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Abstract

This paper tests between three theories of reverse share tenancy, a contract by which a poor landlord leases out 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 Lac Alaotra, Madagascar, I find empirical support for the Stiglitzian risk-sharing hypothesis as well as the asset risk and limited liability hypotheses in the full sample, but find empirical support only for the asset risk and limited liability hypotheses in the restricted sample of reverse tenancy, thereby indicating the need to broaden the canonical model of sharecropping so as to account for reverse share tenancy.

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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 Adam Smith's *The Wealth of Nations*. Two and a half centuries later, the canonical explanation for the existence of sharecropping, following Cheung (1969a), 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.

There exist nevertheless situations of reverse share tenancy, in which a poor landlord contracts with a rich tenant on shares, and these situations do not necessarily 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.[2,3]

In this paper, I present three theoretical models of sharecropping that broaden the theory of share tenancy by being consistent with both reverse share tenancy as well as traditional sharecropping contracts, and then test between them using field data from Lac Alaotra, Madagascar's most important rice-producing region. The first model explains sharecropping as the result of

[1]Another strand in the literature on sharecropping is that on transactions cost, which started with Cheung (1968, 1969b). 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.

[3]It is unfortunately impossible to present statistics for the prevalence of reverse share tenancy throughout the world. Reverse tenancy – reverse fixed rent and/or reverse sharecropping – has gotten some attention due to its prevalence in Lesotho (Lawry, 1993), South Africa (Lyne and Thomson, 1995), Ethiopia (Little et al., 2003, and Tikabo and Holden, 2003), Bangladesh (Pearce, 1983), Malaysia (Pearce, 1983), Mexico (Colin and Bouquet, 2001), India (Pearce, 1983; IFPRI, 2002), and the Philippines (Roumasset, 2002).

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 – a likely situation in places where property rights are weak or insecure – 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. 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 the tenant can 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. Since situations where the principal is risk-averse and the agent is risk-neutral are not exclusive to developing countries, I also discuss a few examples of situations in which some of the theoretical models presented in this paper might apply.

After presenting these competing models of reverse share tenancy, I proceed to test them empirically using field data. I find that the asset risk and limited liability explanations, along with the Stiglitzian risk-sharing hypothesis, explain the emergence of sharecropping in Lac Alaotra, but that only the asset risk and limited liability hypotheses are supported by the data in the sub-sample of reverse share tenancy, thereby indicating the need for a broadening of the Stiglitzian framework.

The rest of the paper is organized as follows. In section 2, I briefly review the empirical literature on sharecropping. Section 3 presents 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 discusses the survey methodology and presents some summary statistics. In section 6, I present and analyze the estimation results. Section 7 concludes and briefly discusses implications for policy.

2 Literature Review

In comparison to the considerable theoretical literature on sharecropping, the empirical literature on share tenancy has so far been somewhat scant, although this is a problem that has plagued the broader field of applied contract theory until well into the 1990s (Chiappori and Salanié, 2003). Moreover, a good number of empirical papers on sharecropping have been concerned with determining whether there is Marshallian inefficiency,[4] which in turn led to testing which of the Marshallian or Cheungian view was best supported by the data.

Among those who have tried to determine which of the Marshallian or Cheungian framework prevailed, Bell (1977) has found evidence in favor of the Marshallian view in a small sample of households in Bihar. Likewise, Shaban (1987) tests between both models using data from six Indian villages and, finding that there are significant differences in productivity between owned or cash rented plots and sharecropped plots, rejects the null hypothesis of no Marshallian inefficiency. Using a different testing strategy, Laffont and Matoussi (1995) and Ai, Arcand, and Éthier (1996) find evidence of Marshallian inefficiency for the Tunisian village of El Oulja. The latter authors, however, also find partial support for the Cheungian view.

Regarding whether observed contracts correspond to the predictions of the theory, Allen and Lueck (1992, 1993) develop a transactions cost-based model of sharecropping that formalizes the Cheungian view. Using data on US farms, they find strong empirical support for their model. 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. Using data from a rural area of the Philippines, he finds that the predictions of his theoretical model are supported by his data. Similarly, Pandey (2004) tests whether the principal-agent model is accurate in predicting how sharecropping contracts change as technology varies and, using a data from Uttar Pradesh, she finds support for the principal-agent model.

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

This dichotomy in the empirical sharecropping literature – some studies seek to determine whether incentives matter empirically, while other studies test wether the observed contract shapes are consistent with contract shapes predicted by the theory – finds its parallel in the broader applied contract-theoretic literature. Prendergast (1999) laments the fact that too many studies are concerned with whether incentives matter, and too few with whether contract shapes are accurately predicted. This paper, by testing which theoretical explanation is best supported by the data, is closer in spirit to the latter strand in the literature. Moreover, to my knowledge, no empirical study has tested any formal hypothesis regarding reverse share tenancy. This paper thus aims at filling an important gap in the literature on agrarian contracts.

3 Theoretical Framework

3.1 The Standard Model

This section formally shows why reverse share tenancy contracts may not fit the canonical model of sharecropping. 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 $U'' \leq 0$. I assume that the principal and the agent's utility functions both exhibit decreasing absolute risk aversion (ARA). 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, $e \in \mathbb{E}$. 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 twice continuously differentiable 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:

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

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

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

where the first constraint is the agent's individual rationality (IR) constraint and the second constraint is his incentive compatibility (IC) constraint. Assume that the agent's maximization problem has a unique solution. 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 maximization problem and differentiating inside the integral sign with respect to $w(q)$ and the multipliers associated with each constraint yields the usual first-order conditions, and assuming for now that the multipliers λ and μ are both positive, i.e., assuming that the IR and IC' constraints both bind, one gets the following equation

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

a familiar result in contract theory which summarizes the trade-off between risk-sharing and incentives. If the IC' constraint does not bind ($\mu = 0$), the ratio of marginal utilities of the principal and the agent is constant and equal to λ. In this case, the principal offers a wage contract $\overline{w}$ which the agent accepts. If, however, the IC' constraint binds ($\mu > 0$), 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. My reason for doing so is twofold. First, landlords and tenants overwhelmingly tend to use linear sharecropping contracts in practice, as is the case in the empirical application in the second part of this paper. Second, behavioral evidence suggests that individuals tend to use heuristics in order to reduce complex decision-making problems into tractable ones, and 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 paper.[5]

Differentiating equation 7 with respect to q yields

$$(8) \quad w'(q) = \frac{\mu (U')^2 \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] - V''U'}{-V''U' - U''V'},$$

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, 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 8 by $U'V'$ yields

$$(9) \quad w'(q) = \frac{\mu \frac{U'}{V'} \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + R_L}{R_L + R_T},$$

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 9, I can now state the following result:

[5] Holmstrom and Milgrom (1987) have identified conditions under which a linear contract is optimal.

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 one observes instead 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

$$(10) \quad \lim_{R_T \to 0} w'(q) = \frac{\mu \frac{U'}{V'} \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + R_L}{R_L} \geq 1,$$

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 paper: 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 possible. 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; and (ii) under some conditions, 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 two parts of the proposition, let $\rho \equiv R_T/R_L$ capture the degree of risk aversion of the agent relative to the degree of risk aversion of the principal, such that

$$(11) \quad w'(q) = \frac{\frac{\mu}{R_L} \frac{U'}{V'} \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right] + 1}{1 + \rho}.$$

We can establish part (i) by setting $V'' = 0$ in equation 8 above. This yields

$$(12) \quad w'(q) = \frac{\mu (U')^2 \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right]}{-U''V'} > 0,$$

i.e., when the principal is risk-neutral and the agent is risk-averse, a sharecropping contract obtains. This is the well-known Stiglitzian result.

Turning to part (ii), note that simply calculating $\frac{dw'(q)}{d\rho}$ from equation 11 cannot establish this part of the proposition since, as ρ varies, so does the ratio of marginal utilities in $w'(q)$. The proof must therefore proceed in a roundabout way, first showing that an increase in agent wealth is equivalent to a decrease in ρ, and then showing that an increase in agent wealth leads to an increase in $w'(q)$ if the agent is sufficiently decreasingly absolutely risk-averse. Thus, as agent wealth increases, the lower his level of absolute risk aversion. As he gets less risk-averse, the more production risk he bears.[6]

Let z denote agent wealth. We first need first need to establish that $\frac{d\rho}{dz} < 0$, i.e., that the richer the agent, the lower his degree of risk aversion relative to that of the principal. Since decreasing ARA of the agent has been assumed above, we have that

$$(13) \quad \frac{dR_T(z)}{dz} = \left[R_T^2 - \frac{U'''(z)}{U'(z)}\right] < 0.$$

But then

$$(14) \quad \frac{d\rho}{dz} = \left[\frac{U'''(z)}{U'(z)} - R_T^2\right]\frac{V''}{V'} < 0,$$

i.e., the richer the agent, the less absolutely risk-averse he is relative to the principal.

But then, recall from equation 9 that

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

Let $\Psi = \frac{d}{dq}\left[\frac{f_e(q|e)}{f(q|e)}\right]$ to simplify notation. Taking the derivative of $w'(q)$ with respect to z yields

$$(16) \quad \frac{dw'(q)}{dz} = \frac{\left[\mu\frac{U''(z)}{V'}\Psi\right]\left[-\frac{V''}{V'} - \frac{U''(z)}{U'(z)}\right] - \left[R_T^2 - \frac{U'''(z)}{U'(z)}\right]\left[\mu\frac{U'(z)}{V'}\Psi - \frac{V''}{V'}\right]}{\left[-\frac{V''}{V'} - \frac{U''(z)}{U'(z)}\right]^2}.$$

[6] Part (ii) could also be established by looking at the principal's side of things, but that would only unnecessarily complicate the algebra.

Since the denominator is positive, the first term of the numerator is negative, and the second bracket of the second term of the numerator is also positive, the sign of $\frac{dw'(q)}{dz}$ hinges upon the sign of the first bracket of the second term of the numerator, i.e., on the sign of $\left[R_T^2 - \frac{U'''(z)}{U'(z)}\right]$, which is the derivative of the agent's level of absolute risk aversion with respect to his wealth, as in equation 13. Three cases are possible: (a) the tenant's utility function exhibits decreasing ARA; (b) it exhibits constant ARA; or (c) it exhibits increasing ARA.

It should be obvious that in cases (b) and (c), $\frac{dw'(q)}{dz} < 0$. In case (a), however, the sign of $\frac{dw'(q)}{dz}$ is ambiguous. If the agent is sufficiently decreasingly absolute risk-averse, then $\frac{dw'(q)}{dz} > 0$, i.e., the richer the agent gets, the more production risk he will bear through a higher share of the output. If, however, the agent is not sufficiently decreasingly absolutely risk-averse, then $\frac{dw'(q)}{dz} \leq 0$. Thus, the slope of the contract is monotonically decreasing in the relative degrees of absolute risk aversion of the agent and the principal only when the agent exhibits a sufficiently decreasing level of ARA. ■

Both Propositions 1 and 2 make intuitive sense. First, under the present assumptions, 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). Third, 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 is relative to the agent, the more high-powered the contract (Williamson, 1985), and vice versa.

Finally, the above framework allows me to derive the first testable implication, i.e., when both parties to the contract are risk-averse, sharecropping does emerge as an optimal contract. This will be the Stiglitzian risk-sharing hypothesis, against which the other theoretical explanations will be tested. If, however, the tenants can be assumed risk-neutral, then one needs to broaden the standard framework to accommodate the existence of reverse share tenancy. The three following sub-sections do so.

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 subsequent claim to the contracted plot of land. Alternatively, one can view this assumption as one over property rights: the more involved in agricultural production on her own plot the principal is perceived to be, the stronger her property right over the same plot. This assumption is especially fitting in places where the tenurial system is weak or non-existent and property rights are ill-defined, or in places where the poor have weaker property rights than the rich, and it is akin to use-it-or-lose-it water rights in the Western United States (Milgrom and Roberts, 1992).

Note that I do not look at the choice between a rental contract and hiring an agent on a fixed wage. First, it would suffice to assume that the principal is sufficiently liquidity-constrained to rule out such cases. Second, and more importantly, there is an important empirical 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, which I discuss in section 4.1.

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 my 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), and let h_t be the plot area. For a fixed amount of land, let the production function be such that $q_t = \nu_t f(e_t)$, where ν 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 $h_t = r(a_t)h_{t-1} + \epsilon_t$ and $E(h_t) = E[r(a_t)h_{t-1}]$, where ϵ is a shock with mean equal to zero which I assume to be additive for tractability, a is the share of output that goes to the agent, and $r(\cdot)$ represents asset risk.[7] This equation is 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 expected payoff is then

(17) $a_t E[\nu f(e_t)] + b_t - \psi(e_t).$

The principal's expected payoff is

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

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

The principal's problem is to solve

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

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

(20) $a_t E[\nu f(e_t)] + b_t - \psi(e_t) \geq \bar{U}$ (IC),

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

(22) $E(h_t) = r(a_t) h_{t-1} + \epsilon_t,$

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

(23) $a_t E[\nu f_e] - \psi_e = 0$ (IC').

The Bellman equation for the above problem is then

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

[7] Once again, I focus on linear contracts, both for the reasons enumerated above and because the tools of contract theory do not allow us to determine the shape of the optimal contract in a dynamic setting (Dubois, 2002).

subject to

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

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

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

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

But then, $b_a = -e_a(aE[\nu f_e] - \psi_e) - E[\nu f(e)]$, and from the agent's IC constraint, 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:

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

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

$$(29) \quad v_0(x) = \max_{x' \in \Gamma(x)} \big\{F(x, x') + \delta v_0(x')\big\},$$

$v_0(\cdot)$ is strictly increasing if (i) the state space X, which includes x and 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 ℓ arguments; and (iv) Γ 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, is nonempty, compact-valued, and its expectation is continuous. The returns function $F(\cdot)$, in this case the utility function of the principal, is assumed bounded and is continuous by virtue of being a von Neumann-Morgenstern utility function, and it is also increasing in its one 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:

$$(30) \quad a^* = 1 + \frac{\delta E v_0' r_a h}{E \nu U' f_e e_a},$$

where the first term represents the first-best contract 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 decreases, the slope of the optimal contract increases, i.e., the greater r_a, the higher a^*. In the limit, $r_a = 0$ and $a^* = 1$, i.e., when there is no asset risk, the first-best contract obtains because the second term in equation 33 is equal to zero. ■

Proposition 4 provides an important result: given a data set that includes enough variation in 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. This is my first candidate explanation for the existence of reverse share tenancy contracts.

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 (Stiglitz and Newbery, 1981). While some have looked at the firm's behavior in the presence of price risk (Baron, 1970; Sandmo, 1971), 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 developed.

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.[8]

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 $pc \leq (1-a)p\nu f(e) - b$, where p is the (uncertain) staple price, ν is a multiplicative shock with mean equal to one, and the right-hand side of the inequality represents the principal's income from the contract.

The principal's problem is thus to

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

subject to

(32) $pc \leq (1-a)p\nu f(e) - b,$

(33) $ap\nu f(e) + b - \psi(e) \geq \bar{U}$, (IR)

and

(34) $e \in \text{argmax}_{\hat{e} \in \mathbb{E}} ap\nu f(e) + b - \psi(e)$. (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

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

subject to

(36) $aE[p\nu f(e)] + b - \psi(e) \geq \bar{U}$, (IR)

[8] I omit looking at crop fixed rent contracts, which can be ruled out simply on the basis of the transactions cost that would be incurred by having to weigh the crop at harvest. This is a reasonable assumption in rural areas of developing countries, where weighing instruments may be hard to come by.

and

(37) $aE[p\nu f_e] - \psi_e = 0$, (IC')

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

(38) $V(p, a, b) = \max_c u(c)$

subject to

(39) $pc = (1 - a)p\nu f(e) - b$.

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

(40) $E\{V_w p\nu f_e e_a - V_w p\nu f - a^* V_w p\nu f_e e_a\} = 0,$

from which $a^* = 1 - \frac{E\{V_w p\nu f\}}{E\{V_w p\nu f_e e_a\}}$ 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 price risk-averse the principal, the more she will prefer to get paid in crop, which ensures a fixed consumption bundle, rather than in cash, which yields a stochastic consumption bundle when the price of the staple is itself 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

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

But then, note that

$$(42)\quad Cov(V_w p, \nu f_e e_a) = E\{V_w p \nu f_e e_a\} - E\{V_w p\}E\{\nu f_e e_a\},$$

and that, as a result, equation 41 becomes

$$(43)\quad aCov(V_w p, \nu f_e e_a) + aE\{V_w p\}E\{\nu f_e e_a\} = E\{V_w p \nu f_e e_a\} - E\{V_w p \nu f\}.$$

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

$$(44)\quad a^* = \frac{E\{V_w p \nu f_e e_a\} - E\{V_w p \nu f\}}{Cov(V_w p, \nu f_e e_a) + Cov(V_w, p)E\{\nu f_e e_a\} + E\{V_w\}E\{\nu f_e e_a\}\mu}.$$

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

$$(45)\quad \text{sign}[Cov(V_w, p)] = \text{sign}(V_{wp}) = \text{sign}[\beta(\eta - R)],$$

where β is an individual's budget share of the staple crop, η 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 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 β, since R almost always exceeds η 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 β 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 data set that allows one to compute the covariance between marginal indirect utility of income and the staple price (as in 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 versus the alternate hypothesis implied by Proposition 6. This will be my second candidate explanation for the existence of reverse share tenancy contracts.

3.4 The Limited Liability Model

The model presented here, due to Ghatak and Pandey (2000), assumes risk-neutral agents.[9] The agent has a limited liability constraint, i.e., there exists an output threshold below which he cannot repay the principal, and he 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.[10]

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 $q \in [\underline{q}, \overline{q}]$. The distribution function of output is $F(q|e, r)$, and the bounds of the support of q are assumed not to depend on e and r, and the cumulative distribution function $F(\cdot)$ is twice continuously differentiable. Further,

$$(46) \quad \frac{\partial F(q|e,r)}{\partial q} = f(q|e,r), \text{ and}$$

$$(47) \quad \frac{\partial}{\partial q}\left[\frac{f_e(q|e,r)}{f(q|e,r)}\right] \geq 0.$$

In other words, the monotone likelihood ratio property 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 symmetrically shift probability mass towards the tails of the output distribution, *ceteris paribus*.

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[9]Note that assuming that the landlord is risk-averse, as I have done in the asset risk and price risk models, would only strengthen the conclusions of this model.

[10]The distinction between "technical moral hazard" and moral hazard was introduced in the literature by Basu (1992) in an effort to distinguish between moral hazard in the choice of technique or the application of inputs other than labor and moral hazard in labor effort, respectively.

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 q to obtain information on these two variables.

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

(48) $y_L = \min\{(1-a)q - b, q\}$, and

(49) $y_T = \max\{aq + b, 0\}$

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

(50) $U_L = E(q) - \int_{\hat{q}}^{\overline{q}} [aq + b] f(q|e, r) dq$, and

(51) $U_T = \int_{\hat{q}}^{\overline{q}} [aq + b] f(q|e, r) dq - \psi(e, r)$.

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 $U_T \geq \overline{U}$. The agent's choice of e and r are given by the following incentive constraints (IC):

(52) $-a \int_{\hat{q}}^{\overline{q}} F_e(q|e, r) dq = \psi_e(e, r)$, and

(53) $-a \int_{\hat{q}}^{\overline{q}} F_r(q|e, r) dq = \psi_r(e, r)$.

Ghatak and Pandey then characterize the full information benchmark, i.e., the case in which both effort and risk are contractible, and after deriving propositions characterizing what happens when the principal can enforce e and r, they present the following two propositions, which are of interest in studying reverse share tenancy.[11]

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

Proposition 7 *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. Ghatak and Pandey's last proposition characterizes this.

Proposition 8 *When neither e nor r can be enforced by the principal, if the distribution of q 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. This is my third candidate explanation for the existence of reverse share tenancy contracts.

3.5 Other Applications

Situations where the principal is risk-averse and the agent is risk-neutral are not the exclusive preserve of developing countries and are not as uncommon in industrialized countries as one might think. Consignment stores (e.g., "eBay stores"), for example, sell items on behalf of individuals (who keep their claim to the items until they are sold), and there is variety in the contracts observed between consignees and consignors: in the majority of cases, the consignee asks for a percentage of the proceeds of the sale, but there exist cases where the consignee retains a fixed fee from the proceeds of the sale. In this case, fixed fee and percentage contracts with the consignment store are equivalent to wage and sharecropping contracts, respectively. This begs the following questions: (i) why would a risk-averse consignor expose herself to too much risk by signing a percentage contract; or (ii) why would a risk-averse consignor sign the lowest-powered possible contract – and expose herself to even more risk as well as to moral hazard – by signing a fixed fee contract? Instead of going to a consignment store, she could take her item to a thrift shop, which would pay to buy the item, just as in a fixed rent contract above. Although these questions constitute an interesting puzzle, their answers are beyond the scope of this paper.

Likewise, the agency problem between an individual investor and a mutual fund manager has been the object of several papers in the economics literature. For example, Ou-Yang (2003) develops a continuous-time framework where the optimal contract takes the form $aq+b+r$, where q are the total assets under management, a is a fraction of the total assets under management, b is a fixed fee, and r is a bonus or a penalty, depending on performance. Such symmetric rewards have been enforced by Congress since 1970, but prior to that, fund managers only received bonuses for good performances, with no penalties for bad performances. In such situations, the principal and the agent are likely risk-averse and risk-neutral, respectively, and the enforcement of the bonus/penalty system by Congress is likely a response to limited liability, which induced risk-taking behavior on the part of the fund managers (Chevalier and Ellison, 1997).

4 Empirical Framework

In order to test the three competing explanations for share tenancy presented above against the Stiglitzian risk-sharing hypothesis and against one another, I rely on a reduced form 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 me 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 conditional upon having decided to lease out and allows me 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 non-canonical models of reverse share tenancy presented above. The following subsections respectively discuss the details of the econometric model and the identification strategy.

4.1 Econometric Model

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* desirable 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 an approach would however lead to two problems.

First, although a can in theory lie anywhere in the $[0,1]$ interval, what one usually 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 and would take care of the potential heteroskedasticity problem associated with treating the dependent variable as continuous when the dependent variable is, in fact, discrete.

Second, and this is a much more important problem, 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.[12] Indeed, because landowners self-select into the land tenancy market by deciding whether to lease out or not, one must carefully control for this by modeling both stages of decision.

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.

4.2 Identification Strategy

In order to properly test between the above competing hypotheses, I regress the choice between sharecropping and fixed rent on plot-level controls, landlord household-level controls, tenant household-level controls, and the following variables of interest: (i) proxies for the landlord and the tenant's levels of income risk aversion; (ii) the landlord's subjective perception of asset risk; (iii) the estimated covariance between the landlord's marginal indirect utility of income and the staple price; and (iv) an indicator variable equal to one if

[12] 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.

there is an explicit limited liability clause in the contract and equal to zero if such a clause is absent from the contract.

Following Laffont and Matoussi (1995), and assuming decreasing absolute risk aversion (DARA), I use the landlord and the tenant's total level of assets net of working capital and of the value of their land holdings as a proxy for their level of income risk aversion.[13] Thus, in order to test the risk-sharing hypothesis, I proceed as follows. In the contract choice equation, in which the dependent variable is equal to one if a sharecropping contract has been chosen and equal to zero if a fixed rent contract has been chosen, let β_{W_L} and β_{W_T} denote the regression coefficients on the landlord and the tenant's level of assets, respectively. To test whether risk matters for both parties, I simply test the null hypothesis that H_0: $\beta_{W_L} = 0$ and $\beta_{W_T} = 0$ versus the alternative hypothesis that H_0: $\beta_{W_L} > 0$ and $\beta_{W_T} < 0$. While this is not *per se* a test that the landlord is risk-averse and the tenant is risk-neutral, it is the best I can do given that the data does not allow me to compute Arrow-Pratt coefficients of absolute risk aversion.

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 was asked to distribute them between two boxes, one labeled with 0, one labeled with 1. The landlord was told that the latter box represented a state of the world where she lost her claim to the land as a result of the contract signed, whereas the former box represented a state of the world where she kept her claim to the land. Data on the landlord's hypothetical perception of asset risk under the alternate contract were also collected.[14] Ideally, for a closer correspondence between the theoretical and empirical models, the asset risk hypothesis would be tested by using both observed and hypothetical asset risk variables

[13]For all landlord- and tenant-specific covariates, I use absolute rather than relative levels so as to include as much information as possible in the regression. Given the sufficiently high number of observations, this does not pose a degrees of freedom problem.

[14]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 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 perceived and hypothetical price risk.

in order to compute r_a, the slope of the asset risk function $r(a)$ in section 3.2. There are, however, no valid instruments for r_a in the data, so that I simply use the perceived level of asset risk under the observed contract. It then suffices to test the null hypothesis that the estimated coefficient for the subjective probability is equal to zero. Rejection coupled with a positive coefficient estimate would then mean that the data support the asset risk hypothesis.

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 use the following instruments: (i) two dummy variables that are equal to one if the security conditions with respect to crime in the village were perceived respectively as good or bad, with the base case being average security conditions; and (ii) variables measuring the number of zebu thefts, crop thefts, and burglaries in the village over the previous year. Like asset risk, those variables are thought to be correlated to the amount of social capital and trust within a village, but unlike asset risk, they are uncorrelated with contract choice.

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 function for the marketed surplus of rice, 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 a 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 contract is signed in commune i and zero otherwise.[15] Note that a tilde ($\tilde{}$) indicates a variable that was normalized by dividing by its mean prior to taking the logarithm. 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 data set. Estimation results

[15]In Madagascar, a commune is a unit roughly equivalent to a county in the United States.

for this auxiliary regression are available upon request.

Estimating the marketed surplus function above allowed me to compute β, the budget share of marketed surplus (PM/W), and η, the income-elasticity of marketed surplus. In order to compute $Cov(V_w, p) = \beta(\eta - R)$, I then had 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 assumptions: (i) $R_1 = 2$ for every landlord in the data set; and (ii) $R_2 = 1.5$ for landlords whose endowment of land is less than 50 ares,[16] 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. In the empirical results that follow, however, I only present results for R_1 given that the overall results do not change whether I use R_1 or R_2. Furthermore, given that β, η, and R are given by the preferences of the landlords, the covariance term is exogenous to contract choice.

Finally, as regards the limited liability variable, it is simply an indicator variable equal to one if there is an explicit limited liability clause in the contract and equal to zero if there is no such clause. The presence of such a limited liability clause was determined by asking landlords whether there was such an explicit provision in the contract, whether the latter is verbal or written. 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. The data include 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. In short, the data do not include a valid instrument for limited liability, but Ghatak and Pandey (along with others who have devised limited liability models of sharecropping, such as Basu, 1992) assume that limited liability is a primitive in their model, and therefore exogenous to contract choice. Whether that is empirically true or not, it is unfortunately the best one can do given the data at hand.

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

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.[17]

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 Madagascar's Institut national de la statistique (INSTAT) and the Centre national de la recherche appliquée au développement (FOFIFA) (Minten and Razafindraibe, 2003). 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 15 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 each of 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 (Goodman, 1961; Berg, 1981) makes for a richer data set and, to my knowledge, the *Enquête sur la location des parcelles de terre* is the first survey to use such a sampling methodology to study agrarian contracts. Most studies usually select households and find either their landlords or their tenants, but not both. A detailed discussion of the survey methodology is available upon request.

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

Table 1: Summary Statistics for the First-Stage Decision

Variable	**Mean**	**Std. Dev.**	**N**
Leased Out Dummy	0.386	0.487	1029
Plot Size (Ares)	132.63	395.878	1005
Tanety Dummy	0.207	0.405	1029
Bas-Fond 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
Annual *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
Annual *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 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 hectares. The vast majority of plots are in rice paddies, with only 21 percent of plots being *tanety* (hillside plots) and 12 percent of plots being *bas-fonds*.[18] The average distance between the plot and the landowner's house (in walking minutes) is about 40 minutes and over 30 percent of plots have been previously owned by the landowner's family, i.e., passed down through bequest or intra-family gift. The average number of *fady* days per plot is one day per week, usually Thursday.[19]

Turning to household-level covariates, the average household size is a little over six individuals, and the average household's dependency ratio is over 0.4.[20] 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 ten percent of household heads are female. One third of all households are liquidity constrained, as proxied by whether they asked for a bank, microfinance, or informal loan and were denied such loans over the last year,[21] and the average number of *fady* days per household is significantly higher than the number of such days per plot. Finally, household income (the sum of the incomes from animal sales, agricultural and non-agricultural wages, and proceeds from leases of cattle and equipment; household income is net of income from land leases) was about \$60 per capita[22] in the year

[18]In this study, *bas-fond* refers to a plot located at the bottom of a valley on which rice is not grown. Although the term *bas-fond* means rice paddy in the High Plateaux of Madagascar, it has a different meaning in coastal areas, such as Lac Alaotra.

[19]The term *fady* roughly translates as "forbidden" or "taboo". Agricultural work is prohibited on *fady* days, both at the individual and at the household level. For an interesting account of the multiple *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).

[20]One obtains the dependency ratio, a proxy for the degree of dependency within the household, 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.

[21]Note that this is a downwardly biased proxy since it ignores self-selection out of lending because of expected rejection as well as loans granted in an amount less than that requested.

[22]The ariary is both an old and new currency. When data collection took place in 2004, the government had just started introducing ariary on the market again although the FMG was still the major currency. Note that 1 ariary = FMG 5 and \$1 $\approx$ FMG 10,000. Since peasants are used to thinking in ariary because it was the old currency, that denomination

preceding the survey, while the average household has about \$450 worth of working capital and about \$150 worth of assets per capita.[23]

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, i.e., slightly closer than the average owner-exploited plot. 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, household characteristics are essentially the same between parties to the contract but landlords tend to be significantly older and are much more likely to be female than their tenants, and 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 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 data set.

As regards the variables of interest, 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 0.9 percent. Finally, about 55 percent of contracts included an explicit limited liability clause, and the mean covariance between marginal indirect utility of income and the price of the staple, under the assumption that $R = 2$, was equal to -7.7, a number whose magnitude cannot be read-

was used in the survey questionnaire so as to minimize measurement error.

[23] I define the value of the household's working capital as the sum of the values of its hoe, harrow, cart, plow, tractor, and small tractor known in Lac Alaotra by its brand-name (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.

Table 2: Summary Statistics for the Second-Stage Decision

Variable	**Mean**	**Std. Dev.**	**N**
Sharecropping Dummy	0.687	0.464	387
Plot Size (Ares)	108.829	84.761	397
Tanety Dummy	0.068	0.252	397
Bas-Fond 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 (100,000 Ariary)	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 (Out of 20 Tokens)	0.183	1.192	388
Limited Liability Dummy	0.549	0.498	388
$Cov_1(V_w, p) = \beta(\eta - R_1)$	-7.693	35.388	319

ily interpreted, but whose sign indicates that the average household in our data set is a net seller. This is consistent with Lac Alaotra being the most important 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., rice dummy, type of protection structure to counter the effects of wind and erosion, position on the toposequence, soil characteristics, slope, and irrigation source) and commune dummies used in the following estimations, 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 4.1. I first present the results of nonparametric regressions of contract choice on the variables of interest in order to determine whether the unconditional relationships between contract choice and these variables are consistent with the theoretical predictions of section 3. After controlling for the possibility of endogenous matching between landlords and tenants (Ackerberg and Botticini, 2002), I present the results of the bivariate probit with selection. Finding that the two decision stages are uncorrelated, I then estimate two separate probits, i.e., one for each of the leasing out and contract choice decisions. I then re-estimate the contract choice equation for the sub-sample of reverse share tenancy cases and finally test whether there is selection into reverse tenancy on the part of the landlords.

6.1 Preliminaries

Estimation results for the marketed surplus OLS regression and the asset risk instrumenting regression are presented in tables 3 and 4, respectively. As regards the asset risk instrumenting regression, note that given the count data nature of the asset risk variable, one should *a priori* use a count data model. Given that the mean of the 20-token asset risk variable is 0.183 and its variance is 1.192, and given the prevalence of zero responses for the asset risk question, it seems like it would be appropriate to estimate a zero-inflated negative binomial regression. There are, however, not enough non-zero responses to properly estimate such a regression, so that I estimated an OLS

Table 3: Estimation Results for the Marketed Surplus Function (OLS)

Variable	Coefficient	(Std. Err.)
Log Land	1730.868***	(295.399)
Log Labor	1252.291***	(320.309)
Log Income	76.537	(48.335)
Log Price	-9799.593***	(2429.065)
Commune 2	1307.671***	(361.678)
Commune 3	2255.532***	(542.033)
Commune 4	4581.486***	(1227.714)
Commune 5	1296.806***	(404.950)
Commune 6	4175.765***	(768.862)
Intercept	63351.602***	(15141.341)
N	986	
R^2	0.272	
$F_{(9,976)}$	10.678	
p-value	0.000	

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

regression with robust standard errors for the instrumenting regression in order to counter the possible heteroskedasticity problem resulting from the use of a linear regression.

6.2 Nonparametric Regressions

In order to determine whether the variables of interest have the predicted effect on contract choice, I first ran two nonparametric regressions. Figures 1 and 2 present the results of nonparametric regressions of contract choice on the instrumented subjective asset risk probability and on the covariance between marginal indirect utility of income and the staple price. 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.

Figure 1 presents a nonparametric regression of contract choice on instrumented asset risk. From that figure, it appears that the more asset risk the

Table 4: Estimation Results for Instrumentation of Asset Risk (OLS)

Variable	Coefficient	(Std. Err.)
L Dependency Ratio	-0.322**	(0.164)
L Age	-0.009	(0.019)
L Age Squared	0.000	(0.000)
L Female	0.089	(0.143)
L Sihanaka	0.141	(0.145)
L Agricultural Activity	0.067	(0.119)
L Household Income Per Capita	-0.020	(0.013)
L Household Assets Per Capita	0.000	(0.005)
L Household Working Capital Per Capita	0.000	(0.000)
L Liquidity Constraint	0.120	(0.083)
Tanety	-0.516	(0.335)
Bas-Fond	-0.424*	(0.252)
Distance from House	0.002	(0.002)
Distance from Road	-0.003	(0.009)
Irrigated Plot	-0.124	(0.230)
Good Soil	0.144	(0.152)
Bad Soil	-0.047	(0.120)
Plot Previously Owned by Family	-0.093	(0.139)
Same Ethnic Group	0.023	(0.089)
Kin	-0.094	(0.097)
A Age	-0.021	(0.025)
A Age Squared	0.000	(0.000)
A Household Income Per Capita	0.017	(0.016)
A Household Assets Per Capita	0.010	(0.015)
A Working Capital	0.000	(0.000)
Good Security Conditions	-3.282**	(1.644)
Bad Security Conditions	-0.447	(0.300)
Zebu Thefts	0.070*	(0.038)
Crop Thefts	-0.012*	(0.007)
Burglaries	-0.165*	(0.089)
Intercept	1.111	(0.838)
N	371	
R^2	0.169	
$F_{(36,334)}$	0.359	
p-value	0.999	

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

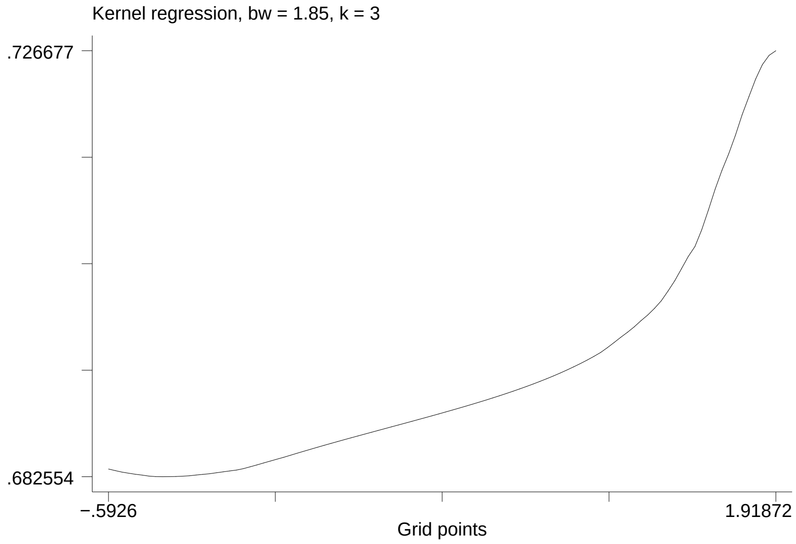
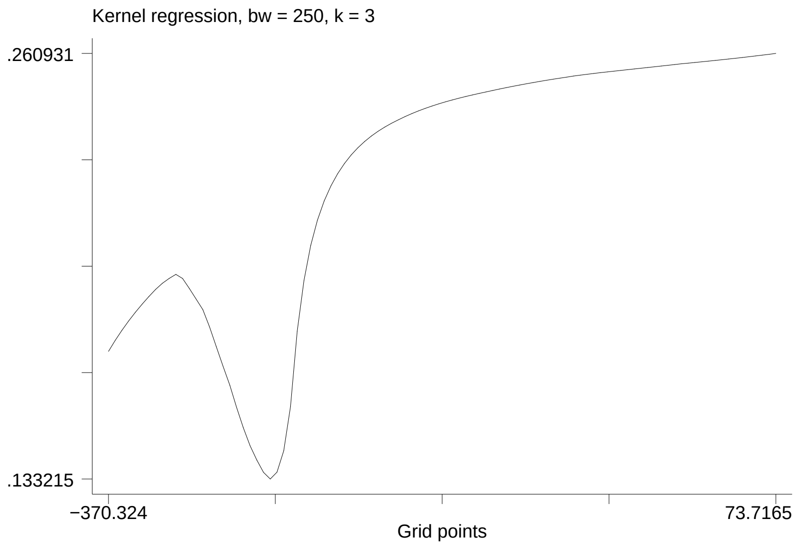


Figure 2: Nonparametric Regression of Contract Choice on $Cov_1(V_w, p)$.



landlord perceives, the more likely she is to choose a sharecropping agreement, and that the relationship between the two variables is monotonic. This is consistent with the theoretical model of section 3.2.

Figure 2 presents a nonparametric regressions of contract choice on $Cov_1(V_w, p)$. The relationship between contract choice and the variable of interest, albeit non-monotonic, is generally positive. This is also consistent with the theoretical model of section 3.3.

Finally, table 5 cross-tabulates contract choice and the limited liability dummy. It is then obvious that going from no limited liability to the presence of a limited liability clause is associated with an increase in the number of sharecropping cases and with a decrease in the number of fixed rent cases, a result that is consistent with the model of Ghatak and Pandey (2000).

Table 5: Tabulation of Contract Choice and Limited Liability

	Limited Liability	
	0	1
Fixed Rent	71	50
Sharecropping	104	162

It thus appears that all three variables of interest unconditionally have the predicted effect on contract choice. The nonparametric regressions and the cross-tabulation, however, only crudely regress contract choice on the variables of interest, since they fail to control for other factors that might affect contract choice at the margin. In order to truly test between the four hypotheses presented in section 3, I now turn to a parametric model that nests all my hypotheses together.

6.3 Endogenous Matching

Following Ackerberg and Botticini (2002), it is likely that landlords and tenants match endogenously, and that this leads to biased coefficient estimates in the contract choice equation when using imperfect proxies for risk aversion. In order to identify whether there is endogenous matching between the landlords and tenants in my data, I regressed the landlord (tenant) levels of assets per capita within the household on the tenant (landlord) characteristics for the sub-sample of cases where the contract was not signed between

Table 6: Estimation Results for the T Assets Per Capita (OLS)

Variable	Coefficient	(Std. Err.)
L Household Size	-0.048	(0.069)
L Dependency Ratio	0.214	(0.797)
L Age	0.007	(0.015)
L Female	-0.079	(0.474)
L Education	0.036	(0.057)
L Liquidity Constraint	0.128	(0.441)
L Working Capital	-0.003	(0.006)
L Assets Per Capita	-0.026	(0.029)
L Income Per Capita	-0.093	(0.088)
Number of Other Tenants Considered	-0.102	(0.084)
Relationship Length	-0.022	(0.047)
Intercept	1.740*	(1.013)
N	252	
R^2	0.021	
$F_{(11,240)}$	.477	
p-value	0.916	

Table 7: Estimation Results for the L Assets Per Capita (OLS)

Variable	Coefficient	(Std. Err.)
T Household Size	-0.372	(0.242)
T Dependency Ratio	0.510	(2.462)
T Age	-0.001	(0.061)
T Female	-2.343	(4.175)
T Education	0.001	(0.162)
T Agricultural Experience	0.110*	(0.065)
T Liquidity Constraint	0.753	(0.987)
T Working Capital	0.002	(0.031)
T Assets Per Capita	-0.254	(0.187)
T Income Per Capita	0.045	(0.322)
Intercept	3.158	(2.203)
N	239	
R^2	0.037	
$F_{(10,228)}$	.869	
p-value	0.563	

Table 8: Estimation Results for the Instrumenting Regression for T Agricultural Experience (OLS)

Variable	**Coefficient**	**(Std. Err.)**
Commune 2*L Assets Per Capita	-0.817	(1.005)
Commune 3*L Assets Per Capita	-0.412	(0.290)
Commune 4*L Assets Per Capita	-0.058	(0.080)
Commune 5*L Assets Per Capita	-0.084	(0.101)
Commune 6*L Assets Per Capita	0.180	(0.139)
L Assets Per Capita	0.179***	(0.057)
T Age	0.664***	(0.066)
T Female	-7.602	(5.247)
T Education	-0.793***	(0.135)
Commune 2	-1.564	(1.703)
Commune 3	-0.713	(1.673)
Commune 4	-3.892***	(1.365)
Commune 5	-0.083	(1.472)
Commune 6	-4.585**	(2.297)
Intercept	-1.839	(2.809)
N	370	
R^2	0.566	
$F_{(14,355)}$	41.172	
p-value	0.000	

kin, or where the contract was signed between kin but the landlord did not have any other prospective tenant. Tables 6 and 7 present the results of those regressions.[24] Given that the estimated coefficient on the number of years of agricultural experience of the tenant is significant in the regression of landlord level of assets per capita on agent characteristics, there is evidence of endogenous matching. It appears that less risk-averse landlords tend to match with more experienced tenants.

In order to control for this possibility, I follow Ackerberg and Botticini's method, which consists in using geographical dummies as instruments for the tenant's agricultural experience. Table 8 presents the estimation results for the instrumenting regression of the number of years of agricultural experience of the tenant. Given that the levels of migration in and out of each village are extremely low – in ten out of 12 villages, the number of individuals moving in and out of the village over the last five years was less than ten – it is unlikely that people migrate based on higher expected payoffs to their characteristics. Moreover, there is no reason to believe *a priori* that contracts are influenced by the geographical area in which they are signed. I thus exclude the commune dummies from the contract choice equation and use them, along with their interactions with the landlord's level of assets per capita, as my instruments for endogenous matching.

6.4 Bivariate Probit with Selection

Tables 9 and 10 present the estimation results for the first and second stages 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 landowner household-level covariates. For brevity, the estimation results omit a subset of the plot-level covariates in both the leasing out and contract choice equations as well as the commune dummies in the leasing out equation, but those are available upon request. Note that all the estimation results in this paper control for the oversampling of households that enter sharecropping agreements by incorporating sampling weights. Ideally, I would also control for the choice-based nature of the sample (Manski and Lerman, 1977). Unfortu-

[24]For the remainder of this paper, T and L denote tenant and landlord household characteristics, respectively.

Table 9: Estimation Results for the First Stage of the Bivariate Probit

Variable	**Coefficient**	**(Std. Err.)**
Plot Size	-0.001**	(0.000)
Tanety	0.134	(0.240)
Bas-Fond	0.530**	(0.211)
Distance from House	-0.002*	(0.001)
Family-Owned Plot	-0.277**	(0.115)
Days to Evacuate Flood Waters from Plot	-0.010	(0.010)
Fady Days on Plot	0.001	(0.002)
Dependency Ratio	0.646**	(0.262)
Household Size	-0.057***	(0.022)
Age	0.012**	(0.005)
Female	0.944***	(0.142)
Education	-0.015	(0.018)
Agricultural Experience	-0.010**	(0.004)
Fady Days	0.001	(0.002)
Liquidity Constraint	0.024	(0.171)
Income Per Capita	0.083**	(0.035)
Working Capital	0.001	(0.002)
Liquidity Constraint*Working Capital	-0.021	(0.026)
Assets Per Capita	-0.104***	(0.031)
Intercept	-2.004***	(0.622)

nately, population proportions at the contract-level have never been collected for Lac Alaotra, making the choice-based sampling correction impossible to implement.

Considering first the decision to lease out versus exploiting one's own plot, larger plots have a higher likelihood of being exploited by the landowner, and *bas-fond* plots are more likely to be leased out than rice paddies, which indicates that landowners tend to keep the more desirable plots for themselves. Plots that are further away from the landowner's household are also less likely to be leased out, most likely due to the transactions cost of monitoring the tenant, which are increasing in distance. Plots that have previously been owned by someone in the landowner's extended family are less likely to be leased out, which is likely due to the fact that these plots are perceived intrinsically as more valuable since they are *tanindrazana*, i.e., the land of the ancestors. At the household level, the higher the landowner household's dependency ratio, the more likely the landowner is to lease out her plot, an intuitive result given that higher dependency ratios are associated with less efficient household labor. Household size, for its part, decreases the likelihood that a landowner will lease out her plot. This result is also intuitive, given the greater quantity of household labor available in larger households.

Elderly and female landowners are more likely to lease out their plots, a result that is partially consistent with the "stylized widow" hypothesis often put forth when discussing reverse share tenancy (Pearce, 1983; Jarosz 1991, 1994), and which states that landlords in reverse share tenancy agreements are typically single, elderly women.[25] More experienced landlords, for their part, are less likely to lease out their plots, another intuitive result since an individual who is experienced in a given sector is much more likely to choose to work in that sector. As regards the economic variables of interest, a higher level of household income per capita increases the likelihood of leasing out one's plot. This is likely because higher incomes are associated with employment outside of agriculture and therefore the level of household income per capita captures the landlord's opportunity cost of exploiting her own plot. Finally, a higher level of assets per capita decreases the likelihood of leasing out one's plot. This result is somewhat puzzling, especially in light of the fact

[25]Marital status has been omitted from the independent variables given that all female household heads are single.

that the level of working capital is not statistically significant: one would expect the level of working capital to have such a negative effect rather than the level of nonproductive assets.

Turning to the contract choice equation, older landlords are more likely to choose fixed rent than sharecropping, a result which contradicts the stylized widow hypothesis. A higher level of working capital makes sharecropping more likely, most likely due to the fact that landlords with more working capital are in a better position to share production activities with their tenants, mixing landlord capital with tenant labor, as in Laffont and Matoussi (1995). Additionally, the higher the landlord household's income per capita, the lower the likelihood of a sharecropping contract. Once again, this likely captures the fact that landlords who have higher incomes tend to be employed in sectors other than agriculture, and so are more likely to choose a fixed rent contract since they cannot monitor their tenants as well as landlords who work in agriculture. Note that relationship length, i.e., the number of years that the landlord and the tenant have been contracting together, increases the likelihood of observing a sharecropping contract. This is consistent with landlords having better information about the tenants they have contracted with in the past, putting them in a better position to detect shirking, and therefore more likely to sign a contract in which shirking might be a problem (Laffond and Matoussi, 1995).

Younger tenants are more likely to be offered a sharecropping contract, a result that is consistent with the stylized facts of reverse share tenancy (Pearce, 1983). Education and agricultural experience, for their part, both increase the likelihood that the tenant will be offered a sharecropping contract. Finally, the likelihood of observing a sharecropping contract increases with the tenant household's income per capita.

Turning to the variables of interest, the asset risk variable has the expected sign and is statistically significant. Similarly, the limited liability variable has the expected sign, a point estimate large in magnitude, and is strongly statistically significant. I also reject the joint hypothesis that both proxies for risk aversion are not significantly different from zero: the χ^2_2 statistic for the test is equal to 8.05 and is significant at the 95% significance level. Thus, from the results of the bivariate probit with selection, it appears that the data support both asset risk and limited liability and cannot reject the Stiglitzian

Table 10: Estimation Results for the Second Stage of the Bivariate Probit

Variable	Coefficient	(Std. Err.)
Tanety	0.726	(1.181)
Bas-Fond	0.668	(0.841)
Distance from House	-0.003	(0.004)
Family-Owned Plot	-0.077	(0.280)
L Household Size	0.034	(0.051)
L Dependency Ratio	0.156	(0.594)
L Age	-0.025**	(0.010)
L Female	-0.485	(0.372)
L Education	-0.057	(0.041)
L Liquidity Constraint	0.460	(0.292)
L Working Capital	0.010*	(0.005)
L Assets Per Capita	0.112**	(0.048)
L Income Per Capita	-0.177**	(0.071)
Relationship Length	0.147*	(0.083)
Kin Contract	-0.158	(0.313)
T Household Size	-0.068	(0.058)
T Dependency Ratio	1.035	(0.703)
T Age	-0.140**	(0.067)
T Female	1.669	(1.147)
T Education	0.243***	(0.088)
T Agricultural Experience (Instrumented)	0.224**	(0.101)
T Liquidity Constraint	-0.129	(0.241)
T Working Capital	0.004	(0.007)
T Assets Per Capita	-0.080	(0.053)
T Income Per Capita	-0.141**	(0.067)
Asset Risk (Instrumented)	0.932**	(0.386)
Limited Liability	1.088***	(0.332)
$Cov(V_w, p)$	-0.003	(0.002)
Intercept	2.065	(1.634)
$\rho(\widehat{\epsilon}_1, \widehat{\epsilon}_2)$	-0.460	(0.413)
N	769	
Log-Likelihood	-413.785	
χ^2_{42}	88.156	
p-value	0.000	

risk-sharing hypothesis in determining agrarian contracts.

6.5 Separate Probits

Given that the correlation coefficient between the two equations of the bivariate probit is not statistically different from zero, I re-estimated the two equations again using separate probit. The results of the first-stage equation, presented in table 11, do not change substantially: only the distance between the landowner's house and the plot, the family-owned plot dummy, and the landowner household's income per capita drop out of significance. The results of the second-stage equation, presented in table 12, also do not substantially change: the landlord household's assets and income per capita drop out of significance, and the tenant household's assets per capita are now significant and have a negative effect on the likelihood of observing a sharecropping contract. Moreover, liquidity-constrained landlords are now more likely to choose a sharecropping contract, as are landlords whose tenant is female. Once again, the data supports the limited liability and asset risk hypotheses, and I cannot reject the Stiglitzian hypothesis that risk matters, as the χ^2_2 statistic for the test is equal to 5.39 and is significant at the 90% level of confidence.

6.6 Reverse Tenancy Sample

The results of the preceding sub-sections were estimated using the full sample of land tenancy contracts in Lac Alaotra, which means that those results explain both traditional and reverse tenancy agreements, i.e., tenancy agreements between landlords and tenants as a whole, with no consideration of who is the richer party. To explore the specific phenomenon of reverse share tenancy, however, 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 re-estimated the second-stage probit based on a sample which only comprises the cases where the tenant's level of assets exceeds the landlord's. Estimation results for the restricted sample contract choice equation are presented in table 13.[26] Once again, the data support the limited liability and asset risk hypotheses, but this time I cannot reject the hypoth-

[26]Estimation results for the plot-level controls are available upon request.

Table 11: Estimation Results for the First-Stage Probit

Variable	**Coefficient**	**(Std. Err.)**
Plot Size	-0.001*	(0.001)
Tanety	0.131	(0.328)
Bas-Fond	0.541*	(0.315)
Distance from House	-0.001	(0.002)
Family-Owned Plot	-0.168	(0.143)
Days to Evacuate Flood Waters from Plot	-0.018	(0.013)
Fady Days on Plot	0.001	(0.002)
Dependency Ratio	0.807***	(0.309)
Household Size	-0.089***	(0.026)
Age	0.024***	(0.007)
Female	0.891***	(0.194)
Education	-0.005	(0.027)
Agricultural Experience	-0.013**	(0.005)
Fady Days	0.000	(0.002)
Liquidity Constraint	0.043	(0.171)
Income Per Capita	0.056	(0.038)
Working Capital	0.000	(0.003)
Liquidity Constraint*Working Capital	-0.024	(0.020)
Assets Per Capita	-0.042**	(0.018)
Intercept	-1.867**	(0.732)
N	838	
Log-likelihood	-389.891	
$\chi^2_{(33)}$	218.696	
p-value	0.000	
Pseudo-R^2	0.274	

Table 12: Estimation Results for the Second-Stage Probit

Variable	**Coefficient**	**(Std. Err.)**
Plot Size	0.003	(0.002)
Tanety	0.781	(1.160)
Bas-Fond	0.616	(0.741)
Distance from House	-0.005	(0.003)
Family-Owned Plot	-0.269	(0.267)
L Household Size	0.008	(0.048)
L Dependency Ratio	0.171	(0.494)
L Age	-0.016*	(0.009)
L Female	-0.143	(0.306)
L Education	-0.055	(0.036)
L Liquidity Constraint	0.525*	(0.284)
L Working Capital	0.011**	(0.004)
L Assets Per Capita	0.007	(0.037)
L Income Per Capita	-0.067	(0.048)
Relationship Length	0.089*	(0.048)
Kin Contract	-0.402	(0.266)
T Household Size	-0.063	(0.062)
T Dependency Ratio	1.255*	(0.664)
T Age	-0.219***	(0.050)
T Female	2.846**	(1.111)
T Education	0.279***	(0.063)
T Agricultural Experience (Instrumented)	0.326***	(0.071)
T Liquidity Constraint	-0.251	(0.223)
T Working Capital	0.006	(0.007)
T Assets Per Capita	-0.096**	(0.042)
T Income Per Capita	-0.145**	(0.065)
Asset Risk (Instrumented)	0.694**	(0.334)
Limited Liability	1.047***	(0.235)
$Cov(V_w, p)$	-0.003	(0.002)
Intercept	2.892*	(1.557)
N	281	
Log-likelihood	-115.608	
$\chi^2_{(36)}$	91.544	
p-value	0.000	
Pseudo-R^2	0.312	

Table 13: Estimation Results for the Second-Stage Probit (Reverse Tenancy Sample)

Variable	**Coefficient**	**(Std. Err.)**
Plot Size	0.002	(0.004)
Tanety	1.533	(1.612)
Bas-Fond	1.909	(1.264)
Distance from House	-0.006	(0.004)
Family-Owned Plot	-0.134	(0.516)
L Household Size	0.138	(0.091)
L Dependency Ratio	1.162	(0.825)
L Age	-0.019	(0.015)
L Female	-0.392	(0.459)
L Education	-0.073	(0.064)
L Liquidity Constraint	-0.065	(0.489)
L Working Capital	-0.089	(0.093)
L Assets Per Capita	0.380	(0.337)
L Income Per Capita	-0.125	(0.189)
Relationship Length	-0.017	(0.084)
Kin Contract	-0.429	(0.404)
T Household Size	-0.262***	(0.092)
T Dependency Ratio	3.178***	(1.188)
T Age	-0.193**	(0.083)
T Education	0.245**	(0.106)
T Agricultural Experience (Instrumented)	0.331***	(0.116)
T Liquidity Constraint	-0.667*	(0.398)
T Working Capital	0.010	(0.009)
T Assets Per Capita	-0.042	(0.055)
T Income Per Capita	-0.211*	(0.111)
Asset Risk (Instrumented)	0.974**	(0.464)
Limited Liability	0.663*	(0.372)
$Cov(V_w, p)$	0.000	(0.003)
Intercept	2.662	(2.095)
N	140	
Log-likelihood	-50.357	
$\chi^2_{(35)}$	73.791	
p-value	0.004	
Pseudo-R^2	0.413	

esis that risk-sharing does not matter, as the χ^2_2 statistic for the test is equal to 2.03 and, with a p-value of 0.363, is not significant at any of the usual levels of confidence.

It is likely, however, that there is selection into reverse tenancy. In order to explain such a selection effect, I use two variables that can be excluded from the contract choice equation but which can serve to explain selection into reverse share tenancy, i.e., the number of days spent looking for a tenant, and a dummy equal to one if the tenant approached the landlord first in order to contract and zero otherwise. The first variable captures the fact that landlords who spend more time looking for a tenant might be more willing to accept a poorer tenant, and the second variable captures whether landlords choose their tenant – and thus there is indeed self-selection – or whether tenants choose their landlord.

Table 14: Estimation Results for the Selection into Reverse Tenancy Equation

Variable	**Coefficient**	**(Std. Err.)**
Plot Size	0.000	(0.001)
Tanety	-0.788	(0.684)
Bas-Fond	-0.453	(0.520)
Distance from House	-0.001	(0.002)
Family-Owned Plot	-0.212	(0.225)
L Household Size	-0.073**	(0.038)
L Dependency Ratio	-0.100	(0.411)
L Age	-0.015**	(0.007)
L Female	-0.353	(0.235)
L Education	-0.049	(0.032)
L Liquidity Constraint	-0.097	(0.214)
L Working Capital	-0.029	(0.033)
L Assets Per Capita	-0.452***	(0.085)
L Income Per Capita	-0.082	(0.067)
Time Spent Looking for a Tenant	0.021	(0.039)
T Approached L First	-0.054	(0.174)
Intercept	8.634	(360.278)

Given that the bivariate probit with selection would not converge using any of the usual algorithms, I had to resort to using Heckman's two-step procedure, which treats the second-stage as a linear probability model in this application. Since there does not seem to be any selection into reverse tenancy, I only present the estimation results for the selection equation in table 14. Looking at those results, it turns out that the number of days spent looking for a tenant and the dummy for whether the tenant approached the landlord first are not significantly different from zero. Moreover, the estimated coefficient for the inverted Mills ratio (not shown) is not statistically significant either, which constitutes a non-rejection of the null hypothesis of no selection.

7 Conclusion

Using data from Madagascar's most important rice-producing region, this paper has tested among three theoretical explanations that broaden the theory of share tenancy proposed by Stiglitz (1974) by accommodating the existence of reverse share tenancy contracts. Estimation results indicate that the asset risk and limited liability explanations best explain the emergence of sharecropping in Lac Alaotra, along with the usual Stiglitzian risk-sharing explanation. Reverse share tenancy contracts, however, are explained solely by asset risk and limited liability. The canonical model of sharecropping thus fails to account for the emergence of reverse share tenancy, which points to the necessity of broadening the Stiglitzian model to account for the existence of such contracts.

From a policy perspective, the empirical results indicate that insurance markets are thin or missing in Madagascar, and that weak property rights over land may matter more than was previously thought (Jacoby and Minten, 2005). In this sense, recent land titling policy interventions by the World Bank, aimed at reducing tenurial insecurity, may have been well targeted.

To my knowledge, this paper is the first study to offer formal theoretical modeling and econometric evidence on the oft-observed phenomenon of reverse share tenancy. This opens up an important area of research, as reverse share tenancy has been discussed in the context of several other countries. It would thus be useful to conduct empirical studies for other countries so as to determine whether the explanations I offer in this paper hold elsewhere, or whether the canonical model should be extended further.

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