# Testing Between Competing Models of Reverse Share Tenancy: Evidence from Madagascar*

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**Abstract**

This paper tests between three competing theoretical models of reverse share tenancy, a contract by which a poor landlord leases out her land to a richer tenant in exchange for a share of the crop. The first model posits that landlords rent out on shares due to asset risk, i.e., sharecropping reduces the probability that a landlord will lose her claim to the land. The second model posits that landlords lease out on shares to minimize the amount of uncertainty they face over the price of a staple crop. The third model posits that landlords rent out on shares due to limited liability. Using data from Madagascar's biggest rice-producing region, I find strong empirical support for the limited liability hypothesis and reject the other two explanations.

***JEL* Classification Codes**: C35, D82, D89, O12, O13, Q12, Q15.

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# 1 Introduction

Sharecropping, an agrarian contract by which a landlord leases out land to a tenant in exchange for a share of the crop, has been studied by economists ever since the publication of Adam Smith's *The Wealth of Nations* in 1776. Almost two and a half centuries later, the canonical explanation for the existence of sharecropping, following Cheung (1969b), Stiglitz (1974) and Newbery (1977), remains that share tenancy matches a relatively richer landlord whose comparative advantage lies in risk-bearing with a tenant whose comparative advantage lies in labor monitoring.[1] By trading off incentives and risk-sharing in the Principal-Agent framework, sharecropping could thereby dominate both fixed rent contracts that are considered too risky by the tenant and wage contracts that predictably lead to underprovision of effort by the laborer.

Not every sharecropping contract fits the above stylized facts, however. There exist situations of reverse share tenancy, in which a poor landlord contracts with a rich tenant, and these situations do not fit the canonical model of sharecropping because the poorer landlord no longer holds comparative advantage in risk-bearing over the tenant, a situation in which the Principal-Agent model predicts a fixed rent contract. Indeed, few of the extant models of sharecropping are consistent with the oft-observed phenomenon of reverse share tenancy.[2]

In this paper, I present three theoretical models of sharecropping that are consistent with both reverse share tenancy and traditional sharecropping contracts and test between them using field data from Madagascar's biggest rice-producing region. The first model explains sharecropping as the result of asset risk, or weak property rights: assuming that a landlord's claim on her land is an increasing function of the share of the crop she receives as rent, she might choose to offer her tenant a low-powered contract (Williamson, 1985) even though such a contract could in theory lead to opportunistic behavior.

[1]Another strand in the literature on sharecropping is that on transactions cost, which started with Cheung (1968, 1969a). The transactions cost approach to modeling sharecropping contracts assumes that the landlord can perfectly monitor the tenant and thus enforce the optimal level of effort, making sharecropping first-best.

[2]I distinguish between "reverse share tenancy" and "reverse tenancy" since the latter term could refer to both fixed rent and sharecropping contracts.

The second model explains sharecropping as the result of price risk: if there is too much *ex ante* uncertainty over the price of a staple crop, a landlord might choose to get paid in kind in order to reduce the consumption uncertainty she faces due to temporal food price risk. Finally, the third model explains sharecropping as the result of limited liability: if the landlord expects her tenant's limited liability constraint to bind, and if there is scope for the tenant to choose among various techniques that differ in their expected yields and variances, the landlord will choose a sharecropping contract in order to mitigate the tenant's risk-taking behavior.

After presenting these competing models of reverse share tenancy, I proceed to test them empirically using household-level data from Madagascar. I find that the limited liability explanation is the only theoretical explanation that is supported by the data at hand.

The rest of the paper is organized as follows. In section 2, I review the empirical literature on sharecropping. Section 3 presents an impossibility result as well as the three theoretical models of sharecropping described above. In section 4, I present the empirical framework that will be used to test between competing models of reverse share tenancy. Section 5 briefly discusses the survey methodology as well as the data used and discusses some summary statistics. In section 6, I present and analyze the estimation results. Section 7 concludes.

# 2 Literature Review

In comparison to the considerable theoretical literature on sharecropping, the empirical literature on share tenancy has so far been rather scant, although to be fair, this is a problem that has plagued the broader field of applied contract theory until well into the 1990s (Prendergast, 1999; Chiappori and Salanié, 2003). Moreover, a good number of empirical papers on sharecropping are concerned first and foremost with determining whether or not incentives matter, i.e., whether there is Marshallian inefficiency[3], which in turn led to testing which of the Marshallian or Cheungian view was best

[3]Following Marshall (1920), the term "Marshallian inefficiency" has been used to refer to the moral hazard that might arise from signing a sharecropping contract instead of a fixed rent contract.

supported by the data.

In one of the first empirical papers on sharecropping, Shaban (1987) tests between the Marshallian theory of share tenancy – in which tenants who lease in on shares are less productive at the margin than tenants who lease in on a fixed rent – and the transactions cost (or monitoring) theory of share tenancy – in which landlords are assumed to be able to perfectly monitor their tenants – using data from six Indian villages. His approach, which compares the productivity of farmers on owned and fixed-rented versus sharecropped plots, allows him to reject the monitoring approach in favor of the Marshallian approach, i.e., he finds that there are significant differences in productivity between owned or cash rented plots versus sharecropped plots.

Allen and Lueck (1992, 1993), for their part, elaborate two transactions-cost based theoretical models of sharecropping that trade off the incentives between land overuse and the cost of dividing the output at the end of the season. Their models offer sharp prediction regarding the division of costs and output. Using data on US farms, they find strong empirical support for their model. Allen and Lueck, however, do not test for Marshallian inefficiency, given that their model does not posit any kind of risk-sharing behavior on the part of landlords and tenants, an assumption justified by the fact that in their sample, parties to sharecropping agreements are essentially similar.

Laffont and Matoussi (1995) develop a theoretical model that incorporates moral hazard as well as financial constraints. They then test the implications of their theoretical framework using data from the Tunisian village of El Oulja and find strong empirical support for their model as well as clear evidence of Marshallian inefficiency.

Ai, Arcand, and Éthier (1996) also use a panel dataset from the Tunisian village of El Oulja and test for the presence of Marshallian inefficiency, but they control for four aspects of agrarian contracts that had been hitherto neglected in the empirical literature on sharecropping, i.e., cost-sharing between the landlord and tenant, the managerial inputs of the landlord, supervision, and repeated interaction. This leads them to find support both for the Cheungian and the Marshallian view of sharecropping. On the one hand, supervision is important and incurs a cost to the landlord, but on the other hand, input intensity is higher on sharecropped plots than on owned plots for a majority of inputs.

Dubois (2002) builds on the framework of Allen and Lueck and develops a dynamic Principal-Agent model in which landlords choose sharecropping agreements in order to trade off moral hazard and incentives to overuse land, i.e., whereas moral hazard pushes landlords to sign fixed rent agreements, such contracts induce tenants to overuse the land they lease in from their landlords, so that landlords might choose a low-powered contract in order to maintain soil fertility. Using data from a rural area of the Philippines, he finds that the predictions of his theoretical model are supported by his data.

Finally, Arimoto (2005) introduces a model that builds on the limited liability literature by incorporating state-contingent rent reduction clauses in agrarian contracts (temporary reductions in fixed rent in case of a poor harvest) after presenting empirical results from historical Japanese and Korean data. As such, his study is very much in the spirit of the limited liability hypothesis in the present study.

The few empirical studies on sharecropping contracts discussed above have been somewhat limited in scope, and to my knowledge, no empirical study has ever tested any hypothesis regarding reverse share tenancy. The present study thus aims at filling that gap in the literature on agrarian contracts, as well as providing an additional contribution to the relatively small empirical literature on sharecropping.

# 3 Theoretical Framework

## 3.1 The Standard Model

Consider the standard model of sharecropping. A principal whose utility function is $V(\cdot)$, with $V' > 0$ and $V'' \leq 0$, contracts with an agent whose utility function is $U(\cdot)$, with $U' > 0$ and $U'' \leq 0$. The principal hires the agent to exploit a plot of land and produce output $q \in [\underline{q}, \overline{q}]$. The level of output is stochastic, and its realization depends on the effort of the agent, $e \in E$. Both output and effort are linked through the probability density function $f(q|e)$, which describes the likelihood of observing output level $q$ given effort level $e$. The agent's payoff from accepting the contract offered by the principal is additively separable in the utility derived from the contract and in the cost of effort, which is represented by the function $\psi(e)$, with $\psi' > 0$ and $\psi'' > 0$.

As in the standard principal-agent model (Bolton and Dewatripont, 2005), the principal must solve the following problem by offering a contract $\{w(q)\}$ to the agent:

$$(1) \quad \max_{w(q)} \int_{\underline{q}}^{\overline{q}} V[q - w(q)] f(q|e) dq, \text{ subject to}$$

$$(2) \quad \int_{\underline{q}}^{\overline{q}} U[w(q)] f(q|e) dq - \psi(e) \geq \overline{U} \text{ (IR)}$$

$$(3) \quad e \in \text{argmax}_{\hat{e} \in E} \left\{ \int_{\underline{q}}^{\overline{q}} U[w(q)] f(q|\hat{e}) dq - \psi(\hat{e}) \right\} \text{ (IC)},$$

where the first constraint is the agent's individual rationality (IR) constraint and the second constraint is his incentive compatibility (IC) constraint. As is common in contract theory, assume that the agent's maximization problem has a unique solution, and since his utility is the sum of concave functions, one can then apply the first-order approach (Rogerson, 1985) and replace the agent's incentive compatibility constraint (IC) by its first-order condition (IC'). The principal's problem then becomes

$$(4) \quad \max_{w(q)} \int_{\underline{q}}^{\overline{q}} V[q - w(q)] f(q|e) dq, \text{ subject to}$$

$$(5) \quad \int_{\underline{q}}^{\overline{q}} U[w(q)] f(q|e) dq - \psi(e) \geq \overline{U} \text{ (IR)}$$

$$(6) \quad \int_{\underline{q}}^{\overline{q}} U[w(q)] f_e(q|e) dq - \psi'(e) = 0 \text{ (IC')},$$

where $f_e(q|e) = \frac{\partial f(q|e)}{\partial e}$. Forming the Kuhn-Tucker maximization problem and differentiating inside the integral sign with respect to $w(q)$ and the multipliers associated with each constraint yields the following first-order conditions:

$$(7) \quad -V'[q - w(q)] f(q|e) + \lambda U'[w(q)] f(q|e) + \mu U'[w(q)] f_e(q|e) = 0$$

$$(8) \quad \lambda\{U[w(q)] f(q|e) dq - \psi(e) - \overline{U}\} = 0$$

$$(9) \quad \mu\{U[w(q)]f_e(q|e)dq - \psi'(e)\} = 0$$

Assuming for now that the multipliers $\lambda$ and $\mu$ are both positive, i.e., assuming that the IR and IC' constraints both bind, Rearranging the first-order condition with respect to $w(q)$ yields

$$(10) \quad \frac{V'[q - w(q)]}{U'[w(q)]} = \lambda + \mu \frac{f_e(q|e)}{f(q|e)},$$

a familiar result in contract theory which summarizes the trade-off between risk-sharing and incentives. If the IC' constraint does not bind, i.e., if $\mu = 0$, implying no moral hazard, then the ratio of marginal utilities of the principal and the agent is constant and equal to $\lambda$, and the principal offers a wage contract $\overline{w}$ which the agent accepts. If, however, the IC' constraint binds, i.e., if $\mu > 0$, then one either observes a sharecropping contract or a fixed rent contract.

In what follows, I focus on linear contracts, i.e., contracts of the form $w(q) = aq + b$, where $a \in [0, 1]$ is the share of the crop that goes to the agent, and $b \in \mathbb{R}$ is a side payment from the principal to the agent, i.e., a fixed rent if $b$ is negative, and a fixed wage if $b$ is positive. The reason for doing so is twofold. First, landlords and tenants overwhelmingly tend to use linear sharecropping contracts in practice. Second, behavioral evidence suggests that individuals tend to use heuristics in order to reduce complex decision-making problems into tractable ones, and in my view, the use of linear contracts represents either the use of such a heuristic or an example of bounded rationality (Simon, 1957), a discussion of which is beyond the scope of this article.[4]

Differentiating equation (10) with respect to $q$ yields

$$(11) \quad w'(q) = \frac{\mu(U')^2 \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] - V''U'}{-V''U' - U''V'},$$

which is the slope of the contract $w(q) = aq + b$. In other words, $w'(q)$ is the share of the crop that goes to the agent as his payment for exploiting the land, i.e., $a$. Since the side payment parameter $b$ enters the contract linearly,

[4]While Holmstrom and Milgrom (1987) have identified conditions under which a linear contract can be used, these conditions are somewhat restrictive and rely on assumptions rather than on empirically verifiable facts.

the principal will adjust it in order to make the agent's IR constraint bind (Stiglitz, 1974).

Assume now that both the principal and the agent are risk averse, i.e., $V'' < 0$ and $U'' < 0$. Assume further that $\frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] \geq 0$, i.e., the monotone likelihood ratio property holds. Then, $w'(q) > 0$, i.e., the agent gets a strictly positive share of output $q$.

Multiplying each term of the numerator and each term of the denominator in equation (11) by $U'V'$ yields

$$(12) \quad w'(q) = \frac{\mu \frac{U'}{V'} \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + R_L}{R_L + R_T},$$

where $R_L = -\frac{V''}{V'}$ and $R_T = -\frac{U''}{U'}$ are the Arrow-Pratt coefficients of absolute risk-aversion of the principal and the agent, respectively. Given equation (12), I can now state the following result:

**Proposition 1 (Impossibility Result)** *Under the assumptions made so far, reverse share tenancy is impossible. That is, when the principal is risk-averse and the agent is risk-neutral, sharecropping cannot obtain, and what one observes instead is a fixed rent contract.*

**Proof** When the principal is risk-averse and the agent is risk-neutral, $R_L > 0$ and $R_T$ goes to zero. The slope of the contract thus becomes

$$(13) \quad \lim_{R_T \to 0} w'(q) = \frac{\mu \frac{U'}{V'} \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + R_L}{R_L} \geq 1,$$

but since the share of the output that the agent can get from the contract lies in the $[0, 1]$ interval, then $w'(q) = 1$ and a fixed rent contract obtains ■

The result stated in Proposition 1 is the prime motivation behind this article: whereas reverse share tenancy has been observed the world over, economic theory has yet to explain such contracts. Moreover, Proposition 1 shows that under the standard principal-agent model, sharecropping is impossible between a sufficiently poor principal and a sufficiently rich agent, i.e., the model needs additional assumptions in order for reverse share tenancy to be a theoretical possibility.

Before presenting my theoretical explanations for reverse share tenancy, however, I can state the following additional results.

**Proposition 2 (Standard Optimal Contract)** *Given the above assumptions: (i) If the principal is risk-neutral and the agent is risk-averse, the principal offers a sharecropping contract; (ii) If the principal is risk-averse and the agent is risk-neutral, the principal offers a fixed rent contract; and (iii) The slope of the contract is monotonically decreasing in the relative degrees of absolute risk-aversion of the agent and the principal.*

**Proof** Before proving the three parts of the proposition in order, let $r \equiv R_T/R_L$ capture the degree of risk-aversion of the agent relative to the degree of risk-aversion of the principal. Before establishing (i), parts (ii) and (iii) need to be established. Part (ii) can be established by taking the following limit

$$(14) \quad \lim_{r \to 0} w'(q) = \lim_{r \to 0} \frac{\frac{\mu}{R_L}\frac{U'}{V'}\frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + 1}{1 + r} \geq 1.$$

Given the physical constraint the $w'(q) \in [0, 1]$, the above result means that $w'(q) = 1$ when the principal is risk-averse and the agent is risk-neutral. Also note that

$$(15) \quad w'(q) = \frac{\frac{\mu}{R_L}\frac{U'}{V'}\frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + 1}{1 + r}.$$

But then,

$$(16) \quad \frac{dw'(q)}{dr} = -r\left(\frac{\mu}{R_L}\frac{U'}{V'}\frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + 1\right) < 0,$$

which establishes part (iii). Having established (ii) and (iii), part (i) can now be established by setting $V''$ equal to zero in equation (11) above, which yields

$$(17) \quad w'(q) = \frac{\mu(U')^2\frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right]}{-U''V'} > 0.$$

Note that (ii) and (iii) guarantee that the slope of the contract will be less than unity when the principal is risk-neutral and the agent is risk-averse ■

Both Propositions 1 and 2 make intuitive sense. First off, one should not expect a sharecropping agreement to be signed between a risk-averse principal and a risk-neutral agent since in such a case, the principal no longer has a comparative advantage in risk-bearing, which now resides with the agent. Therefore, since the agent also has a comparative advantage in terms of monitoring labor effort, one should expect the agent to be full residual claimant on the output. Second, that a risk-averse agent is offered a sharecropping contract by a risk-neutral principal is a well-known result of contract theory (Bolton and Dewatripont, 2005) and of development microeconomics (Stiglitz, 1974). Finally, the monotonicity of the contract slope in the relative degree of absolute risk-aversion of the parties to the contract is non-trivial, since it clearly establishes the trade-off between insurance and incentives: the more risk-averse the principal relative to the agent, the more high-powered the contract (Williamson, 1985), and vice versa.

## 3.2 The Asset Risk Model

This section develops a model in which sharecropping can emerge as the optimal contract when the principal is risk-averse and the agent is risk-neutral. This result hinges upon the asset risk assumption, i.e., the higher-powered the contract the principal offers the agent, the weaker the principal's claim to the plot of land contracted on. Alternatively, one can view this assumption as one over property rights: the more involved in agricultural production the principal is perceived to be, the stronger her property right. This assumption is especially fitting in places where the tenurial system is weak or non-existent and property rights are ill-defined.

Note that I do not look at the choice between hiring a agent on a fixed wage, first because it would suffice to assume that the principal is sufficiently liquidity-constrained to rule out such cases, and more importantly because there is an important conceptual difference between leasing out a plot of land on a fixed rent or a sharecropping contract and exploiting one's own plot using wage laborers.

The following model is closely related to that of Dubois (2002), with an important difference: whereas in Dubois' model, the agent's effort could influence future production possibilities, in our model, the terms of the contract directly affect the principal's land value. Let the production function be linear homogeneous with respect to land (Otsuka, Chuma, and Hayami, 1992). For a fixed amount of land, let $y_t$ be the output, $e_t \in E$ be the agent's work effort, and $h_t$ be the plot area. The production function is such that $y_t = \nu_t f(e_t)$, where $\nu$ is a multiplicative shock with mean equal to one and $f(\cdot)$ is a production function with $f_e > 0$, $f_{ee} < 0$, and $f(\cdot)$ is twice continuously differentiable.

Moreover, let $E(h_t) = E[r(a_t)h_{t-1} + \epsilon_t]$, where $\epsilon$ is an additive shock with mean equal to zero, $a$ is the share of output that goes to the agent, and $r(\cdot)$ represents asset risk.[5] This equation is thus the law of motion for land, and $r(\cdot)$ represents the principal's claim to the land (or the strength of her property right), with $r_a < 0$.

Assume the principal is risk-averse and the agent is risk-neutral. The agent's payoff is then

$$(18) \quad a_t E\nu f(e_t) + b_t - \psi(e_t),$$

where $\psi_e > 0$, $\psi_{ee} > 0$, and $\psi(\cdot)$ is twice continuously differentiable and represents the agent's cost of exerting effort level $e$. The principal's payoff is

$$(19) \quad EU[(1 - a_t)\nu f(e_t) - b_t],$$

where $U(\cdot)$ is a von Neumann-Morgenstern utility function that is also bounded. Finally, let $\bar{U}$ denote the agent's reservation utility.

The principal's problem is to solve

$$(20) \quad v_0(h) = \max_{a_t, b_t} E_{\nu_t, \epsilon_t} \sum_{t=0}^{\infty} \delta^t EU[(1 - a_t)\nu f(e_t) - b_t]$$

subject to, for all $t \geq 0$,

$$(21) \quad a_t E\nu f(e_t) + b_t - \psi(e_t) \geq \bar{U} \text{ (IC)},$$

[5] As in the last section, I focus on linear contracts. I choose to do so for the reasons enumerated above, but also because the tools of contract theory do not allow us to determine the shape of the optimal contract in a dynamic setting (Dubois, 2002).

(22) $e_t \in \text{argmax}_{\hat{e} \in E} a_t E\nu f(e_t) + b_t - \psi(e_t)$ (IR), and

(23) $E(h_t) = E[r(a_t)h_{t-1} + \epsilon_t]$.

where $\delta \in (0, 1)$ is the principal's discount factor and the two constraints are respectively the agent's individual rationality and incentive compatibility constraints. Applying the first-order approach, one can rewrite the latter constraint as

(24) $a_t E\nu f_e - \psi_e = 0$ (IC').

The Bellman equation for the above problem is then

(25) $v_0(h_0) = \max_{a,b} \{EU[(1-a)\nu f(e) - b + \delta E v_0(h_1)]\}$,

subject to

(26) $aE\nu f(e) + b - \psi(e) \geq \bar{U}$, and

(27) $aE\nu f_e - \psi_e = 0$,

where $h_0$ denotes the initial plot area, and $h_1 = r(a)h_0 + \epsilon$.

Before deriving the optimal contract, it is necessary to establish the following result.

**Lemma 1** *Agent effort is increasing in crop share, i.e.,* $e_a > 0$.

**Proof** From the agent's incentive compatibility constraint, one gets that $a = \psi_e / E\nu f_e$. Thus, as $a$ increases, the ratio $\psi_e / E\nu f_e$ also increases. Since $\psi_{ee} > 0$ and $f_{ee} < 0$, this means that as $a$ increases, $e(a)$ also increases, so that $e_a > 0$ ■

In order to solve the Bellman equation, it is necessary to establish the following result, which will be useful in substituting for $b$ using the agent's IR constraint.

**Lemma 2** *The side payment is decreasing in crop share, i.e.,* $b_a < 0$.

**Proof** From the agent's IR constraint, one gets that

(28) $b(a) = \bar{U} + \psi(e(a)) - aE\nu f(e(a))$.

But then, $b_a = -e_a[aE\nu f_e - \psi_e] - E\nu f(e)$, and from the agent's IC constraint, one knows that the bracketed expression is identical to zero. Therefore, $b_a = -E\nu f(e) < 0$ ■

This leaves us with the following expression for the Bellman equation:

$$(29) \quad v_0(h) = \max_a \left\{ EU[(1-a)\nu f(e(a)) - b(a)] + \delta E v_0[r(a)h + \epsilon] \right\},$$

The following lemma is the last necessary step in establishing the result of Proposition 3.

**Lemma 3** *The function $v_0(\cdot)$ is strictly increasing.*

**Proof** When faced with the following problem

$$(30) \quad v_0(x) = \max_{x' \in \Gamma(x)} \left\{ F(x, x') + \delta v_0(x') \right\}$$

$v_0(\cdot)$ is strictly increasing if (i) the state space $X$ is a convex subset or $\mathbb{R}^\ell$ and the correspondence $\Gamma : X \to X$ is nonempty, compact-valued, and continuous; (ii) $F : A \to \mathbb{R}$ is bounded and continuous and $\delta \in (0, 1)$; (iii) For all $y$, $F(\cdot, y)$ is strictly increasing in each of its first $\ell$ arguments; and (iv) $\Gamma$ is monotonic (Stokey and Lucas, 1989, p.80).

That the state space – the land area of a given plot, $h$ – is a subset of $\mathbb{R}$ is obvious. The $\Gamma(\cdot)$ correspondence, in this case the law of motion, which is nonempty, compact-valued, and whose expectation is continuous. The returns function $F(\cdot)$, in this case the utility function of the principal, has been assumed bounded and is continuous by virtue of being a von Neumann-Morgenstern utility function, and is also increasing in its only argument, i.e., the principal's income. Also, $\delta \in (0, 1)$ by assumption. Finally, the law of motion is monotonic in expectation, so that $v_0(\cdot)$ is strictly increasing ■

**Proposition 3 (Asset Risk Optimal Contract)** *In the presence of asset risk, sharecropping emerges as the optimal contract between a risk-averse principal and a risk-neutral agent.*

**Proof** In order to maximize the Bellman equation, one needs to take the derivative with respect to $a$. Doing this and using the substitution method to solve yields the following expression for $a^*$, the crop share in the optimal contract:

$$(31)\quad a^* = 1 + \frac{\delta E v_0' r_a h}{E \nu U' f_e e_a},$$

where the first term represents the first-best contract – a fixed rent contract – and the second term represents the effect of introducing asset risk in the model. Since all the variables in the second term are positive except for $r_a$, the optimal contract is lower-powered than the first-best contract, so that sharecropping emerges as the optimal solution ■

The following proposition provides a useful testable implication for applied work.

**Proposition 4 (Comparative Statics)** *In the absence of asset risk, the principal offers the agent a sequence of fixed rent contracts. Moreover, the slope of the optimal contract is decreasing in asset risk.*

**Proof** Taking the derivative of the slope of the optimal contract with respect to the asset risk parameter yields $da^*/dr_a = \frac{\delta E v_0' h}{E \nu U' f_e e_a} > 0$, which means that as asset risk increases, so does the slope of the optimal contract, i.e., the lower $r_a$, the higher $a^*$. In the limit, $r_a = 0$ and $a^* = 1$. That is, when there is no asset risk, the first-best contract obtains ■

Proposition 4 provides an important result: given a dataset that includes enough variation on the perception of asset risk and in the shape of the contract chosen by the principal, one can test the null hypothesis that asset risk has no effect on the probability of observing a sharecropping contract relative to the probability of observing a fixed rent contract.

## 3.3 The Price Risk Model

This section develops an alternative model in which sharecropping emerges as the optimal contract between a risk-averse principal and a risk-neutral agent. This result hinges upon price risk, i.e., the principal's attitude to fluctuations in the price of a staple crop that agents both consume and produce. Economists have typically ignored price risk in favor of income risk. While some have looked at the firm's behavior in the presence of price risk (Sandmo, 1971; Baron, 1970), others have looked at the behavior of agricultural households in the presence of price risk (Finkelshtain and Chalfant, 1991; Barrett 1996). The derivations in this section are based on Barrett (1996), in which a method to compute coefficients of price risk aversion is outlined.

The intuition behind the price risk model is simple: when faced with fluctuations in the price of a staple crop, a risk-averse principal will choose sharecropping in order to mitigate the effect of these price fluctuations on her consumption bundle. Once again, I only look at the choice between a fixed rent and a sharecropping contract and rule out wage contracts.

The novelty of this approach comes from the fact that the principal must choose the contract $\{a, b\}$ *ex ante* but can revise her consumption $c$ *ex post*. That is, the principal must choose the slope of the contract and the side payment before the price of the staple crop is known, but can revise her consumption bundle after the price is known. Moreover, the budget constraint of the principal is such that $pc \leq (1-a)pf(e) - b$, where $p$ is the (uncertain) staple price and the right-hand side of the inequality represents principal's income from the contract.

The principal's problem is thus to

(32) $\max_{a,b} \; E \max_{c} u(c)$

subject to

(33) $pc \leq (1-a)pf(e) - b,$

(34) $apf(e) + b - \psi(e) \geq \bar{U}$, (IR)

and

(35) $e \in \text{argmax}_{\hat{e} \in E} apf(e) + b - \psi(e)$. (IC)

Given that the principal's preferences are locally non-satiated, the first constraint will bind. By Epstein's (1975) duality result, the above problem is equivalent to

(36) $\max_{a,b} \; EV(p, w)$

subject to

(37) $apf(e) + b - \psi(e) \geq \bar{U}$, (IR)

and

(38) $apf_e - \psi_e = 0$, (IC')

where the first-order approach has been applied to the problem and where

(39) $V(p, w) = \max_c u(c)$

subject to

(40) $pc = (1 - a)pf(e) - b$ .

The above framework leads to the following proposition.

**Proposition 5 (Price Risk Optimal Contract)** *In the presence of price risk, sharecropping emerges as the optimal contract between a risk-averse principal and a risk-neutral agent.*

**Proof** Taking the first-order condition with respect to $a$ and setting it equal to zero yields

(41) $E\{V_w pf_e e_a - V_w pf - a^* V_w pf_e e_a\} = 0$,

from which $a^* = 1 - f/f_e e_a$ obtains. Given that the second term is strictly positive, $a^* < 1$, i.e., the slope of the optimal contract is less than the slope of the first-best contract, and sharecropping obtains since $a^*$ is bounded below by zero and wage contracts are ruled out ■

Based on the model above, one can also make the following statement about comparative statics, which provides an important testable implication. The intuition behind the result is as follows: the more the principal is price risk-averse, the more she will prefer to get paid in crop, which ensures a fixed consumption bundle, rather than in cash, which ensures a stochastic consumption bundle when the price of the staple is stochastic.

**Proposition 6 (Comparative Statics)** *The slope of the contract is decreasing in the degree of price risk aversion of the principal.*

**Proof** First rewrite the first order condition in the last equation as

$$(42)\quad aE\{V_w p\}f_e e_a = E\{V_w p\}f_e e_a - E\{V_w p\}f.$$

Subtracting $aE\{V_w\}\mu f_e e_a$ from both sides of the equation, where $\mu = E(p)$, yields the following expression for $a^*$, the slope of the optimal contract:

$$(43)\quad a^* = \frac{E\{V_w p\}f_e e_a - E\{V_w p\}f}{[Cov(V_w, p) + E\{V_w\}\mu]f_e e_a}.$$

Before proceeding with the analysis, I need to discuss an individual's degree of price risk aversion. From Barrett's (1996) analysis,

$$(44)\quad \text{sign}[Cov(V_w, p)] = \text{sign}(V_{wp}) = \text{sign}[\beta(\eta - R)],$$

where $\beta$ is an individual's budget share of the staple crop, $\eta$ is an individual's income-elasticity of marketable surplus, and $R$ is an individual's Arrow-Pratt coefficient of absolute risk aversion. The first equality sign essentially indicates that the covariance between marginal indirect utility of income and the price of the staple is of the same sign as $V_{wp}$. The second equality sign essentially indicates that the key to signing the covariance is $\beta$, since $R$ almost always exceeds $\eta$ for staples. Thus, for net buyers of the staple, i.e., individuals for whom $\beta < 0$, $Cov(V_w, p) > 0$, and for net sellers of the staple, i.e., individuals for whom $\beta > 0$, $Cov(V_w, p) < 0$. Thus, as $\beta$ decreases, $Cov(V_w, p)$ increases.

But then, since $da^*/dCov(V_w, p) < 0$, i.e., as the covariance between the principal's marginal indirect utility of income and the price of the staple increases, the slope of the contract increases ■

Proposition 6 provides an important result: given a dataset that allows to compute the covariance between marginal indirect utility of income and staple price (Barrett, 1996) and that includes observations on the shape of the contract chosen by the principal, one can test the null hypothesis that the attitude to price fluctuations has no effect on the probability of observing a sharecropping contract relative to the probability of observing a fixed rent contract.

## 3.4 The Limited Liability Model

The model presented here, due to Ghatak and Pandey (2000), starts from risk-neutral agents and assumes that $a$, the slope of the contract, is in the

$[0, 1]$ interval. The agent has a limited liability constraint below which he cannot repay the principal and has two choice variables, effort in labor, $e \in [\underline{e}, \overline{e}]$, where $\overline{e} > \underline{e} \geq 0$ and a level of risk $r \in [\underline{r}, \overline{r}]$, where $\overline{r} > \underline{r} \geq 0$. The former variable incorporates Marshallian inefficiency into the model, while the latter incorporates technical moral hazard.

Production requires one unit of land and one unit of labor, respectively owned by the principal and the agent. Given the agent's choices of $e$ and $r$, nature chooses an output $x \in [\underline{x}, \overline{x}]$. The distribution function of output is $F(x|e, r)$, and the bounds of the support of $x$ are assumed not to depend on $e$ and $r$ and the cumulative distribution function $F(\cdot)$ is twice continuously differentiable. Further,

$$(45) \quad \frac{\partial F(x|e, r)}{\partial x} = f(x|e, r), \text{ and}$$

$$(46) \quad \frac{\partial}{\partial x}\left[\frac{f_e(x|e, r)}{f(x|e, r)}\right] \geq 0.$$

In other words, the monotone likelihood ratio property (Bolton and Dewatripont, 2005) holds, i.e., an increase in labor effort will result in a new output which first-order stochastically dominates the previous output.

As for $r$, the riskiness of the project undertaken by the agent, the model assumes that an increase in $r$ causes a mean-preserving spread in the distribution of output. That is, an increase in the level of risk chosen by the agent, holding the effort level constant, causes a mean-preserving spread in the distribution of output. Thus, an increase in $r$ will shift probability mass towards the tails of the output distribution, *ceteris paribus*.

As regards labor effort and risk, the agent incurs a private cost $\psi(e, r)$, where $\psi(\cdot)$ is twice continuously differentiable, $\psi_e > 0$, $\psi_r > 0$, $\psi_{ee} > 0$, $\psi_{rr} > 0$, $\psi_{er} \geq 0$ and $\psi(0, 0) = 0$. The principal cannot observe the agent's provision of labor effort and his choice of risk. She must thus rely on the realization of output $x$ to obtain information on these two variables.

As in the previous two models, the agent receives $ax + b$ from the contract. Thus, the principal and the agent's incomes from the contract are

$$(47) \quad y_L = \min\{(1 - a)x - b, x\}, \text{ and}$$

(48) $y_T = \max\{ax + b, 0\}$

Thus, Ghatak and Pandey implicitly assume that the limited liability constraint binds at $\hat{x} = -b/a$. The principal and the agent's expected payoffs are thus:

(49) $U_L = E(x) - \int_{\hat{x}}^{\overline{x}} [ax + b] f(x|e, r) dx$, and

(50) $U_T = \int_{\hat{x}}^{\overline{x}} [ax + b] f(x|e, r) dx - \psi(e, r)$.

And, letting the agent's reservation utility be equal to $\overline{U}$, it is obvious that the agent's individual rationality (IR) constraint is that $U_T \geq \overline{U}$. By backward induction, i.e., assuming the principal has already chosen a contract $\{a, b\}$, the agent's choice of $e$ and $r$ are given by the following incentive constraints (IC):

(51) $-a \int_{\hat{x}}^{\overline{x}} F_e(x|e, r) dx = \psi_e(e, r)$, and

(52) $-a \int_{\hat{x}}^{\overline{x}} F_r(x|e, r) dx = \psi_r(e, r)$.

In this model, the expected social surplus $E(S)$, i.e., the sum of the expected payoffs of the principal and the agent, is such that

(53) $E(S) = E(x) - \psi(e, r)$.

Ghatak and Pandey then characterize the full information benchmark, i.e., the case in which both effort and risk are contractible. Label the choices of $e$ and $r$ which maximize expected social surplus as $e^o$ and $r^o$. Then, the following proposition obtains.[6]

**Proposition 7** *For all linear contracts $\{a, b\}$ in which the limited liability constraint binds and there is moral hazard both in effort and in risk, $e < e^o$ and $r \geq r^0$. For $a > 0$, $r > r^o$.*

Then, Ghatak and Pandey turn to characterizing what would happen first if risk were contractible, then what would happen if labor effort were contractible, which leads to the following two propositions:

[6]The reader interested in the proofs of the propositions we present here is invited to read the original article by Ghatak and Pandey (2000).

**Proposition 8** *If the principal can enforce her preferred level of $r$, the optimal contract is such that $a = 1$ and $b < 0$, and the principal chooses $r = \underline{r}$. In addition, in such a contract, $e < e^o$, i.e., the contract is second-best.*

**Proposition 9** *If the principal can enforce her preferred level of $e$, the optimal contract is such that $a = 0$ and $b > 0$. In addition, the contract is first-best.*

Propositions 9 and 10 indicate that there is a trade-off between the principal's effort to maximize labor effort and to minimize riskiness of the project undertaken by the agent: it is from this trade-off that sharecropping agreements can emerge as the dominant tenurial arrangement when there is limited liability and moral hazard in effort and in risk. Given that the agent's IR constraint must bind in equilibrium, $b$ is clearly a function of $b$, so that $b = b(a)$. Thus, the only instrument at the principal's disposal to trade-off between labor effort and risk is $a$, the slope of the contract. This leads to the following

**Proposition 10** *When neither $e$ nor $r$ can be enforced by the principal, a contract in which $a = 0$ cannot be optimal. Thus, the optimal contract is such that $0 < a \leq 1$. That is, the optimal contract is either a fixed rent or a sharecropping contract.*

The idea behind the Ghatak and Pandey model, however, is to characterize the conditions under which sharecropping emerges as the dominant tenurial agreement. Intuitively, in the presence of both types of moral hazard, the optimal contract is either a fixed rent or a sharecropping contract. What can make the principal move away from a fixed rent contract? Clearly, it has to be when a fixed rent contract induces the agent to take too much risk. Ghatak and Pandey's last proposition characterizes this.

**Proposition 11** *When neither $e$ nor $r$ can be enforced by the principal, if the distribution of $x$ is less sensitive to changes in $e$ than to changes in $r$, sharecropping emerges as the optimal contract.*

In order to test the limited liability hypothesis, one would only need to test the null hypothesis that the presence of a limited liability clause has no effect on the probability of choosing a sharecropping contract relative to the probability of choosing a fixed rent contract. Note that even though the presence of a limited liability clause can seem endogenous to contract choice *a priori*, Ghatak and Pandey take the existence of such a clause as a primitive of their model.

# 4 Empirical Framework

In order to test between the three competing models of share tenancy presented above, I rely on a simple approach involving the estimation of a bivariate probit with selection. The first stage regresses the choice between leasing out a plot of land versus exploiting it oneself and allows to study the determinants of the landowner's decision to lease out. The second stage regresses the choice between a sharecropping or a fixed rent contract and allows to study the determinants of the landlord's contract choice conditional upon having chosen to lease out in the first stage. The second stage also includes three regressors that serve to test between the above competing hypotheses of reverse share tenancy. The following subsections respectively discuss the details of the econometric model and the identification strategy.

## 4.1 Econometric Model

In the first equation, I estimate the determinants of the landowner's decision to lease out versus the decision to exploit her own land. In the second equation, I estimate the determinants of the landlord's decision to lease out on shares versus the decision to lease out on a fixed rent contract, conditional upon having chosen to lease out in the first stage.

Given that the canonical Principal-Agent model of sharecropping posits that $a$, the share of the crop that goes to the tenant, lies in the $[0, 1]$ interval, it might seem *a priori* appropriate to regress $a$ on the covariates thought to affect contract choice using a tobit model with left-censoring at zero and right-censoring at one. Such a naïve approach would however lead to two problems. First, although $a$ can in theory lie anywhere in the $[0, 1]$ interval, what one observes in practice is a handful of focal points, e.g., $a \in \{0, \frac{1}{2}, 1\}$, so that a model which accounts for the discrete, ordered nature of $a$ would be more appropriate. Second, simply regressing $a = 0$ on the same covariates as $0 < a \leq 1$ would lead to false inference by way of selection bias since the decision between leasing out ($0 < a \leq 1$) versus exploiting one's own land ($a = 0$)

and the decision to choose a sharecropping contract ($a \in (0,1)$) versus a fixed rent contract ($a = 1$) are likely driven by different data-generating processes.[7]

Therefore, in what follows, I test between competing theories of reverse share tenancy using a bivariate probit with selection (Van de Ven and Van Praag, 1981) in which the first stage estimates the determinants of leasing out versus exploiting one's plot and the second stage estimates the determinants of contract choice conditional upon having chosen to lease out the plot in the first stage. The model is estimated by full-information maximum likelihood using Stata.

## 4.2 Identification Strategy

In order to properly test between the competing theories of reverse share tenancy presented above, it suffices to regress the choice between sharecropping and fixed rent on plot-level controls, landlord household-level controls, tenant household-level controls, and three variables of interest: (i) the landlord's subjective perception of asset risk; (ii) the landlord's estimated covariance between her marginal indirect utility of income and the staple price; and (iii) an indicator variable equal to one if there is a limited liability clause in the contract and equal to zero if such a clause is absent from the contract.

The landlords' subjective perceptions of asset risk were elicited as follows. Given the contract signed by the landlord with her tenant, i.e., fixed rent or sharecropping, the landlord was given 20 tokens and asked to distribute them between two boxes, one labeled with "0", one labeled with "1". The landlord was told that the latter box represented the probability of losing her claim to the land as a result of the contract signed. Thus, in order to test whether the asset risk model of share tenancy is supported by the data, it suffices to test the null hypothesis that the coefficient of the subjective probability is equal to zero. Failure to reject coupled with a positive coefficient would then mean that the data supports the asset risk hypothesis.

[7]Although it would be ideal to incorporate an ordered probit in the second stage, the data only comprises sharecropping contracts for which the agent's crop share is equal to $\frac{1}{2}$, except for one case in which it is equal to $\frac{2}{3}$. This obviously leaves too little variation in the crop share to use an ordered second stage.

These subjective probabilities are likely endogenous to contract choice, however, given that a landlord's perceived probability that she will lose her claim to the land is influenced by the contract she chooses. In order to instrument for asset risk, I used three instrumental variables: (i) two dummy variables that were equal to one if the security conditions in the village were perceived respectively as good or bad, with the base case being average security conditions; (ii) a variable measuring the number of zebu thefts in the village over the last year; and (iii) a variable that measured the hypothetical perception of asset risk under the alternative contract.[8]

As regards the covariance between the landlords' marginal indirect utility of income and the staple price, following Barrett's (1996) method, I estimated the following production function for marketed surplus $M$:

$$(54)\quad M = \alpha_0 + \alpha_1 \ln \tilde{A} + \alpha_2 \ln \tilde{L} + \alpha_3 \ln \tilde{W} + \alpha_4 \ln P + \sum_{i=2}^{6} \gamma_i C_i + \epsilon,$$

where $A$ denotes the amount of cultivable land a landlord owns, $L$ denotes the amount of household labor available to the landlord, $W$ denotes a landlord household's income, $P$ is a household-specific price measure for the staple, and $C_i$ is a dummy variable equal to one if the landlord resides in commune $i$ and zero otherwise.[9] Note that a tilde indicates a variable that was normalized by subtracting its mean and dividing by its standard error. Due to a mistake in survey design, I had to generate observations for the amount of land owned by a subset of the landlords in the dataset. Results of this regression are omitted for brevity but are available upon request.

Estimating the marketed surplus production function above allowed me to compute $\beta$, the budget share of marketed surplus, and $\eta$, the income-elasticity of marketed surplus. In order to compute $Cov(V_w, p) = \beta(\eta - R)$, I then had

[8]The perception of asset risk under the alternative contract simply asked landlords what their perception of asset risk would be were they to sign the alternative contract. The two asset risk questions, i.e. our variable of interest and our instrument, were asked in two separate survey instruments fielded four months apart. This eliminates the risk of anchoring one answer to the other (cf. Tversky and Kahneman, 1982, and Hastie and Dawes, 2001), thereby eliminating any spurious correlation between our variable of interest and our instrument.

[9]In Madagascar, a commune is an administrative roughly equivalent to a county in the United States.

to make an assumption regarding $R$, the Arrow-Pratt coefficient of relative risk aversion, given that I do not have the data to estimate this coefficient. Following Barrett (1996), I made two alternative assumption: (i) $R_1 = 2$ for every landlord in the dataset; and (ii) $R_2 = 1.5$ for landlords whose endowment of land is less than 50 ares, with an increment of 0.2 in $R_2$ for each 25-are interval, for a maximum of 2.5 for landlords whose endowment of land is above 200 ares. Note that given that $\beta$, $\eta$, and $R$ are given by the preferences of the landlords, the covariance term is strictly exogenous to contract choice.

Finally, as regards the limited liability variable, it is simply an indicator variable equal to one if there is an implicit or explicit limited liability clause in the contract and equal to zero if there is no such clause. This limited liability clause is likely determined jointly with the dependent variable, however, and ideally, one would instrument for it by interacting a dummy variable for whether or not the tenant chooses the agricultural technique on the leased out plot with the number of techniques available on the plot. Note that the dataset includes both these variables, but that using this instrument does not take care of the endogeneity problem since the technique choice dummy is also endogenous to contract choice. The truth of the matter is that the dataset does not include a valid instrument for limited liability, but the Ghatak and Pandey model assumes that limited liability is a primitive and is therefore exogenous to contract choice. Whether that is true or not, it is unfortunately the best one can do given the dataset at hand.

# 5 Data and Descriptive Statistics

The data used in the following sections were collected in Lac Alaotra, Madagascar, between March and August 2004 under the *Enquête sur la location des parcelles de terre*. Lac Alaotra lies about 300 km northeast of Antananarivo, the capital, and is the country's most important rice-producing region. Rice being the staple of Malagasy diet, and sharecropping being mainly observed on rice plots in Madagascar, it makes sense to choose this region to conduct one of the first empirical studies of share tenancy in Madagascar.[10]

[10]The only other empirical studies of share tenancy in Madagascar I know were conducted by Jarosz (1991, 1994). To my knowledge, this paper is the first study that combines formal theoretical modelling and econometric evidence on sharecropping in Madagascar.

The survey methodology was as follows. First, the six communes with the highest density of sharecropping around Lac Alaotra were selected from the 2001 commune census conducted by Cornell University in collaboration with INSTAT and FOFIFA. Then, the two villages with the highest density of sharecropping were chosen in each commune after determining the density of sharecropping in each village by going through communal records. In each village, five households known not to lease in or lease out land were selected, five households known to lease in or lease out under a fixed rent contract were selected, and fifteen households known to lease in or lease out under a sharecropping contract were selected. All households were from within the sampling frame in each village. The end result is a sample of 300 selected households, i.e., 25 households in twelve villages.

For each selected household, plot-, household- and contract-level data were collected. I then collected household- and (leased-in) plot-level data for the tenants of the 300 selected households as well as household-level and contract-level data for the landlords of the 300 selected households. This quasi snowball sampling approach makes for a richer dataset and, to our knowledge, the *Enquête sur la location des parcelles de terre* is the first survey to use such a sampling methodology: most studies usually select households and find either their landlords or their tenants, but not both. Bellemare (2005a) presents a detailed discussion of the survey methodology and of the survey instruments.

Table 1 presents summary statistics for the plots owned by the 300 selected households. Almost 40 percent of plots are leased out, and the average plot covers 1.3 hectare.[11] The vast majority of plots are rice paddies, with only 21 percent of plots being *tanety* (hillside plots) and 12 percent of plots being lowlands.[12] The average distance between the plot and the landowner's house (in walking minutes) is about 40 minutes and over 30 percent of plots in the dataset are plots that have been previously owned by the landowner's family. In case of a cyclone, the average plot takes two and a half days to evacuate excess water, and the average number of fady[13] days per plot is one day per

[11]One are is equal to 100 $m^2$, or approximately 0.025 acre.

[12]In this study, "lowland" refers to lowland plots on which crops other than rice are grown.

[13]The term "fady" roughly translates as "forbidden" or "taboo" in English. Fady days are days on which agricultural work is prohibited. For an interesting account of the mul-

week (usually Thursday).

Turning to household-level covariates, note that the average household size is a little over six individuals, and that the average household's dependency ratio is over 0.4.[14] The average household head is 50 years of age and has about five years of formal education and 25 years of agricultural experience. Moreover, approximately 10 percent of household heads are female. One third of all households are liquidity constrained, as proxied by whether they asked for a bank loan, a microfinance loan or an informal loan and were denied such loans over the last year, and the average number of fady days per household is significantly higher than the number of such days per plot. Finally, household income[15] was about \$60 per capita in the year preceding the survey, while the average household has about \$450 worth of working capital and about \$150 worth of assets per capita.[16]

Table 2 presents similar descriptive statistics for the sub-sample of contracted plots. In the sample, 69 percent of plots are sharecropped, which provides ample variation to study the determinants of contract choice. The average leased out plot covers a little over one hectare, and about 85 percent of contracted plots are rice plots, reflecting the importance of rice in the Malagasy diet, and the average leased out plot is about 30 walking minutes from the landlord's house. Finally, note that one fifth of leased out plots were previously owned by the landlord's family before she took possession of her plot.

Comparing landlord and tenant households, we notice that household characteristics are essentially the same between parties to the contract but that landlords tend to be significantly older and are much more likely to be female

titude of fady observed by the Malagasy, see Ruud (1960). For a discussion of fady days for the Sihanaka, the dominant ethnic group in Lac Alaotra, see Jarosz (1994).

[14]By adding the number of individuals under 15 and the number of individuals over 64 and dividing this sum by the total number of individuals in the household, one obtains the dependency ratio, which is a proxy for the degree of dependency within the household.

[15]Although the currency in Madagascar is now the Malagasy franc (FMG), peasants are generally more used to using the old ariary denomination, where 1 ariary = 5 FMG, with \$1 $\approx$ 10,000 FMG.

[16]I define the value of the household's working capital as the sum of the values of the its hoe, harrow, cart, plow, tractor, and small tractor known in Lac Alaotra by its brandname (Kubota). I then define the value of the household's assets as the sum of the values of its non-productive assets, i.e., house, television, radio, car, and bank account balance.

than their tenants, and that while tenant households have more working capital than landlord households, the latter have higher incomes and more assets per capita than the former. Note, however, that regarding the incidence of reverse share tenancy in the dataset, the landlord household had lower income and assets per capita than the tenant household in about half of the cases, and the landlord household had less working capital than the tenant household in about three-quarters of the cases. Looking at absolute rather than per capita numbers and summing over assets and working capital, the proportion of landlord households who had less assets and working capital than their tenant households was also about half of the dataset, which allows for proper testing regarding reverse share tenancy as well as traditional sharecropping.

As regards the variables of interest, i.e., the variables that will allow testing between competing theories of reverse share tenancy, note that the 20-token subjective binomial distribution of asset risk has a low mean, i.e., the landlord perceived that the probability that she would lose her land as a result of the contract signed was about 1 percent. Finally, about 55 percent of contract included an explicit limited liability clause, and the covariances between marginal indirect utility of income and the price of the staple under both assumptions for the Arrow-Pratt coefficient of relative risk aversion were respectively $-7.6$ and $-6.5$, two numbers whose magnitude cannot be readily interpreted, but whose signs indicate that the average household in our dataset is a net seller, which is consistent with Lac Alaotra being the biggest rice-producing region in Madagascar.

Note that for brevity, tables 1 and 2 do not include the descriptive statistics for the plot-level controls (e.g., type of protection structure, toposequence, soil characteristics, slope, and irrigation source) used in the following estimation, but that these descriptive statistics are available upon request.

# 6 Estimation Results and Analysis

This section presents the estimation results for the econometric model outlined in section 4. I first present the results of nonparametric regressions of contract choice on the variables of interest in order to know whether the relationships between contract choice and these variables are consistent with the theoretical predictions of section 3. After presenting the results of the bivariate probit with selection, estimation results for two separate probits – one for the first-stage equation, one for the second-stage equation – are presented. I then discuss robustness checks comparing the full sample with the reverse tenancy sample, using alternative definitions of wealth to compare landlords and tenants.

## 6.1 Nonparametric Regressions

In order to determine whether the variables of interest in testing between competing theories of reverse share tenancy have the predicted effect on contract choice, I first ran four nonparametric regressions. Figures 1 to 4 present the results of Nadaraya-Watson nonparametric regressions of contract choice on the instrumented subjective asset risk probability distributions, on the covariance between marginal indirect utility of income and the staple price under both assumptions made for the Arrow-Pratt coefficient of relative risk aversion, and on the limited liability dummy. Note that in what follows, the dependent variable is equal to one if the landlord chose a sharecropping agreement and is equal to zero if the landlord chose a fixed rent contract.

Estimation results for the asset risk instrumenting regression are presented in table 8 below, and figure 1 presents the nonparametric regression of contract choice on instrumented asset risk. From that figure, it appears that the more asset risk the landlord perceives, the more likely she will be to choose a sharecropping agreement, and that the relationship between the two variables is monotonic. The asset risk variable therefore has the expected effect on the dependent variable. Estimation results for the marketed surplus production function discussed in section 4.2 are presented in table 7 below, and figures 2 and 3 present nonparametric regressions of contract choice on $Cov_1(V_w, p)$ and $Cov_2(V_w, p)$. The relationship between contract choice and the variable of interest, albeit non-monotonic, seems to be positive, which is also consistent with the theoretical model of section 3. Finally, in figure 4, the relationship between contract choice and the limited liability clause dummy is positive and monotonic, a result that is consistent with the Ghatak-Pandey framework.

It thus appears that all four variables of interest have, *a prima facie*, the predicted effect on contract choice. These nonparametric regressions, however, only crudely regress contract choice on the variables of interest, since they fail to control for other factors which might affect contract choice at the margin. In order to truly test between the three hypotheses presented in section 3, I now turn to the parametric model.

## 6.2 Bivariate Probit with Selection

Tables 4 and 5 present the estimation results for the first stage and the second stage of the bivariate probit with selection, respectively. The first stage regresses a dummy variable equal to one if the plot is leased out and equal to zero if the plot is exploited by the landowner on a set of plot- and household-level covariates. The estimation results omit a subset of the plot-level covariates as well as the commune dummies for brevity, but those are available upon request.

The fact that a plot has been previously owned by a landowner's family decreases the likelihood that it will be leased out. In Madagascar, where the land of one's ancestors (*tanindrazana*) is seen as sacred, it makes sense for landowners to lease out the plots they have acquired in their lifetime before leasing out plots they have inherited, especially if there's a certain amount of tenurial insecurity.

As regards the landowner's household, higher dependency ratios and smaller household sizes make the plot less likely to be leased out. These results are intuitive: a higher dependency ratio is associated with less efficient household labor, and a larger household with more household labor. For the Sihanaka of Lac Alaotra, working on other's plots on wages is perceived as equivalent to slavery (Jarosz, 1994), so that hired laborers are hard to find. It is therefore not surprising that households whose resources are more strained are more likely to lease out and that larger households are less likely to lease out.

Unsurprisingly, the landowner's age and gender have an important impact on the probability that a plot will be leased out. Conventional wisdom among policymakers and other social scientists who have studied land tenancy in Madagascar is that the landlords in reverse share tenancy agreements are typically single, elderly women, i.e., the "stylized widow" hypothesis. Whether this is true or not, it appears from the first-stage results that single, elderly women are at the very least more likely to lease out their plots. Additionally, the more agricultural experience a landowner has, the less likely it is for the plot to be leased out.

Turning to the economic variables of interest, it is surprising to find that the amount of working capital of the landowners has no effect on the probability that a plot will be leased out. The higher the household assets per capita, however, the less likely it is for a landowner to lease out, so that assets other than working capital might explain why landlords choose to lease out their plots. As for household income per capita, the higher it is, the more likely the landowner is to lease out, which likely captures the opportunity cost of landowners who have sources of income other than agriculture.

The second stage regresses a dummy variable equal to one if the plot is leased out on a sharecropping agreement and equal to zero if the plot is leased out on a fixed rent contract on a set of plot-, landlord (L) household- and tenant (T) household-level covariates. Once again, the estimation results omit a subset of the plot-level covariates as well as the commune dummies for brevity, but those are available upon request.

At the plot-level, the larger the plot, the more likely it is to be leased out on a sharecropping agreement. If landlords are concerned with their subsistence, then it makes sense for them to choose to get paid in kind on larger plots given that those typically have a higher yield than smaller plots, *ceteris paribus*. Turning to the landlord household-level covariates, the age of the landlord actually decreases the likelihood that the tenant will be offered a sharecropping agreement, contrary to what the "stylized widow" hypothesis states. It thus appears that single, elderly women are more likely to lease out their plots, but that gender does not matter when it comes to contract choice, and that age has an effect opposite to what the conventional wisdom states. As for the number of other potential tenants considered by the landlord, it decreases the likelihood that a tenant will be offered a sharecropping contract, which likely reflects a better bargaining position for the landlord, who elects to bear less production risk when faced with more potential tenants.

As for the tenant household-level covariates, the larger the tenant household's size, the more likely the tenant is to be offered a fixed rent contract over a sharecropping agreement, and the higher the tenant household's dependency ratio, the more likely the tenant is to be offered a sharecropping contract. It thus seems that the less strained the tenant household's resources are, and the more household labor the tenant has, the more the tenant will have to bear production risk. The older the tenant, the more likely he is to be offered a sharecropping agreement. Finally, the more educated the tenant, the less likely he is to be offered a sharecropping contract, which might reflect better risk-management abilities on the tenant's part.

As regards testing between competing theories of reverse share tenancy, both the instrumented asset risk variable and the limited liability clause dummy have the expected sign, but of all three variables of interest, only the latter is statistically significant. It thus appears that limited liability is the only explanation that accounts for the emergence of share tenancy in Lac Alaotra. This result should be taken with a grain of salt, however, given that it is likely that the limited liability clause dummy is endogenous to contract choice and that there are unfortunately no good instruments in the dataset. Still, this is the best one can do with the data at hand.

## 6.3 Separate Probits

Given that the coefficient of correlation between the two equations of the bivariate probit with selection is not statistically different from zero, I estimated the two equations again using two separate probit models. The results of the first-stage equation do not change substantially except for the household income per capita variable, which drops out of significance.

As for the results of the second-stage equation, it turns out that a contract between kin makes sharecropping less likely. This result is puzzling, especially if one assumes that there is altruism in contracts between kin, which should lead to the landlord being more prone to sharing production risk with the tenant. The tenant household's amount of working capital increases the probability that a sharecropping agreement will be signed between the parties, and the tenant household's assets per capita decrease the probability of a sharecropping agreement. The latter result is not surprising, since richer tenants are in a better position to bear risk than poorer ones.

As regards the variables of interest, limited liability is still the only variable that is statistically significant, but it has now become the only variable of interest that has the expected sign. This offers additional support for the limited liability hypothesis, and in the next section, the robustness of this result is discussed.

### 6.4 Robustness Checks

The results of the preceding sub-sections were estimated using the full sample of land tenancy in Lac Alaotra, which means that these results serve to explain both traditional and reverse tenancy agreements, i.e., tenancy agreements between landlords and tenants as a whole, but to truly discuss reverse share tenancy, it is necessary to look at the sub-sample of cases where the tenant is richer than the landlord.

In order to do so, I use three definitions of wealth: (i) the sum of household working capital and assets; (ii) household working capital; and (iii) household assets. For these definitions, there were respectively 190, 242, and 190 cases in which the tenant was wealthier than the landlord. The second-stage probit of table 6 was thus re-estimated based on these reverse share tenancy sub-samples. Results are omitted for brevity and are available upon request, but the main result is unchanged, i.e., limited liability is still the driving factor behind the emergence of sharecropping in the reverse tenancy sample. From these empirical results, it thus appears that the Ghatak-Pandey limited liability hypothesis is strongly supported by the data and can explain the emergence of both traditional sharecropping and reverse share tenancy contracts in Lac Alaotra.

## 7 Conclusion

This paper has presented three theoretical explanations that broaden the theory of share tenancy by accommodating the existence of reverse share tenancy contracts and has tested these theories against one another using field data from Lac Alaotra, Madagascar's most important rice-producing region. The estimation results, indicate that the limited liability hypothesis best explains the emergence of share tenancy, both traditional and reverse, with one *caveat*: since the limited liability variable is likely endogenous to contract choice, and since there are no valid instruments in the dataset, the results should be taken with a grain of salt.

From a policy perspective, these results indicate the need to develop crop insurance markets, or at the very least provide agricultural households with better access to credit so that risk-averse landlords can lease out on fixed rent contracts and thus avoid bearing some of the production risk without fearing that their tenants' limited liability constraint will bind.

To my knowledge, this paper is the first to present formal theories of reverse share tenancy as well as to offer econometric evidence, both nonparametric and parametric, on this oft-observed phenomenon. Yet there is much work left to be done, as reverse share tenancy has been discussed in the context of several other countries and as panel data would be necessary to test the dynamic implications of reverse share tenancy contracts. Further data will thus be needed to test our hypotheses in other settings and elaborate a theory of share tenancy that will likely encompass most situations of reverse share tenancy.

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Figure 1: Nonparametric Regression of Contract Choice on Instrumented Asset Risk Binomial Distribution.

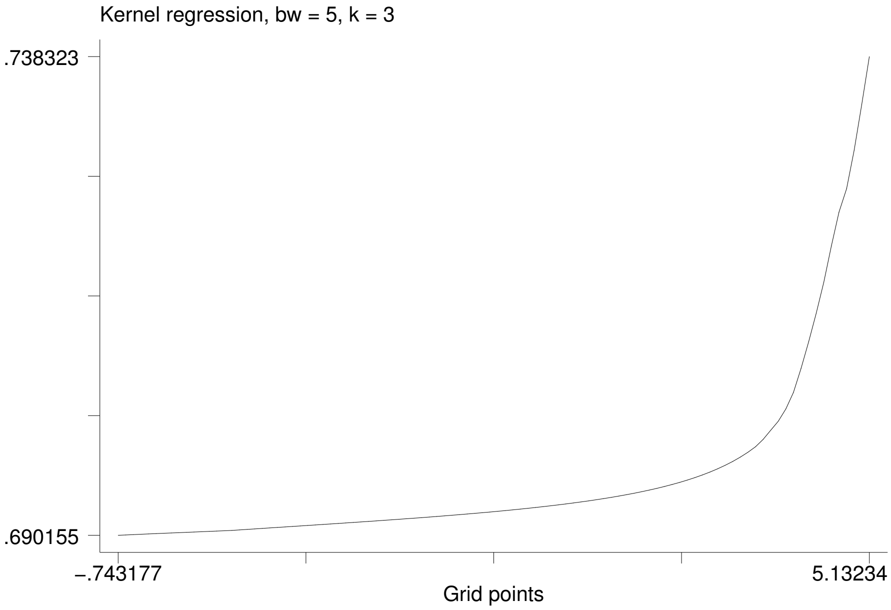


Figure 2: Nonparametric Regression of Contract Choice on $Cov_1(V_w, p)$.

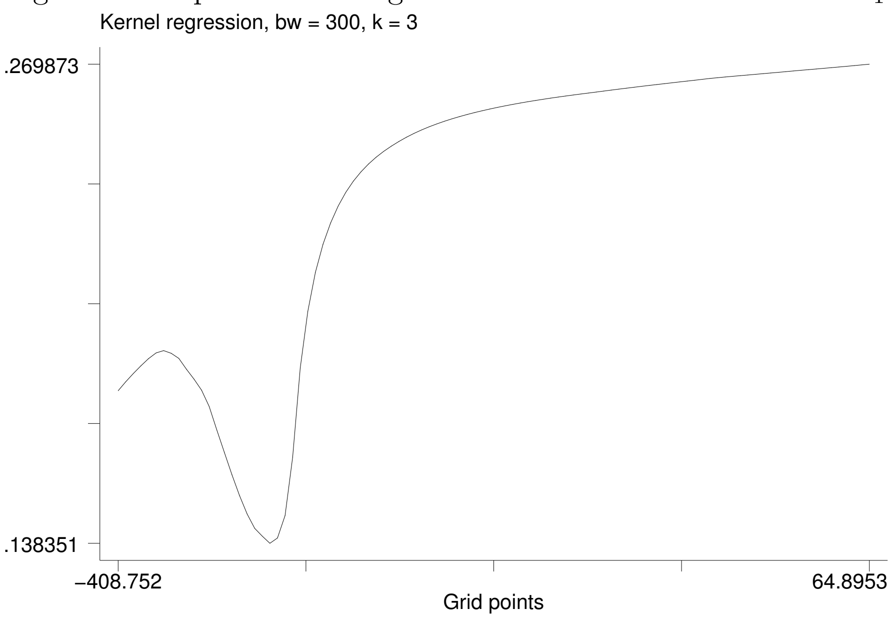

Figure 3: Nonparametric Regression of Contract Choice on $Cov_2(V_w, p)$.

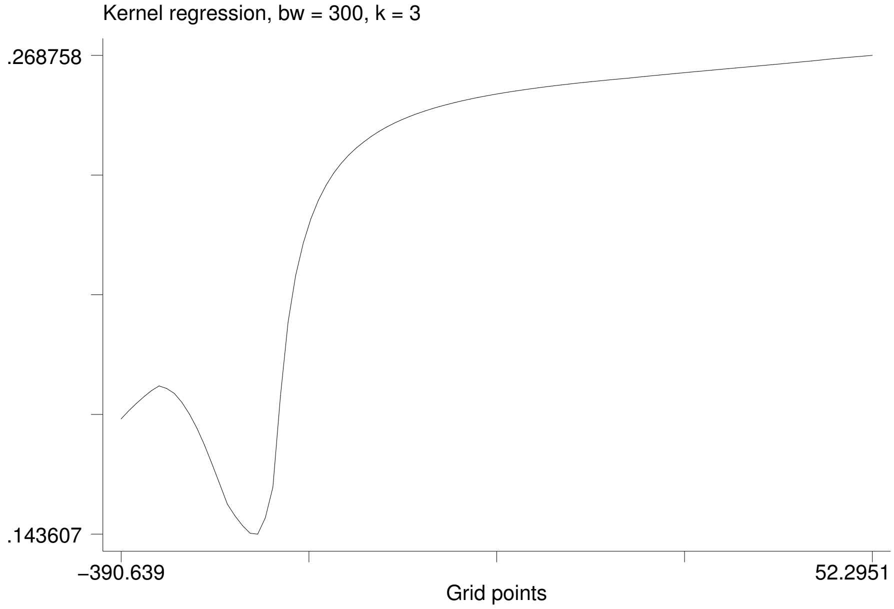


Figure 4: Nonparametric Regression of Contract Choice on Limited Liability.

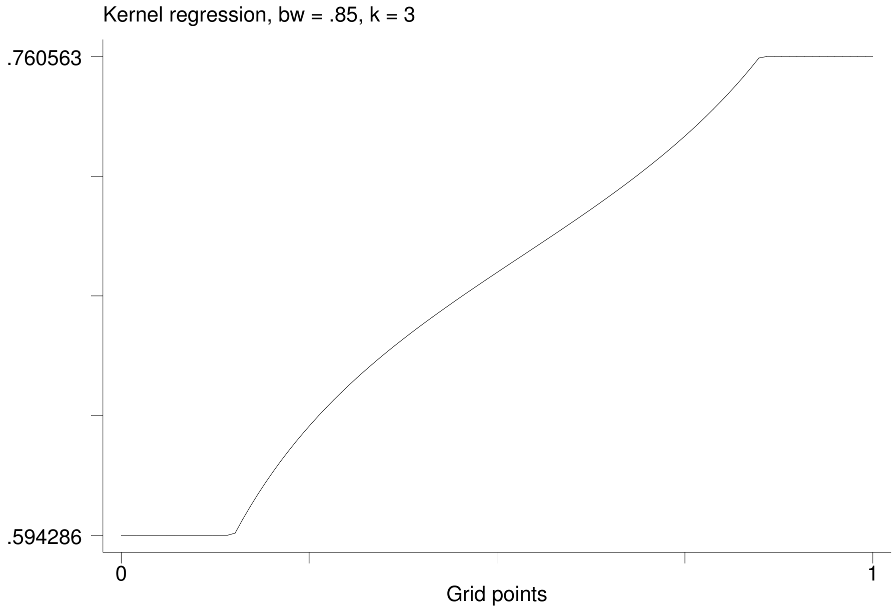

Table 1: Summary Statistics for the First-Stage Decision

| Variable | Mean | Std. Dev. | N |
|---|---|---|---|
| Leased Out Dummy | 0.386 | 0.487 | 1029 |
| Plot Area (Ares) | 132.63 | 395.878 | 1005 |
| Tanety Dummy | 0.207 | 0.405 | 1029 |
| Lowland Dummy | 0.122 | 0.328 | 1029 |
| Distance from House (Walking Minutes) | 38.68 | 46.668 | 1005 |
| Family-Owned Plot Dummy | 0.322 | 0.467 | 1029 |
| Days to Evacuate Plot | 2.554 | 5.183 | 1005 |
| Fady Days on Plot | 54.347 | 44.18 | 997 |
| Dependency Ratio | 0.418 | 0.225 | 1005 |
| Household Size (Individuals) | 6.183 | 2.754 | 1005 |
| Age (Years) | 49.963 | 14.204 | 1005 |
| Female Dummy | 0.11 | 0.314 | 1005 |
| Education (Years) | 5.532 | 3.666 | 1005 |
| Agricultural Experience (Years) | 25.784 | 15.034 | 915 |
| Fady Days for Landowner | 65.142 | 41.962 | 1005 |
| Liquidity Constraint Dummy | 0.322 | 0.467 | 963 |
| Income Per Capita (100,000 Ariary) | 1.17 | 2.57 | 998 |
| Working Capital (100,000 Ariary) | 9.045 | 28.879 | 998 |
| Liquidity Constraint*Working Capital | 2.796 | 13.438 | 956 |
| Assets Per Capita (100,000 Ariary) | 3.043 | 6.246 | 989 |

Table 2: Summary Statistics for the Second Stage Decision

| **Variable** | **Mean** | **Std. Dev.** | **N** |
|---|---|---|---|
| Sharecropping Dummy | 0.687 | 0.464 | 387 |
| Plot Area (Ares) | 108.829 | 84.761 | 397 |
| Tanety Dummy | 0.068 | 0.252 | 397 |
| Lowland Dummy | 0.088 | 0.284 | 397 |
| Distance from L House (Walking Minutes) | 33.688 | 37.215 | 397 |
| Family-Owned Plot Dummy | 0.199 | 0.4 | 397 |
| L Household Size (Individuals) | 5.478 | 2.803 | 389 |
| L Household Dependency Ratio | 0.451 | 0.252 | 389 |
| L Age (Years) | 53.308 | 16.366 | 389 |
| L Female Dummy | 0.198 | 0.399 | 389 |
| L Education (Years) | 5.419 | 3.886 | 389 |
| L Liquidity Constraint Dummy | 0.254 | 0.436 | 382 |
| L Working Capital (100,000 Ariary) | 5.307 | 25.869 | 388 |
| L Assets Per Capita (100,000 Ariary) | 2.715 | 6.501 | 382 |
| L Income Per Capita (100,000 Ariary) | 1.157 | 2.344 | 388 |
| Other Tenants Considered (Individuals) | 1.763 | 2.869 | 389 |
| Relationship Length (Years) | 2.54 | 3.644 | 388 |
| Kin Contract Dummy | 0.627 | 0.484 | 397 |
| T Household Size (Individuals) | 5.766 | 2.557 | 394 |
| T Household Dependency Ratio | 0.413 | 0.217 | 394 |
| T Age (Years) | 39.084 | 11.098 | 394 |
| T Female Dummy | 0.015 | 0.123 | 394 |
| T Education (Years) | 5.962 | 3.424 | 394 |
| T Agricultural Experience (Years) | 17.951 | 11.044 | 385 |
| T Liquidity Constraint Dummy | 0.371 | 0.484 | 375 |
| T Working Capital | 6.028 | 16.734 | 393 |
| T Assets Per Capita (100,000 Ariary) | 1.709 | 2.773 | 393 |
| T Income Per Capita (100,000 Ariary) | 0.936 | 1.502 | 393 |
| Asset Risk Subjective Distribution | 0.183 | 1.192 | 388 |
| Limited Liability Dummy | 0.549 | 0.498 | 388 |
| $Cov_1(V_w, p) = \beta(\eta - R_1)$ | -7.606 | 36.64 | 342 |
| $Cov_2(V_w, p) = \beta(\eta - R_2)$ | -6.596 | 31.877 | 342 |

Table 3: Estimation Results for the First Stage of the Bivariate Probit

| Variable | Coefficient | (Std. Err.) |
|---|---|---|
| Plot Area | -0.001 | (0.001) |
| Tanety | -0.121 | (0.347) |
| Lowland | 0.219 | (0.320) |
| Distance from House | -0.001 | (0.001) |
| Family-Owned Plot | -0.531*** | (0.129) |
| Days to Evacuate Plot | -0.014 | (0.011) |
| Fady Days on Plot | 0.000 | (0.002) |
| Dependency Ratio | 0.644** | (0.279) |
| Household Size | -0.098*** | (0.024) |
| Age | 0.020*** | (0.006) |
| Female | 0.397* | (0.203) |
| Education | 0.018 | (0.021) |
| Agricultural Experience | -0.009* | (0.005) |
| Fady Days for Landowner | 0.000 | (0.002) |
| Liquidity Constraint | -0.110 | (0.135) |
| Income Per Capita | 0.062** | (0.029) |
| Working Capital | 0.001 | (0.002) |
| Liquidity Constraint*Working Capital | -0.003 | (0.005) |
| Assets Per Capita | -0.080*** | (0.020) |
| Intercept | -1.251* | (0.674) |

Significance Levels : $*$ : 10% $**$ : 5% $***$ : 1%

Table 4: Estimation Results for the Second Stage of the Bivariate Probit

| Variable | Coefficient | (Std. Err.) |
|---|---|---|
| Plot Area | 0.005*** | (0.002) |
| Tanety | 1.549 | (1.169) |
| Lowland | 0.509 | (0.935) |
| Distance from P House | -0.002 | (0.003) |
| Family-Owned Plot | 0.164 | (0.395) |
| L Household Size | 0.092 | (0.077) |
| L Household Dependency Ratio | 0.145 | (0.648) |
| L Age | -0.029*** | (0.011) |
| L Female | -0.096 | (0.430) |
| L Education | -0.052 | (0.044) |
| L Liquidity Constraint | 0.252 | (0.331) |
| L Working Capital | 0.014 | (0.010) |
| L Assets Per Capita | 0.026 | (0.076) |
| L Income Per Capita | 0.011 | (0.082) |
| Other Tenants Considered | -0.129* | (0.071) |
| Relationship Length | 0.017 | (0.058) |
| Kin Contract | -0.423 | (0.259) |
| T Household Size | -0.168** | (0.071) |
| T Dependency Ratio | 2.324*** | (0.764) |
| T Age | 0.040** | (0.020) |
| T Female | -1.230 | (0.866) |
| T Education | -0.072* | (0.041) |
| T Agricultural Experience | -0.025 | (0.017) |
| T Liquidity Constraint | 0.171 | (0.264) |
| T Working Capital | 0.015 | (0.010) |
| T Assets Per Capita | -0.063 | (0.053) |
| T Income Per Capita | -0.031 | (0.068) |
| Asset Risk (Instrumented) | 0.100 | (0.441) |
| Limited Liability Clause | 1.442*** | (0.334) |
| $Cov_1(V_w, p)$ | -0.007 | (0.004) |
| Intercept | 0.974 | (2.544) |
| $\rho(\widehat{\epsilon_1}, \widehat{\epsilon_2})$ | -0.249 | (0.984) |
| N | 778 | |
| Log-likelihood | -458.141 | |
| $\chi^2_{(42)}$ | 58.648 | |

Table 5: Estimation Results for the First-Stage Probit

| Variable | Coefficient | (Std. Err.) |
|---|---|---|
| Plot Area | -0.001 | (0.001) |
| Tanety | -0.236 | (0.308) |
| Lowland | 0.207 | (0.288) |
| Distance from House | -0.001 | (0.001) |
| Family-Owned Plot | -0.483*** | (0.117) |
| Days to Evacuate Plot | -0.014 | (0.010) |
| Fady Days on Plot | 0.001 | (0.002) |
| Dependency Ratio | 0.673*** | (0.253) |
| Household Size | -0.113*** | (0.022) |
| Age | 0.018*** | (0.005) |
| Female | 0.571*** | (0.178) |
| Education | 0.028 | (0.019) |
| Agricultural Experience | -0.006 | (0.005) |
| Fady Days for Landowner | -0.001 | (0.001) |
| Liquidity Constraint | -0.086 | (0.124) |
| Income Per Capita | 0.018 | (0.026) |
| Working Capital | 0.000 | (0.002) |
| Liquidity Constraint*Working Capital | -0.006 | (0.006) |
| Assets Per Capita | -0.031*** | (0.011) |
| Intercept | -0.931 | (0.593) |
| N | 838 | |
| Log-likelihood | -421.180 | |
| $\chi^2_{(33)}$ | 238.618 | |
| Pseudo-$R^2$ | 0.2625 | |

Table 6: Estimation Results for the Second-Stage Probit

| Variable | Coefficient | (Std. Err.) |
|---|---|---|
| Plot Area | 0.004*** | (0.002) |
| Tanety | 1.117 | (0.985) |
| Lowland | 0.227 | (0.776) |
| Distance from P House | -0.002 | (0.003) |
| Family-Owned Plot | 0.009 | (0.270) |
| L Household Size | 0.048 | (0.043) |
| L Dependency Ratio | 0.137 | (0.429) |
| L Age | -0.009 | (0.008) |
| L Female | 0.071 | (0.289) |
| L Education | -0.014 | (0.032) |
| L Liquidity Constraint | 0.225 | (0.261) |
| L Working Capital | 0.011 | (0.009) |
| L Assets Per Capita | 0.000 | (0.023) |
| L Income Per Capita | -0.012 | (0.049) |
| Other Tenants Considered | -0.086* | (0.045) |
| Relationship Length | 0.009 | (0.026) |
| Kin Contract | -0.570*** | (0.220) |
| T Household Size | -0.143*** | (0.055) |
| T Dependency Ratio | 2.169*** | (0.564) |
| T Age | 0.029* | (0.016) |
| T Female | -0.919 | (0.791) |
| T Education | -0.094*** | (0.034) |
| T Agricultural Experience | -0.019 | (0.015) |
| T Liquidity Constraint | -0.079 | (0.219) |
| T Working Capital | 0.017* | (0.009) |
| T Assets Per Capita | -0.083* | (0.045) |
| T Income Per Capita | -0.049 | (0.061) |
| Asset Risk (Instrumented) | -0.023 | (0.293) |
| Limited Liability Clause | 1.258*** | (0.229) |
| $Cov_1(V_w, p)$ | -0.005 | (0.004) |
| Intercept | 0.641 | (1.671) |
| N | 295 | |
| Log-likelihood | -132.592 | |
| $\chi^2_{(42)}$ | 94.374 | |
| Pseudo-$R^2$ | 0.2207 | |

Table 7: Estimation Results for the Marketed Surplus Production Function

| **Variable** | **Coefficient** | **(Std. Err.)** |
|---|---|---|
| Log Land | $0.302^{***}$ | (0.029) |
| Log Labor | $0.157^{***}$ | (0.030) |
| Log Income | 0.039 | (0.030) |
| Log Price | $-1.182^{***}$ | (0.341) |
| Commune 2 Dummy | $0.175^{*}$ | (0.097) |
| Commune 3 Dummy | $0.401^{***}$ | (0.097) |
| Commune 4 Dummy | $0.495^{***}$ | (0.099) |
| Commune 5 Dummy | $0.214^{**}$ | (0.096) |
| Commune 6 Dummy | $0.683^{***}$ | (0.104) |
| Intercept | $6.980^{***}$ | (2.107) |
| N | 986 | |
| $R^2$ | 0.182 | |
| $F_{(9,976)}$ | 24.147 | |

Table 8: Estimation Results for Instrumentation of Asset Risk

| **Variable** | **Coefficient** | **(Std. Err.)** |
|---|---|---|
| Dependency Ratio | -0.382 | (0.259) |
| L Age | -0.026 | (0.023) |
| L Age Squared | 0.000 | (0.000) |
| L Female | 0.300* | (0.158) |
| L Sihanaka Dummy | 0.165 | (0.299) |
| L Agricultural Activity Dummy | 0.161 | (0.159) |
| L Income Per Capita | -0.022 | (0.028) |
| L Assets Per Capita | -0.001 | (0.010) |
| L Working Capital Per Capita | 0.000 | (0.000) |
| L Liquidity Constraint | 0.228 | (0.146) |
| Tanety | -0.058 | (0.294) |
| Lowland | -0.314 | (0.278) |
| Distance from House | 0.001 | (0.002) |
| Distance from Road | 0.013*** | (0.004) |
| Irrigated Plot Dummy | -0.023 | (0.193) |
| Good Soil Dummy | -0.124 | (0.152) |
| Bad Soil Dummy | -0.115 | (0.224) |
| Family-Owned Plot | 0.077 | (0.161) |
| Same Ethnic Group Dummy | -0.127 | (0.255) |
| Kin Contract | 0.059 | (0.142) |
| T Age | 0.001 | (0.035) |
| T Age Squared | 0.000 | (0.000) |
| T Income Per Capita | 0.071* | (0.042) |
| T Assets Per Capita | -0.025 | (0.026) |
| T Working Capital Per Capita | 0.000 | (0.000) |
| Good Security Conditions Dummy | -3.236*** | (1.026) |
| Bad Security Conditions Dummy | -0.149 | (0.229) |
| Zebu Thefts | 0.073*** | (0.020) |
| Crop Thefts | -0.006 | (0.012) |
| Burglaries | -0.106 | (0.153) |
| Hypothetical Asset Risk | 0.080** | (0.035) |
| Intercept | 0.857 | (1.034) |
| N | 371 | |
| $R^2$ | 0.256 | |
| $F_{(36,334)}$ | 3.2 | |