors Owned	0.034	0.22	0.026	0.24	0.010	0.10	0.076	0.48	0.040	0.21	0.0243	0.16
Cattle Owned	0.137	0.73	0.140	0.69	0.097	0.64	0.251	0.81	0.145	0.79	0.103	0.54
Vehicles Owned	0.212	0.96	0.180	0.45	0.127	0.38	0.355	0.62	0.232	1.19	0.2016	0.55
% students	0.164	0.19	0.157	0.18	0.157	0.17	0.156	0.18	0.167	0.19	0.1651	0.19
Agricultural Household	0.794	0.40	0.773	0.41	0.766	0.42	0.777	0.41	0.815	0.39	0.7389	0.43
Livestock and Fisheries	0.312	0.46	0.341	0.47	0.309	0.46	0.422	0.49	0.301	0.46	0.2966	0.46
Employer	0.057	0.23	0.044	0.20	0.042	0.20	0.051	0.22	0.058	0.23	0.095	0.29
Govt. Employee	0.154	0.36	0.123	0.32	0.122	0.32	0.124	0.32	0.160	0.36	0.2263	0.41
Self Employed	0.099	0.30	0.105	0.30	0.106	0.30	0.102	0.30	0.095	0.29	0.1037	0.30

Figure 5: Land Adjustment Through Tenancy

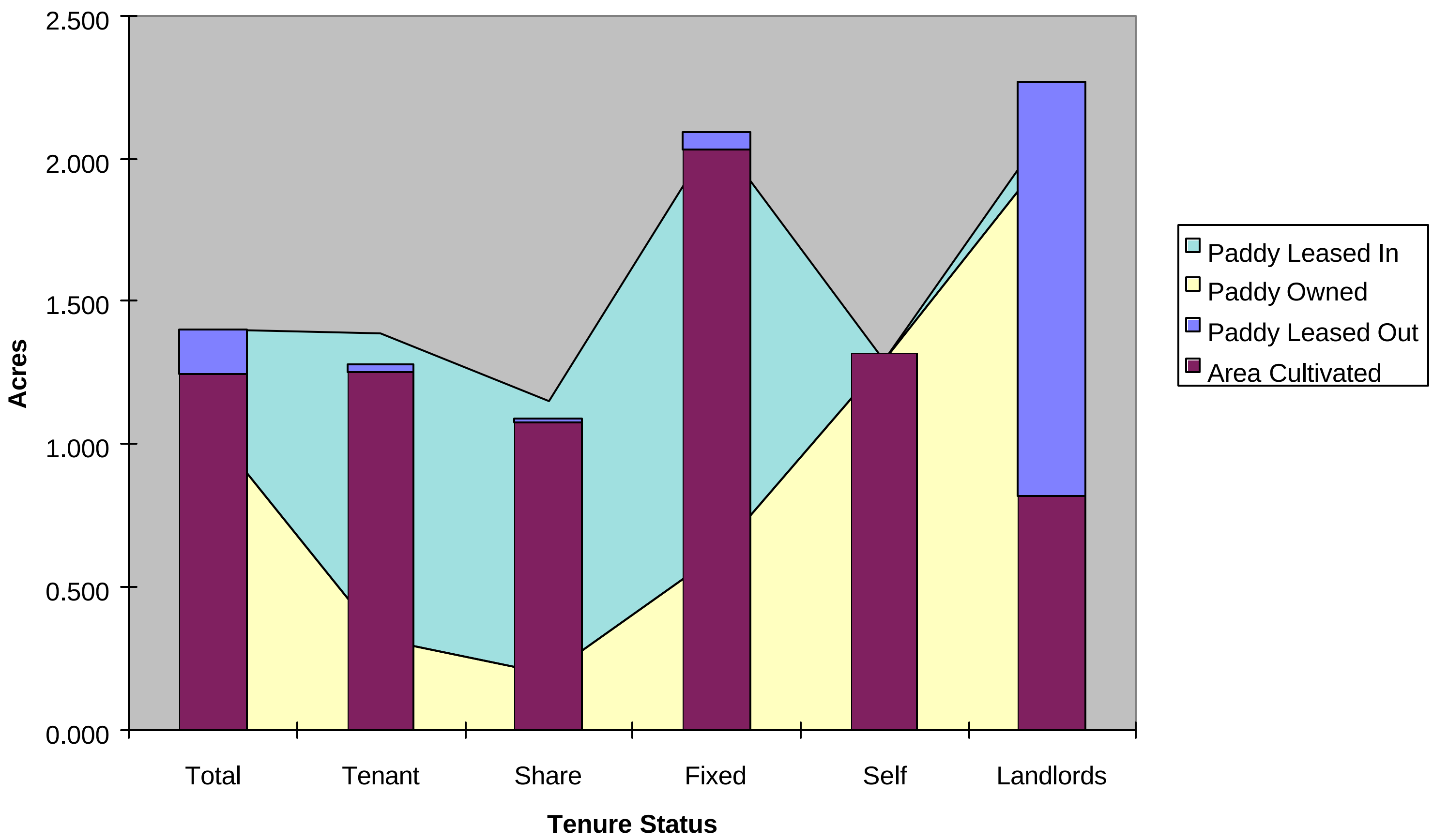

Figure 6: Convergence of Land-Labor Ratios

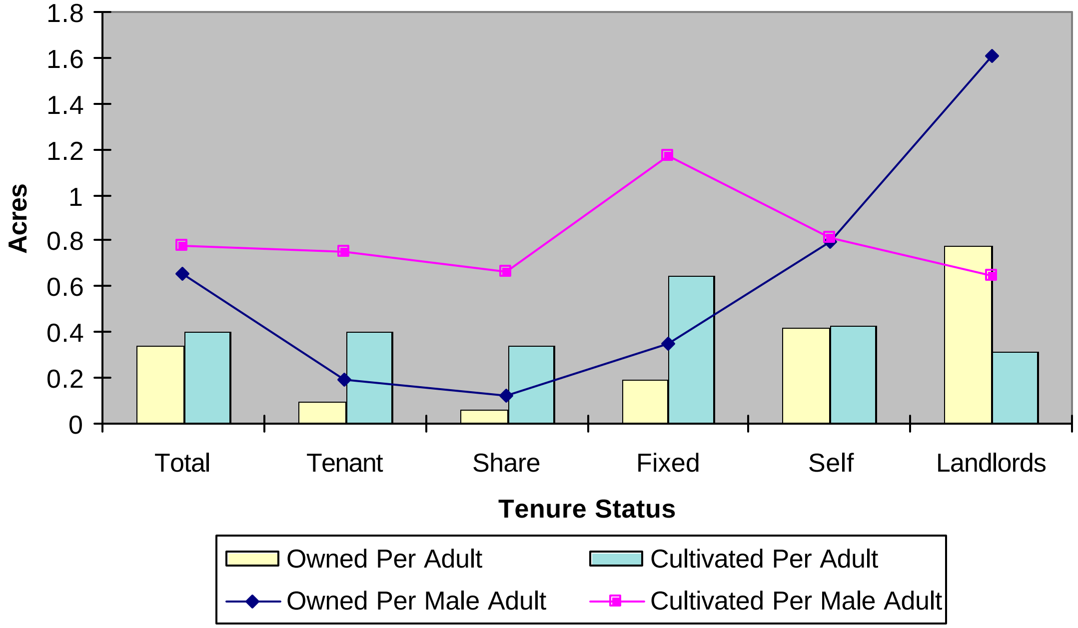

Table 2: Stochastic Production Frontier and Technical Efficiency Estimates

	One Step MLE		Fertilizer Endog.		Two Step		Linear Prod. Fun	
	coeff.	t-stat	coeff.	t-stat	coeff.	t-stat	coeff.	t-stat
Production Frontier								
constant	4.5707	45.32	4.3215	87.55	4.6099	79.46	3.6076	19.59
land	0.4941	25.37	0.5022	38.45	0.4592	37.15	0.4281	16.59
labor	0.2094	15.17	0.1780	18.17	0.2417	28.01	0.3175	20.64
fertilizer	0.0780	8.64	0.0782	52.59	0.0759	13.29	0.0861	7.59
seeds	0.1448	9.38	0.2067	24.03	0.1606	19.38	0.1888	10.16
machines	0.0624	14.54	0.1838	7.98	0.1166	4.47	0.1788	5.88
chemicals	0.0792	2.86	0.0561	16.42	0.0599	18.35	0.0662	13.02
bullocks	-0.0104	-0.96	0.0399	4.29	-0.0002	-0.02	0.0848	6.77
irrigation	0.2132	5.90	0.3702	13.72	0.1912	6.82	0.0596	1.48
Efficiency Equation								
constant	4.1910	3.72	6.4290	3.88	0.5100	16.76		
land owned - paddy	0.1290	5.22	0.2433	8.12	0.0033	2.08	0.0148	1.31
land owned - highland	0.1037	4.86	0.0076	0.13	0.0014	1.70	0.0066	1.53
household size	-0.0540	-2.50	-0.0346	-0.57	-0.0012	-1.14	-0.0065	-1.04
male adults (%)	-1.5427	-3.44	-0.7295	-0.97	0.0078	0.66	0.0503	0.72
female adults (%)	-0.6098	-1.28	-0.0605	-0.07	0.0138	1.08	-0.0106	-0.14
ethnic group	1.1951	1.91	0.4982	0.55	-0.0037	-0.24	-0.0278	-0.33
age of head	-0.0637	-2.02	0.4624	0.40	-0.0011	-1.19	-0.0061	-1.13
age squared	0.0001	0.51	-0.0489	-1.22	0.0000	0.44	0.0000	0.12
education of head	-0.3590	-6.59	-0.4128	-3.05	-0.0041	-2.16	-0.0336	-3.00
education squared	0.0330	7.23	0.0347	3.06	0.0005	3.28	0.0029	3.34
sex of head	0.5177	3.74	0.8964	2.24	0.0123	2.01	0.0244	0.69
% with primary educ.	3.0879	7.62	2.0168	2.73	0.0253	2.06	0.0395	0.55
bullocks owned	0.0731	11.44	0.1100	0.84	0.0039	3.27	0.0026	0.38
tractors owned	1.0970	2.80	0.6722	0.73	-0.0066	-0.77	-0.0015	-0.03
cattle owned	0.3361	4.92	0.2537	1.42	0.0011	0.40	-0.0173	-1.12
vehicles owned	0.1207	20.14	0.0604	2.27	0.0019	0.99	0.0056	0.58
% of students	-0.9295	-2.33	-0.7754	-1.19	0.0005	0.04	0.0608	0.87
agricultural household	0.8127	5.11	0.8613	2.16	0.0209	3.80	0.1145	3.29
fisheries and livestock	0.0598	0.59	0.0555	0.23	-0.0139	-3.21	-0.0370	-1.43
employer	0.1067	0.66	-0.0002	-0.49	0.0129	1.50	0.0403	0.83
govt. employee	0.2366	1.99	-0.2799	-0.63	0.0103	1.73	0.0469	1.33
self employed	1.1198	6.87	0.1930	0.60	0.0137	2.08	0.0912	2.22
sigma-squared	3.7620	10.14			1.9850	41.788		
sigma-v			0.4118	51.80				
sigma-t			2.2208	3.66				
sigma-g			1.0167	92.93				
gamma	0.9386	139.25			1.0457	151.46		
log likelihood	-4836.4		-14285.8		(1) -8522.55			
r-squared					(2) 0.02096		0.6143	
no. of observations	4811		4811		4811		4811	

NOTE: Estimates are not reported for the 17 district dummy variables in both equations.

Figure 7: Estimated Skill Levels: by Type of Farmer

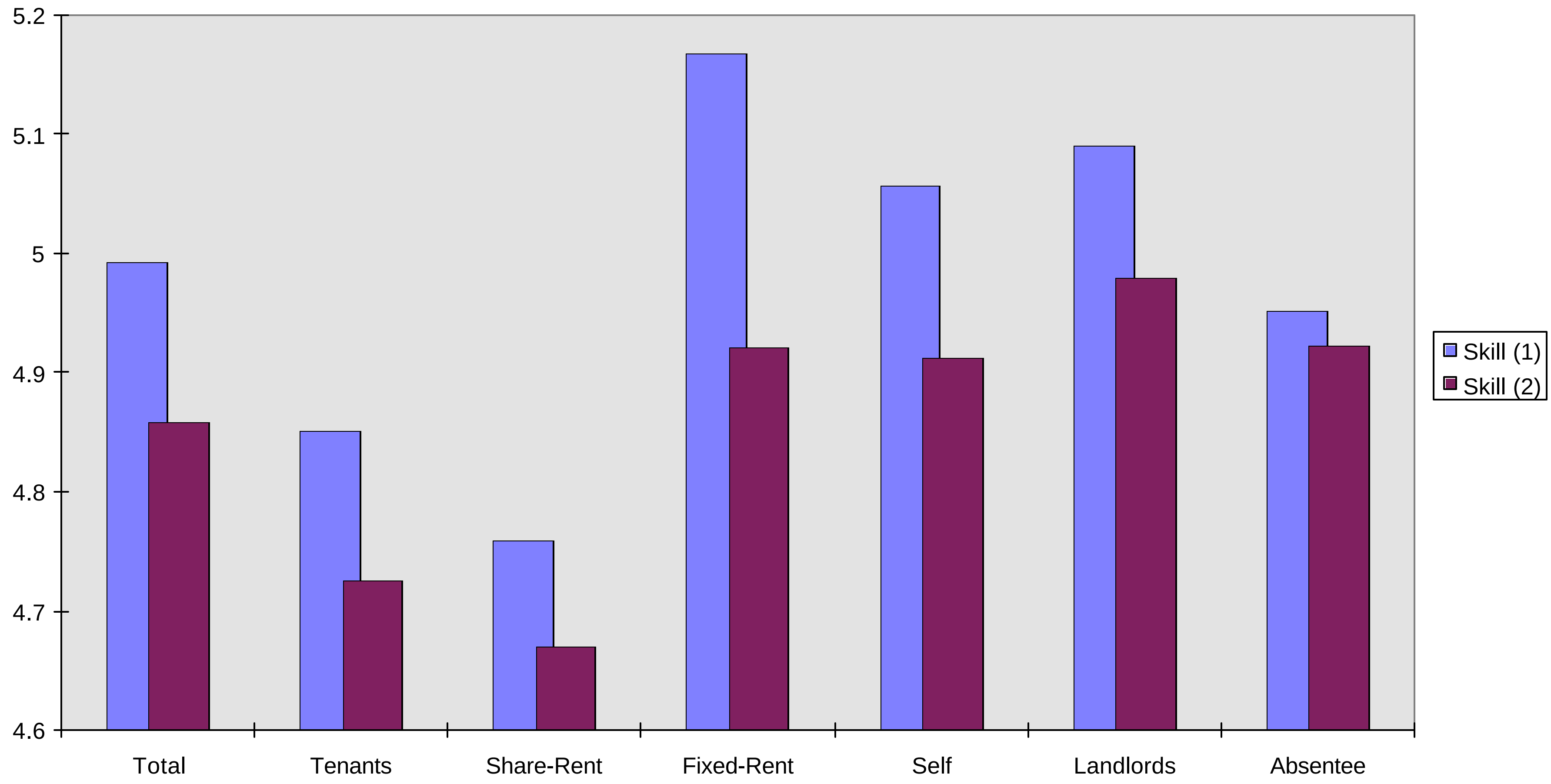

Table 3: Contract Choice: Probit and Tobit Estimates

	Probit				Tobit			
	Share		Fixed		Share		Fixed	
Constant	-0.8220	-4.11	-2.5599	-7.60	-1.4755	-5.61	-8.0859	-7.80
land owned - paddy	-0.8875	-28.10	-0.2763	-10.95	-1.0685	-25.14	-0.7048	-9.46
land owned - highland	-0.0113	-1.17	-0.0737	-4.07	-0.0022	-0.19	-0.2380	-4.36
household size	0.0244	2.50	0.0471	3.64	0.0396	3.14	0.1647	4.28
male adults (%)	0.1467	1.41	0.2189	1.65	0.1978	1.47	0.6682	1.71
female adults (%)	0.1362	1.19	-0.2749	-1.73	0.2803	1.90	-0.8536	-1.81
tractors owned	0.0581	0.63	0.5494	5.14	0.1718	1.44	1.2236	5.54
bullocks owned	0.0420	4.18	-0.0101	-0.64	0.0530	4.00	-0.0219	-0.49
% of students	-0.2297	-2.20	-0.4308	-3.17	-0.2958	-2.19	-1.4061	-3.49
education of head	0.0445	2.45	0.0813	3.39	0.0453	1.94	0.2349	3.31
education squared	-0.0054	-3.38	-0.0071	-3.39	-0.0052	-2.47	-0.0189	-3.07
sex of head	0.3072	5.04	0.0362	0.46	0.4136	5.18	0.1467	0.63
agricultural household	-0.0552	-1.18	-0.1235	-1.98	0.0218	0.36	-0.2887	-1.56
fisheries and livestock	0.1198	2.99	0.3231	6.43	0.1189	2.31	0.9123	6.05
ethnic group	0.1146	0.72	0.9712	3.29	0.1580	0.75	2.9224	3.33
skill	0.0250	0.10	0.1461	4.44	-0.2908	-0.91	0.4406	4.48
dry zone	-0.2345	-5.07	0.5166	8.30	-0.1265	-2.11	1.6967	8.81
hills	0.2278	5.37	0.0254	0.38	0.2723	4.97	0.1228	0.61
sigma					1.4004	52.81	3.0112	27.17
Number of observations	8428		8428		8428		8428	
Log likelihood function	-3473.29		-1840.56		-5239.85		-2569.53	

Table 4: Multinomial Logit Estimates

	(1) Share-Rent			(2) Fixed-Rent			
	coeff	t-stat	P(1)/P(0)	coeff	t-stat	P(2)/P(0)	P(2)/P(1)
Contract Choice Equation							
Constant	-1.680	-4.46		-6.045	-7.56		
land owned - paddy	-2.216	-26.17	0.109	-0.809	-13.44	0.445	4.083
land owned - highland	-0.055	-2.52	0.947	-0.222	-5.12	0.801	0.846
household size	0.051	2.99	1.052	0.100	3.85	1.105	1.050
male adults (%)	0.285	1.60	1.329	0.895	3.35	2.447	1.840
female adults (%)	0.222	1.10	1.248	-0.479	-1.44	0.619	0.496
tractors owned	0.574	2.03	1.775	0.995	4.62	2.704	1.523
bullocks owned	0.081	4.37	1.085	-0.017	-0.46	0.984	0.907
% of students	-0.423	-2.34	0.655	-0.795	-2.81	0.451	0.689
education of head	0.083	2.71	1.086	0.128	2.66	1.136	1.046
education squared	-0.010	-3.75	0.990	-0.012	-2.99	0.988	0.998
sex of head	0.534	4.85	1.706	0.189	1.12	1.208	0.708
ethnic group	0.492	1.58	1.636	1.846	2.55	6.334	3.871
agricultural household	-0.079	-1.02	0.924	-0.145	-1.18	0.865	0.937
fisheries and livestock	0.283	4.06	1.327	0.533	5.25	1.704	1.284
skill	0.041	1.07	1.042	0.223	4.03	1.250	1.199
dry zone	-0.313	-3.81	0.732	1.066	8.08	2.905	3.971
hills	0.416	5.75	1.516	0.264	1.78	1.302	0.859
no. observations	8428						
log likelihood	-5053.94						
Land Extent Equations							
Constant	0.888	0.98		7.954	2.95		
land owned - paddy	0.805	1.58		0.840	4.51		
land owned - highland	0.022	1.05		0.040	0.58		
household size	0.038	1.84		0.018	0.43		
male adults (%)	-0.032	-0.16		-0.416	-0.97		
female adults (%)	0.260	1.15		0.353	0.77		
tractors owned	0.603	1.67		-0.292	-1.17		
bullocks owned	0.006	0.19		0.031	0.66		
% of students	0.049	0.24		0.242	0.64		
education of head	-0.050	-1.34		-0.178	-2.59		
education squared	0.008	2.24		0.018	3.12		
sex of head	-0.111	-0.62		0.095	0.47		
ethnic group	0.483	1.36		-1.806	-1.94		
agricultural household	0.226	2.73		0.261	1.68		
fisheries and livestock	-0.093	-1.07		-0.686	-3.69		
skill	-0.051	-1.27		-0.021	-0.21		
dry zone	0.657	4.47		-0.497	-1.23		
hills	-0.093	-0.76		0.148	0.86		
lambda	-0.828	-1.34		-2.597	-3.44		
number of obs.	1851			535			
r-squared	0.042			0.237			

Table 5: Multinomial Logit Estimates with Alternative Skill Indices

	(1) Share-Rent			(2) Fixed-Rent			
	coeff	t-stat	P(1)/P(0)	coeff	t-stat	P(2)/P(0)	P(2)/P(1)
Linear Index							
Constant	-1.540	-4.09		-4.716	-5.90		
land owned - paddy	-2.217	-26.14	0.109	-0.830	-13.68	0.436	4.001
land owned - highland	-0.052	-2.40	0.949	-0.208	-4.86	0.812	0.855
household size	0.048	2.78	1.049	0.116	4.31	1.123	1.070
male adults (%)	0.259	1.42	1.296	0.570	2.09	1.768	1.364
female adults (%)	0.228	1.13	1.256	-0.502	-1.49	0.605	0.482
tractors owned	0.613	2.20	1.846	1.235	6.01	3.439	1.863
bullocks owned	0.084	4.54	1.088	-0.005	-0.13	0.995	0.915
% of students	-0.422	-2.29	0.656	-0.985	-3.44	0.373	0.569
education of head	0.080	2.48	1.084	0.181	3.59	1.199	1.107
education squared	-0.010	-3.29	0.990	-0.017	-3.86	0.983	0.993
sex of head	0.558	5.12	1.748	0.178	1.06	1.195	0.684
ethnic group	0.542	1.76	1.719	2.246	3.11	9.448	5.495
agricultural household	-0.068	-0.83	0.934	-0.273	-2.10	0.761	0.814
fisheries and livestock	0.294	4.12	1.342	0.711	6.80	2.035	1.517
skill	0.010	0.23	1.010	0.327	4.77	1.387	1.373
dry zone	-0.303	-3.66	0.738	1.020	7.66	2.773	3.754
hills	0.419	5.71	1.520	0.205	1.37	1.227	0.808
no. observations	8428						
log likelihood	-5050.13						
Index without Asset Ownership							
Constant	-1.677	-4.43		-5.986	-7.43		
land owned - paddy	-2.215	-26.16	0.109	-0.804	-13.34	0.447	4.100
land owned - highland	-0.054	-2.50	0.947	-0.217	-5.03	0.805	0.849
household size	0.051	2.98	1.052	0.098	3.73	1.103	1.048
male adults (%)	0.285	1.60	1.330	0.894	3.35	2.445	1.838
female adults (%)	0.222	1.10	1.249	-0.480	-1.44	0.619	0.496
tractors owned	0.624	2.22	1.866	1.249	6.06	3.487	1.869
bullocks owned	0.084	4.57	1.088	-0.001	-0.03	0.999	0.918
% of students	-0.421	-2.33	0.657	-0.774	-2.74	0.461	0.702
education of head	0.083	2.70	1.086	0.124	2.58	1.132	1.042
education squared	-0.010	-3.71	0.990	-0.011	-2.78	0.989	0.999
sex of head	0.537	4.86	1.710	0.218	1.29	1.243	0.727
ethnic group	0.497	1.60	1.643	1.899	2.62	6.681	4.066
agricultural household	-0.077	-0.99	0.926	-0.121	-0.99	0.886	0.957
fisheries and livestock	0.287	4.12	1.332	0.562	5.58	1.755	1.318
skill	0.038	0.95	1.039	0.188	3.02	1.207	1.162
dry zone	-0.310	-3.79	0.733	1.087	8.24	2.964	4.042
hills	0.416	5.74	1.516	0.266	1.79	1.305	0.861
no. observations	8428						
log likelihood	-5057.27						

Table 6: Bivariate Probit (Truncated Sample) Estimates

	(1) Share-Rent				(2) Fixed-Rent			
	hire=1		share=1		hire=1		fixed=1	
	coeff	t-stat	coeff	t-stat	coeff	t-stat	coeff	t-stat
Contract Choice Equation								
Constant	-1.093	-6.67	0.063	0.07	-1.092	-6.79	-1.722	-1.43
land owned - paddy	-0.707	-52.90	-0.544	-3.21	-0.707	-51.57	0.413	1.89
land owned - highland	-0.066	-12.25	0.019	0.53	-0.066	-12.12	-0.011	-0.30
household size	0.042	4.74	-0.001	-0.05	0.042	4.76	0.016	0.65
male adults (%)	0.370	4.01	-0.097	-0.44	0.370	3.98	0.116	0.49
female adults (%)	-0.017	-0.16	0.251	1.42	-0.016	-0.15	-0.300	-1.42
tractors owned	0.616	7.53	-0.074	-0.36	0.615	7.53	0.083	0.34
bullocks owned	0.030	4.58	0.069	3.20	0.030	4.60	-0.093	-4.12
% of students	-0.327	-3.44	-0.130	-0.78	-0.330	-3.47	-0.113	-0.53
education of head	0.067	4.18	0.026	0.83	0.067	4.16	0.007	0.17
education squared	-0.008	-5.58	-0.003	-1.06	-0.008	-5.58	0.000	0.13
sex of head	0.259	4.71	0.287	2.87	0.259	4.71	-0.244	-2.06
agricultural household	-0.058	-1.35	-0.061	-0.99	-0.058	-1.36	-0.041	-0.55
fisheries and livestock	0.226	6.42	-0.025	-0.25	0.227	6.45	0.074	0.64
ethnic group	0.255	2.06	0.056	0.24	0.256	2.12	0.761	1.93
skill	0.062	3.22	-0.035	-0.83	0.062	3.22	0.085	1.62
dry zone	0.123	2.86	-0.527	-3.23	0.122	2.84	0.601	3.49
hills	0.229	5.39	0.158	1.90	0.227	5.36	-0.134	-1.35
rho	0.540	1.29			-0.469	-1.07		
no. observations	8428				8428			
log likelihood	-5908.61				-5516.33			
Land Extent Equation								
Constant	-1.241	-0.82			3.992	2.13		
land owned - paddy	-0.242	-0.47			0.711	4.37		
land owned - highland	-0.009	-0.25			-0.096	-1.90		
household size	0.063	2.58			0.057	1.48		
male adults (%)	0.088	0.39			-0.072	-0.19		
female adults (%)	0.382	1.66			-0.021	-0.05		
tractors owned	0.689	2.16			-0.119	-0.78		
bullocks owned	0.054	1.34			0.042	0.86		
% of students	-0.168	-0.67			-0.040	-0.11		
education of head	0.000	0.00			-0.124	-1.91		
education squared	0.002	0.47			0.015	2.61		
sex of head	0.208	0.86			0.085	0.41		
agricultural household	0.184	2.11			0.237	1.55		
fisheries and livestock	0.031	0.28			-0.458	-3.05		
ethnic group	0.647	1.66			-1.107	-1.13		
skill	-0.037	-0.90			0.074	0.85		
dry zone	0.388	2.06			0.082	0.29		
hills	0.143	0.89			0.200	1.10		
lambda	0.670	0.71			-1.389	-3.04		
number of obs.	1863				537			
r-squared	0.042				0.226			

Table 7: Bivariate Probit (Censored Sample) Estimates

	(1) Share-Rent				(2) Fixed-Rent			
	hire=1		share=1		hire=1		fixed=1	
	coeff	t-stat	coeff	t-stat	coeff	t-stat	coeff	t-stat
Constant	-1.037	-6.33	-0.939	-5.46	-1.048	-6.64	-3.417	-10.60
land owned - paddy	-0.701	-52.89	-0.648	-32.64	-0.711	-47.93	-0.409	-12.84
land owned - highland	-0.065	-11.04	-0.054	-8.28	-0.061	-10.09	-0.069	-4.30
household size	0.067	7.64	-0.005	-0.51	0.041	4.60	0.047	3.45
male adults (%)	0.387	4.28	0.141	1.42	0.379	4.11	0.348	2.55
female adults (%)	0.020	0.19	0.085	0.78	-0.038	-0.36	-0.215	-1.27
tractors owned	0.591	7.06	0.051	0.51	0.631	7.64	0.485	4.19
bullocks owned	0.037	6.95	0.042	2.81	0.028	4.10	-0.038	-2.11
% of students	-0.309	-3.39	-0.251	-2.61	-0.299	-3.19	-0.364	-2.72
education of head	0.042	2.56	0.080	4.92	0.066	4.12	0.061	2.52
education squared	-0.007	-5.28	-0.005	-3.50	-0.007	-5.42	-0.006	-2.84
sex of head	0.264	4.91	0.286	5.02	0.242	4.46	0.057	0.70
agricultural household	0.259	2.14	0.081	0.64	0.232	1.99	0.972	3.54
fisheries and livestock	-0.054	-1.34	-0.071	-1.67	-0.047	-1.07	-0.069	-1.12
ethnic group	0.212	6.13	0.136	3.64	0.214	6.14	0.257	5.07
skill	0.063	3.29	-0.011	-0.53	0.059	3.06	0.115	3.89
dry zone	0.136	3.20	-0.243	-5.53	0.120	2.81	0.590	9.23
hills	0.247	5.98	0.209	5.20	0.226	5.32	0.055	0.81
rho	0.994	91.49			0.954	34.30		
no. observations	8428				8428			
log likelihood	-6175.43				-5539.24			

Table 8 : Explaining the Yield Differences Across Contract Types

	Owner	Fixed	Share	Share/Fixed	Share/Own
Yield (kg/acre)	2130.6	2175.85	1849.91	0.850	0.868
Technical Efficiency	0.5193	0.5789	0.5285	0.913	1.018
Skill	4.993	5.168	4.759	0.921	0.953
Input Intensities					
Fertilizer	213.98	204.97	214.61	1.047	1.003
Chemicals	1320.49	1388.71	998.46	0.719	0.756
Machines	0.0012	0.0324	0.0116	0.358	9.667
Bullocks	0.9181	0.916	0.9256	1.010	1.008
Labor	177.45	121.56	169.16	1.392	0.953

Table 9: Summary of Results

Variable	Share-Rent								Fixed-Rent							
	Probit	Tobit	Mult. Logit		BP (1)		BP (2)		Probit	Tobit	M. Logit		BP (1)		BP (2)	
	S=1	S*	S=1	S*	S=1	S*	S=1	S*	F=1	F*	F=1	F*	F=1	F*	F=1	F*
Skill									+	+	+		(+)		+	
Paddy Land Owned	-	-	-		-		-		-	-	-	+	(+)	+	-	+
Highland Owned			-				+		-	-	-			-	-	-
Household Size	+	+	+	(+)		+		+	+	+	+				+	
% Male Adults									+	+	+				+	
% Female Adults						(+)		(+)								
Tractors Owned			+	(+)		+		+	+	+	+				+	
Bullocks Owned	+	+	+		+		+						-		-	
Education of Head	+	+	+				+		+	+	+	-		-	+	-
Sex of Head	+	+	+		+		+									