Queen's Economics Department Working Paper No. 1269

Tenure Insecurity, Adverse Selection, and Liquidity in Rural Land Markets

Derek Stacey
Queen's University

Department of Economics
Queen's University
94 University Avenue
Kingston, Ontario, Canada
K7L 3N6

4-2011

Tenure Insecurity, Adverse Selection, and Liquidity in Rural Land Markets

Derek G. Stacey*
Department of Economics,
Queen's University
Kingston, Ontario,
Canada, K7L 3N6
staceyd@econ.queensu.ca

April 13, 2011

Abstract

A theory of land market activity is developed for settings where there is uncertainty and private information about the security of land tenure. Land sellers match with buyers in a competitive search environment, and an illiquid land market emerges as a screening mechanism. As a consequence, adverse selection and an insecure system of property rights stifle land market transactions. The implications of the theory are tested using household level data from Indonesia. As predicted, formally titled land is more liquid than untitled land in the sense that ownership rights are more readily transferable. Additional implications of the theory are verified empirically by constructing a proxy variable for land tenure security and studying the differences between markets for unregistered land across Indonesian provinces. Regional land market activity is appropriately linked to the distribution of the proxy variable.

JEL classification: D83; Q15; D23; R23

Keywords: Competitive Search; Land Markets; Tenure Security; Liquidity

*The financial support of the Social Sciences and Humanities Research Council (SSHRC) is gratefully acknowledged. I would like to thank Huw Lloyd-Ellis and Allen Head for valuable comments.

1 Introduction

In this paper I construct a theory of land market activity in settings where land tenure is insecure. I argue that differences in the security of property rights over land can help explain the widely varied volumes of trade across developing country land markets. The framework establishes that asymmetric information about land tenure insecurity can reduce the volume of transactions in a land lease or sales market. As a useful application of the model, I analyze the effect of the performance of the land market on workers' migration decisions. Thinness in the land market can prevent the efficient allocation of workers between the farm and off-farm sectors.

It is a widely held view that systems of property rights have important effects on the functioning of agricultural land markets. In particular, policies that improve tenure security are often argued to improve land transferability and hence strengthen a landowner's capacity to capitalize on the value of his land should he decide to migrate or accept off-farm employment (Place and Migot-Adholla, 1998; Vranken and Swinnen, 2006). This is of economic importance because the process of economic development typically involves a shift in labour from agricultural sectors to more modern manufacturing or service sectors. Workers' incentives for making the transition partly depend on the functioning of the rural land market.

The main theoretical contribution of the paper is establishing the link between tenure security and land market activity. It is the hidden information about the security of land ownership that renders land illiquid. The transferability of a particular plot is determined endogenously by the number of land market participants. A low buyer-seller ratio implies a low probability of selling or leasing out land, which acts as a screening mechanism that allows the demand side of the market to determine the quality of the property rights. The endogenous mechanism is incentive compatible because owners of relatively secure land are willing to accept a lower probability of trade if payment is more favourable in the event of a land transfer.

To evaluate the predictions of the model, I present empirical evidence using household level data from Indonesia. As the model predicts, owners of rural land parcels are more active in the supply side of the land market if their land is registered. Approximately 17 percent of unregistered landowners supplied land to the market, while over 25 percent of certificate holders supplied some or all of their farmland to the market. This is consistent with the theory given that possession of a legal land certificate improves ownership security, and access to a land registry reduces the asymmetry of information. The data also suggest a link between the operation of the land market and non-farm business activity and labour force participation. Rural households with land certificates are more likely to have members earning wages in a non-agricultural sector compared to households with unregistered land. More rigorous analyses with difference-in-difference estimation and probit models support these relationships. Additional implications of the theory are empirically validated by constructing a proxy variable for land tenure security and studying the differences between markets for untitled land across Indonesian provinces.

This paper is related to a large literature on the importance of a well-defined and secure system of property rights over land. The literature has focused on several benefits of tenure security and well-functioning land markets: (i) the appropriate incentives for landowners to engage in long-term productivity enhancing investments (Besley, 1995; Brasselle, Gaspart, and Platteau, 2002; Jacoby, Li, and Rozelle, 2002; Deininger and Jin, 2006; Fenske, 2010); (ii) the ability to use land as collateral, thus improving landowners' access to credit (Feder and Onchan, 1987; Place and Migot-Adholla, 1998); and (iii) the allocation of land to more productive cultivators (Skoufias, 1995; Deininger and Jin, 2005).

In contrast, this paper focuses specifically on the role of land transferability in the efficient allocation of workers between agricultural and off-farm activities. In less developed countries, infrequent land transfers are often accomplished through inheritance and reallocation by village leaders. As non-agricultural sectors start to emerge and population densities increase, so does the need for land sales markets or rental transactions. Accordingly, I model the land market in an environment where a fraction of landowners receive an opportunity to work more productively in a modern sector. With no further need for land as a productive input, an emigrating landowner could benefit from the ability to lease or sell his plot.[1]

The theory presented here is also related to the household models of land rental markets with transaction costs (Besley, 1995; Skoufias, 1995; Carter and Yao, 2002; Deininger and Jin, 2009). In Deininger and Jin (2005) for example, demand for land transferability is driven by off-farm employment opportunities and differences in agricultural ability. By imposing exogenous transaction costs in the land market, illiquidity is introduced in a reduced-form fashion. An increase in transaction costs results in a larger set of self-cultivating agents not participating in the market. Deininger and Jin (2005) point to the costly acquisition of information and the risk of expropriation by village leaders as key determinants of transaction costs. Exactly how tenure insecurity translates into transaction costs that hamper land market participation is not modeled. That is, transaction cost models assume rather than explain the crucial determinants of land market inactivity. Recently, there has been a push in the field of development economics towards the understanding of underlying mechanisms (Deaton, 2010a,b). This paper fills a gap in the literature by applying a framework that allows one to understand the mechanism by which tenure insecurity leads endogenously to illiquidity in the land market.[2]

The plan for the paper is as follows. Section 2 describes the details of the model, Section 3 characterizes the equilibrium, and Section 4 presents the main theoretical results including efficiency implications. Section 5 presents an empirical analysis of land markets in Indonesia to verify the testable implications of the theory. Section 6 concludes. The proofs are presented in Appendices A and B. Appendix C outlines the derivation of the proxy variable for land tenure insecurity. Appendix D presents a variation of the model with land transactions driven by idiosyncratic shocks to household agricultural productivity.

[1] A few other papers acknowledge this important dimension of efficient land markets (Yang, 1997; Yao, 2000; Kung, 2002). For example, Yang (1997) uses a static household model to argue that the prohibition of farmland sales adversely affects the incentives for rural-urban migration, and Kung (2002) estimates a significant relationship between the emergence of off-farm labour markets and land rental market activity in rural China.

[2] In a dynamic setting, a measure of land activity is the number of transactions within a fixed interval of time. In a static context like the environment studied here, the analogous notion of land market activity or liquidity is the probability of trade: i.e., the likelihood of selling a particular plot.

2 The Model

There exist two sectors of production: the traditional agricultural sector (the rural economy) and the emerging off-farm economy with modern sector employment (the urban economy).[3] Rural workers match with urban firms before production takes place. Let q be the exogenous probability that a rural worker receives an urban job offer. The demand for land market transactions is driven by the potential gains from transferring land from an emigrant to a rural worker.

There are two periods. The land market is active in the first period, and production takes place in the second. In the final period, landless rural workers earn the wage rate w^R, and urban workers receive $w^U > w^R$. A rural landowner earns labour income as well as land rent, π. If a landowner fails to sell (or a lessee fails to transfer his lease), he can maintain possession of the land even if he accepts employment in the off-farm sector. In this case, the discounted continuation value of land ownership is $\alpha\pi$, $\alpha \in (0, 1)$. The continuation value is intended to mimic a dynamic setting, wherein an unsuccessful seller could try again to transact the following period.[4] Migration occurs at the beginning of the second period. A worker with an urban job offer decides whether or not to accept the job and migrate to the urban sector. The land market operates when potential emigrants try to transfer their land, and landless workers are willing to purchase/lease farmland. The model is constructed so as to be appropriate for both land lease and sales markets, since both buyers and lessees are exposed to the risk of losing agricultural output. To keep the terminology clear, I continue with the description of the model in terms of sales markets, even though land lease agreements are common for transferring farmland in developing countries.

[3]The sectors may not be separated geographically. The urban sector could therefore refer to the non-agricultural activity in the rural area.

[4]In a dynamic context, π can be thought of as the discounted present value of future land rents. Owners of unsold land lose rent in period two, but can still profit from the value of their land from the end of period 2 onward, $\alpha\pi$. While it is useful to interpret the model in a way that mimics a dynamic version, it will become clear that a fully dynamic model would be significantly complicated by the evolving distribution of land ownership and the possibility of learning under asymmetric information.

There is a fixed number of indivisible farm plots and an initial distribution of landownership among the rural population. To reflect tenure insecurity, suppose that the owner of a plot of land faces a probability $\lambda \in (0, 1)$ of losing ownership of the land.[5] Therefore, a rural landowner's total expected income is $w^R + (1 - \lambda)\pi$ in period two, and an emigrant landowner earns $w^U + \alpha(1-\lambda)\pi$ in expectation. Land is heterogeneous in terms of ownership security.[6] There are only two types: less secure land (type L with $\lambda_L \in (0, 1)$), and land with high tenure security (type H with $\lambda_H \in [0, \lambda_L)$). The rural population, which has measure N, is made up of landless workers and landowners. For simplicity, households are restricted to own and operate at most one plot of land. A share $n_L \in (0, 1)$ of the rural population own type L land, and a share $n_H \in (0, 1)$ own type H land, with $n_L + n_H < 1$. A fraction $1 - n_L - n_H$ of the rural population consists of ex ante homogeneous landless workers.

The quality of the land title is the landowner's private information. Hence there is the potential for a situation of adverse selection in the land market (Akerlof, 1970). I propose a framework with multiple submarkets for agricultural land market participants as an institution to help overcome the adverse selection problem. Submarkets arise endogenously, and each one is characterized by the price at which trade occurs in that particular subdivision of the market. Buyers and sellers observe the set of submarkets and decide in which to participate. Buyers and sellers meet bilaterally, and land transactions can occur at the price specific to that submarket. To highlight the mechanism by which adverse selection and an insecure system of property rights stifle land market transactions, I assume there are no matching frictions. The short side of the market matches with probability one. If,

[5] The notion of tenure insecurity is often thought of as a random probability of losing ownership rights to a particular plot of land. This modelling approach is consistent with the evidence of forced appropriations by local government leaders in rural China (Li, Rozelle, and Brandt, 1998) and the perceived threat of land reallocations in Ethiopia (Deininger and Jin, 2006). Alternatively, λ can be interpreted as the share of land rent spent on costly land disputes (Deininger and Castagnini, 2006; Holden, Otsuka, and Place, 2009). This might be appropriate for understanding the litigation costs in Cameroon for example, where title disputes make up a large number of cases brought before village-level and provincial courts (Firmin-Sellers and Sellers, 1999).

[6] Institutional differences across communities can bring about heterogeneous land titles, a phenomenon which has been documented in terms of land transfer rights in rural China (Liu, Carter, and Yao, 1998). On the other hand, Deininger, Zegarra, and Lavadenz (2003) observe a variety of legal and informal documents that convey different levels of tenure security in Nicaragua. As is discussed in greater detail in Section 5, overlapping property rights regimes have brought about heterogeneity in tenure security in Indonesia.

for example, there are more sellers than buyers in a particular submarket, buyers randomly select a seller to trade with.

Potential sellers are the landowners with urban job offers: qn_LN are type L (owners of insecure land), and qn_HN are type H (own secure land). Sellers can choose not to enter any submarket when the expected payoff is negative. Let $S_L = qn_LN$ denote the measure of type L sellers, and $S_H = qn_HN$ denote the measure of type H sellers. Potential buyers include all landless workers without outside labour market opportunities, $(1-q)(1-n_L-n_H)N$. Potential buyers enter the land market until the expected benefit of doing so is equal to the entry cost, c.

Assumption 1 $q < 1 - n_L - n_H$. *The measure of non-migrant landless workers is enough to ensure that the free entry conditions for buyers hold in equilibrium.*

Note that the migration decision in period two may depend on land market outcomes in the previous period. The accept/reject decisions of each type of agent can be characterized as follows:

1. A landless worker with no opportunity to purchase land will migrate if

$$w^U - w^R \geq 0. \tag{1}$$

2. A landless worker with an opportunity to purchase type i rural land at price p, and a type i landowner with the option of a land sale at price p will migrate if

$$w^U - w^R \geq (1-\lambda_i)\pi - p. \tag{2}$$

3. A type i landowner with no opportunity to sell land will migrate if

$$w^U - w^R \geq (1-\alpha)(1-\lambda_i)\pi. \tag{3}$$

Migration occurs among the landless whenever there exists an urban-rural wage gap. A precondition for land market activity is for the price of land, p, to satisfy inequality (2). Otherwise, landowners would never accept urban employment and there would be no need for a land market. Finally, if condition (3) holds for $i \in \{L, H\}$, all urban job offers are accepted.

A buyer's payoff in a land market transaction involving type i land for price p is $(1-\lambda_i)\pi - p$. A type i seller's gain from a land market transaction is

$$p - \max\{\alpha(1-\lambda_i)\pi, (1-\lambda_i)\pi - (w^U - w^R)\} \tag{4}$$

where the last term represents the opportunity cost of the transaction to the seller, and the maximization operator ensures that expected payoffs are consistent with optimal migration decisions. That is, the migration decisions of potential sellers are consistent with conditions (2) and (3). To simplify the notation, let

$$\xi_i = \max\{\alpha(1-\lambda_i)\pi, (1-\lambda_i)\pi - (w^U - w^R)\}, \quad \text{for} \quad i \in \{L, H\} \tag{5}$$

represent the type-dependent opportunity costs of land transactions. $\xi_H > \xi_L$ is an important property for deriving the results that follow. Choosing not to enter the land market (denoted by submarket $p = \emptyset$), yields a payoff of zero.

Assumption 2 $c < \min\{(1-\alpha)(1-\lambda_L)\pi, w^U - w^R\}$. *The cost of entering the land market, c, is small enough that expected gains from trade are always positive.*[7]

[7]The introduction of entry costs is necessary on the demand side of the market whenever

$$\frac{s_L(p)(1-\lambda_L)\pi + s_H(p)(1-\lambda_H)\pi}{s_L(p) + s_H(p)} - p > 0, \qquad p \in \mathbb{P}$$

to pin down the number of buyers in each submarket using the free entry condition. If entry costs are too high, expected gains from trade can become negative and the land market shuts down. Assumption 2 is a sufficient condition to ensure that a land market exists.

On the supply side of the market, entry costs are unnecessary because there is a fixed measure of potential sellers that enter the market whenever the expected gains from trade are positive. The results are unaffected by the introduction of entry costs on the supply side of the market, except for Proposition 4.3 (see footnote 9, p.16).

3 The Land Market

Definition 3.1 Given a set of submarkets, $\mathbb{P}$, a *land market equilibrium* is a measure $\{b(p)\}_{p\in\mathbb{P}}$, and measures $\{s_L(p)\}_{p\in\mathbb{P}\cup\{\emptyset\}}$, and $\{s_H(p)\}_{p\in\mathbb{P}\cup\{\emptyset\}}$ such that

1. Buyers' offers are consistent with free entry: for any $p \in \mathbb{P}$,

$$\min\left\{1, \frac{s_L(p)+s_H(p)}{b(p)}\right\}\left[\frac{s_L(p)(1-\lambda_L)+s_H(p)(1-\lambda_H)}{s_L(p)+s_H(p)}\pi - p\right] - c \leq 0$$

   (with equality if $b(p) > 0$)

2. Sellers enter submarkets optimally: for $i = L, H$,

   (i) if $s_i(p) = 0$ for all $p \in \mathbb{P}$, then $s_i(\emptyset) = S_i$ and

$$\max_{p\in\mathbb{P}}\left\{\min\left\{\frac{b(p)}{s_L(p)+s_H(p)}, 1\right\}(p-\xi_i)\right\} = 0$$

   (ii) if $s_i(p) > 0$ for some $p \in \mathbb{P}$, then

$$\min\left\{\frac{b(p)}{s_L(p)+s_H(p)}, 1\right\}(p-\xi_i) \geq \max\left\{0, \max_{p\in\mathbb{P}}\left\{\min\left\{\frac{b(p)}{s_L(p)+s_H(p)}, 1\right\}(p-\xi_i)\right\}\right\}$$

3. Aggregation: for any $i \in \{L, H\}$,

$$\sum_{p\in\mathbb{P}\cup\{\emptyset\}} s_i(p) = S_i$$

The last part of the definition says that every potential seller either chooses a submarket or decides not to enter the land market. Part 2 requires that sellers choose optimally between submarkets. The first part of the definition says that free entry drives a buyer's expected payoff down to the cost of entering the market. Notice that an equilibrium allocation of buyers and sellers determines the type-dependent utilities of sellers, $\{\bar{U}_L, \bar{U}_H\}$.

As previously noted, migration decisions in period two may hinge on land market outcomes in period one. Accordingly, the opportunity cost of a land transaction reflects the anticipated migration decision. Depending on the parameter values, the environment can be classified according to the pattern of equilibrium migration decisions. Suppose for example that all job offers are accepted, even without land market transactions. Call this a case 1 environment. A case 2 environment is one in which only type H landowners who fail to sell land reject urban job offers. Finally, a case 3 environment manifests when both types of landowners reject job offers when unable to sell their land. Equilibrium in the land market can be classified in this manner according to the urban-rural wage gap:

$$\text{Case 1 if } w^U - w^R \geq (1-\alpha)(1-\lambda_H)\pi$$
$$\text{Case 2 if } w^U - w^R \in \big[(1-\alpha)(1-\lambda_L)\pi, (1-\alpha)(1-\lambda_H)\pi\big)$$
$$\text{Case 3 if } w^U - w^R < (1-\alpha)(1-\lambda_L)\pi$$

The equilibrium definition does not impose restrictions on prices (i.e., submarkets) that do not appear in the land market. Consequently, many sets of prices and allocations of agents across submarkets satisfy the equilibrium conditions. For instance, an equilibrium with only one submarket with price $p \in (\xi_L, \min\{\xi_H, (1-\lambda_L)\pi - c\})$ is an equilibrium with only a market for type L land: type L sellers choose to enter since $p > \xi_L$; type H sellers choose not to enter whenever $p < \xi_H$; and buyers choose to enter because $p \leq (1-\lambda_L)\pi - c$. Type L land is readily sold, since $p < (1-\lambda_L)\pi - c$ implies $b(p) > S_L$, while type H land is completely illiquid. Moreover, if $p < (1-\lambda_L)\pi - c$, it seems reasonable that the price would be bid upward, since $p' \in (p, (1-\lambda_L)\pi - c)$ would still attract type L sellers and the deviation would yield a strictly positive payoff. To restrict the set of equilibria, consider the following refinement.

Equilibrium Refinement 1 The set of submarkets (prices $\mathbb{P}$, and allocations $\{b(p)\}_{p\in\mathbb{P}}$, $\{s_L(p)\}_{p\in\mathbb{P}\cup\{\emptyset\}}$, and $\{s_H(p)\}_{p\in\mathbb{P}\cup\{\emptyset\}}$) satisfying equilibrium conditions 1, 2, and 3 represents a *competitive search land market equilibrium* if, given the associated seller utilities $\{\bar{U}_L, \bar{U}_H\}$, there is no deviating offer $p' \in \mathbb{R}_+ \backslash \mathbb{P}$ that yields a strictly positive expected payoff to the subset of buyers bidding p'.

The equilibrium refinement turns the land market equilibrium into a competitive search equilibrium like that of Moen (1997), but extended to a setting with asymmetric information. The framework is similar to that developed in Guerrieri, Shimer, and Wright (2010), but without the standard single-crossing condition. In other words, there is no sorting variable allowing buyers to attract type H sellers without also attracting type L sellers. Instead, there is a trade-off between the probability of trade and the price of land that endogenously sorts sellers into submarkets. As in other models of competitive search, there is the implicit restriction on out-of-equilibrium beliefs that agents correctly anticipate the ratio of buyers to sellers in all possible submarkets, not just those that appear in equilibrium.

Proposition 3.1 *Under Assumptions 1 and 2, there exists a unique competitive land market equilibrium with*

1. *land prices:* $p_L = (1-\lambda_L)\pi - c$ *and* $p_H = (1-\lambda_H)\pi - c$

2. *seller allocations:* $\{s_L(p_L), s_L(p_H)\} = \{S_L, 0\}$ *and* $\{s_H(p_L), s_H(p_H)\} = \{0, S_H\}$

3. *buyer allocation:* $b(p_L) = S_L$ *and*

$$b(p_H) = \begin{cases} \left(\dfrac{(1-\alpha)(1-\lambda_L)\pi - c}{(1-\lambda_H)\pi - \alpha(1-\lambda_L)\pi - c}\right) S_H & \text{if} \quad w^U - w^R \geq (1-\alpha)(1-\lambda_L)\pi \\ \left(\dfrac{w^U - w^R - c}{w^U - w^R + (\lambda_L - \lambda_H)\pi - c}\right) S_H & \text{if} \quad w^U - w^R < (1-\alpha)(1-\lambda_L)\pi \end{cases}$$

4. *type-dependent seller utilities:*

$$\bar{U}_L = \begin{cases} (1-\alpha)(1-\lambda_L)\pi - c & \text{if} \quad w^U - w^R \geq (1-\alpha)(1-\lambda_L)\pi \\ w^U - w^R - c & \text{if} \quad w^U - w^R < (1-\alpha)(1-\lambda_L)\pi \end{cases}$$

and

$$\bar{U}_H = \begin{cases} \dfrac{b(p_H)}{S_H}\big[(1-\alpha)(1-\lambda_L)\pi - c\big] & \text{if} \quad w^U - w^R \geq (1-\alpha)(1-\lambda_H)\pi \\ \dfrac{b(p_H)}{S_H}\big[w^U - w^R - c\big] & \text{if} \quad w^U - w^R < (1-\alpha)(1-\lambda_H)\pi \end{cases}$$

In a full information benchmark economy, there is no illiquidity in the land market: $b(p_i) = S_i$ for $i \in \{L, H\}$. In an equilibrium with asymmetric information, however, $b(p_H) < S_H$, implying that there are too few land market transactions in the type H submarket. Some type H landowners with valuable urban job offers fail to sell their land.

In the presence of adverse selection due to private information regarding tenure insecurity, type H land plots are made illiquid as a screening mechanism. The illiquidity arises because too few buyers enter the market for type H land. The mechanism functions appropriately because type L landowners prefer a liquid market in order to avoid being stuck with an insecure land title when production takes place. Type L sellers will therefore enter submarket p_L in order to sell more readily, albeit at a lower price. On the other hand, type H owners are more likely to maintain ownership of their land if they fail to sell. Sellers of secure land are therefore more willing to accept a lower probability of trade if it means a chance at receiving a fair price.

4 The Effects of the Property Rights System

In this section I analyze how changes to the system of property rights affect the functioning of the land market and the allocation of workers across sectors. Let $\lambda_L = \lambda + \varepsilon$ and $\lambda_H = \lambda - \varepsilon$. Since all type L sellers trade in equilibrium and only a fraction $\theta_H \equiv b(p_H)/S_H \in (0, 1)$ of type H sellers trade, the total number of land market transactions is $S_L + \theta_H S_H$. The following proposition summarizes the linkages between the system of land rights (governed by parameters λ and ε) and the functioning of the land market in terms of the number of transactions.

Proposition 4.1 *Equilibrium comparative statics with respect to the system of ownership rights over land imply the following:*

(i) A deterioration of land tenure security undermines the transferability of land:

$$\frac{\partial \theta_H}{\partial \lambda} \leq 0, \quad \text{(strict for high values of } \lambda\text{)}$$

(ii) An increase in the heterogeneity of land titles curtails land market activity:

$$\frac{\partial \theta_H}{\partial \varepsilon} < 0$$

The first result describes the effect of a change in (unweighted) average land tenure security on the rural land market. As average land tenure insecurity increases, it becomes more likely that a case 1 or case 2 land market emerges; i.e., it becomes less likely that land market outcomes influence subsequent migration decisions. Once this is the case, type H land plots become less liquid, and land market activity declines. This is an important but intuitive result. It says that tenure security makes it easier for households to conduct land market transactions. The relationship between land market activity and the security of landowner rights supplements the existing literature on the importance of property rights in land markets. While other researchers focus on the impact of tenure insecurity on incentives for investment and the ability to use land as collateral (Besley, 1995; Place and Migot-Adholla, 1998; Brasselle, Gaspart, and Platteau, 2002; Deininger and Jin, 2006), I emphasize its effect on land transferability. Establishing the link between tenure insecurity and the equilibrium volume of transactions in a land market is one of the main theoretical contributions of the paper. Note that without private information, the security of ownership would not affect the number of land sales.[8]

The second part of Proposition 4.1 describes how a land market is adversely affected by the variability in land title quality. Greater dispersion in land tenure security (the λ_is)

[8] Under perfect information, changes in the λ parameters would affect equilibrium prices, but markets would clear for any $\{\lambda_L, \lambda_H\}$ distribution.

makes it more difficult for landowners with more secure property rights to trade. Substantial differences in tenure security between plots renders the information asymmetry problem more severe. Land market transactions are rare in such environments because the ratio of buyers to sellers adjusts as an effective sorting device.

An accessible system of clear property titles allows land market participants to counteract the effect of tenure uncertainty. It is conceptually possible for a comprehensive land titling initiative to eliminate the asymmetric information problem altogether. A complete and widespread system of property titles in conjunction with a mechanism for land dispute resolution could avoid the manifestation of illiquidity as a screening device if potential buyers can access records of conclusive land title at a low cost. Even when land registration is less comprehensive, land reforms are likely to have several intermediate effects. For example, land legislative reforms should help reduce the incidence and cost of land disputes, as well as reduce the probability of losing ownership due to forced land takings. Proposition 4.1(i) therefore supports land titling initiatives and other land reforms if the aim is to increase the transferability of land via enhanced security of landownership. In addition, land titling efforts should reduce the differences in land tenure security across plots, which is more symptomatic of informal institutions with complex systems of customary land rights. A formal land title is more likely to pin down the property rights for all owners of registered plots, especially if land registration involves a cadastral map. Proposition 4.1(ii) would then imply reinforced land transferability as a result of the reduction in uncertainty surrounding tenure security. These arguments are supported empirically in Section 5 with estimates of land market participation for owners of registered and unregistered land.

4.1 Efficiency

Inefficiencies in the land market distort workers' migration decisions and lead to an inefficient allocation of agents across sectors. The flow of workers from farm to off-farm employment stalls when sellers face a low probability of a successful land transaction. From a labour allocation point of view, all urban job offers should be accepted whenever $w^U - w^R > c$.

This efficient allocation of agents across sectors only occurs in a case 1 equilibrium. The case 1 outcome is efficient in this sense only because the urban wage is so high that the land market becomes irrelevant to the migration decision. In case 2 and case 3 environments, only a fraction $b(p_H)/S_H < 1$ of job offers received by type H landowners are accepted in equilibrium. Migration flows are therefore sub-optimal whenever $w^U - w^R < (1-\alpha)(1-\lambda_H)\pi$.

Illiquidity in the land market enables buyers to distinguish between the types of land plots. It allows plots of all types (at least some plots of each type) to be traded in equilibrium even in an environment with tenure insecurity and adverse selection. The endogenous screening mechanism therefore partly corrects for market failure, moving the equilibrium closer to the full information benchmark: an equilibrium where all beneficial land transactions take place. In certain situations, however, it's possible that the inefficiencies that arise from screening outweigh the benefits of treating both types distinctly. As Guerrieri, Shimer, and Wright (2010) show, a pooling allocation can Pareto dominate the separating competitive search equilibrium. This occurs when there are not too many insecure plots. In other words, the land market equilibrium might not be constrained Pareto efficient. Proposition 4.2 summarizes the efficiency results.

Proposition 4.2 *The equilibrium labour flow from agricultural to off-farm sectors is inefficiently low whenever the wage gap is not too large; that is, if*

$$w^U - w^R < (1-\alpha)(1-\lambda_H)\pi.$$

The competitive land market equilibrium is constrained Pareto optimal if the proportion of type L plots of land is sufficiently large:

$$\frac{S_L}{S_L + S_H} > \begin{cases} \dfrac{(1-\alpha)(1-\lambda_H)\pi - c}{(1-\lambda_H)\pi - \alpha(1-\lambda_L)\pi - c} & \text{if case 1} \\ \dfrac{w^U - w^R - c}{(1-\lambda_H)\pi - \alpha(1-\lambda_L)\pi - c} & \text{if case 2} \\ \dfrac{w^U - w^R - c}{w^U - w^R + (\lambda_L - \lambda_H)\pi - c} & \text{if case 3} \end{cases}$$

The next proposition describes how a land market might not function at all if land tenure becomes too insecure, or the information asymmetry becomes too extreme. Intuitively, the land market shuts down when the risk of land appropriation drives the gains from trade to zero. Interestingly, even when there are gains from transferring the relatively more secure land, all land transactions can be rendered infeasible because the screening mechanism unravels when the gains from trading the least secure land fall to zero.[9]

Proposition 4.3 *If land tenure becomes too insecure, such that λ rises above the threshold*

$$\bar{\lambda} \equiv \frac{(1-\varepsilon)(1-\alpha)\pi - c}{(1-\alpha)\pi},$$

the land market shuts down completely. Moreover, a high degree of heterogeneity in land rights, ε, restricts the range of λ for which a land market can operate.

Proposition 4.3 offers an explanation as to why land markets have failed to emerge in some developing countries. Low tenure security and asymmetric information might also explain why administrative land reallocations are sometimes used to transfer land when land sales markets are absent and the incidence of rental activity is low.

This result is related to other studies of asset markets in settings with private information. Guerrieri, Shimer, and Wright (2010) show that an entire asset market can shut down when the gains from trading the bad asset fall below zero. Lester, Postlewaite, and Wright (2009) construct an environment with information frictions in which some assets become non-transferable when the seller cannot recognize their quality. Chiu and Koeppl (2010) model a financial asset market using search theory in a setting with adverse selection and show that the market "freezes" when the average quality of the asset falls below a certain threshold.

[9]When both buyers and sellers pay entry costs to participate in the land market, the market for secure land can shut down before the entire market collapses. This is because the cost of illiquidity can dominate the gains from trade in the type H market, while type L land continues to be readily transferable.

5 Evidence from Indonesian Land Markets

I test whether registered ownership is associated with a higher incidence of land market participation using an interesting micro dataset from Indonesia. Then, I present a descriptive analysis of the link between the degree of tenure security and the transferability of land among unregistered landowners. The Indonesian data is particularly appropriate because of the way the government is implementing its land registry program. Indonesian farmland is being titled in a sporadic manner so that land with varying degrees of tenure security are spread across the country, rather than having land certificates concentrated in specific areas. This provides a useful environment for examining the link between tenure security and land market participation.

5.1 Background

Over the past few decades, population growth, declining land fertility, and the conversion of agricultural land for non-farm utilization have made it more difficult for farming households in Indonesia to cultivate enough land to achieve a sufficient standard of living. Well-functioning land markets could allow households to seize off-farm labour market opportunities and transfer land to those who remain. As I have argued in this paper, land tenure insecurity and an ill-defined system of property rights over land reduce the scope of market transactions.

The system of land ownership rights in rural Indonesia exhibits many of the salient features of the theoretical model described above, including the following:

Land Tenure Insecurity: Sources of tenure insecurity in Indonesia include under-compensated land confiscation by governments and frequent land disputes. Land disputes among rural residents arise because of ill-defined boundary definitions, a complex system of land rights, and overlapping land deeds.

Heterogeneous Land Titles: Indonesia's complicated system of land rights is the result of colonial governments instituting statutory law when land titles under traditional (*adat*) law already existed. The Basic Agrarian Law (*Undang-undang Pokok Agraria*/UUPA) of 1960 was established to unify both the traditional and the statutory land laws. The UUPA recognizes a variety of land rights, the most secure of which is *Hak Milik*, or the right of perpetual ownership and use.

Asymmetric Information: Article 19 of the UUPA states the government's intention to register all land in the Republic of Indonesia. The purpose of the land registry is not only to protect the rights of landowners and users, but also to make available land right information for potential buyers, banks, real estate firms, and other interested individuals or organizations. As of 2006, however, only 36 percent of land had been registered, or about 34 million land certificates issued (Risnarto, 2009). Until all land is registered, land title under customary law and land transactions of unregistered land are still recognized. Informal transfers are acknowledged in the court system but rely on private conveyances and possibly the testimony of a witness of the land transaction. "Private conveyancing is inefficient and potentially dangerous since it can be subject to fraud as there is no easy proof that the vendor is the true owner" (Walijatun and Grant, 1996).

An overview of the empirical section of the paper is as follows. First I describe the Indonesian data. Then I outline the empirical methods used to study the relationship between the possession of a land certificate and a farmer's participation in the land market on the supply side. Comparing the land market participation of registered landowners and owners without legal documentation reveals to what extent tenure insecurity and asymmetric information influence the volume of land market transactions. To investigate further, I analyze the land market participation of unregistered owners using a proxy variable for tenure insecurity. By exploiting regional differences in tenure security in rural Indonesia, I find evidence to support Proposition 4.1; specifically, I find that regional land markets tend to be more active when tenure security is high (on average) and when there is minimal heterogeneity in tenure security across plots.

5.2 Data

The data used in the analysis come from the 2000 and 2007 rounds of the Indonesian Family Life Survey (IFLS). The IFLS is a longitudinal household panel dataset that began in 1993, but has expanded after four rounds to to cover over 15,000 households in 13 of the 27 Indonesian provinces. The surveys cover standard household and individual level characteristics, farm assets, labour earnings, and land use data. The IFLS collects additional community level information about land use and off-farm sectors. Only the most recent survey directly asked landowners about land certificates. Fortunately, respondents were also asked when the land title/document was obtained, which allows one to determine which households held land certificates in previous IFLS waves. I use the two most recent cross sections of the IFLS because of the expanded sample size relative to the first two waves. Since there are missing values in the date of certification variable in the most recent survey, most of the econometric analysis focuses on the 2007 cross section (IFLS4), with one lagged land market variable from the 2000 wave (IFLS3).

I limit the sample to IFLS households that own farmland. The IFLS sample is large enough that even after this restriction, 3,607 IFLS4 households and 2,746 IFLS3 households are left for the analysis. The sales market for land in rural Indonesia is very inactive. Less than one percent of the sample sold land in the last year. Instead, households conduct land transactions in the lease market. It could be that rental or profit-sharing arrangements are preferred when potential buyers are borrowing constrained. Table 1 provides basic descriptive statistics for the relevant subset of the IFLS4 sample. The data reveal a moderate level of activity on the supply side of the land lease market: 25.1 percent of households with land certificates lease out land, while only 16.5 percent of households without formal title documentation rent out or profit-share land. Conditional on renting out land, the total area of land rented out does not appear to be constrained for unregistered landowners relative to registered owners. The data suggest that land market frictions affect the extensive but not the intensive margin.[10]

[10]This is inconsistent with land models with transaction costs proportional to the area rented, as in

Moreover, households with at least one member operating an off-farm enterprise are more likely to possess land certificates: 41.1 percent of households with registered land are involved in non-agriculture business, while only 33.7 percent of unregistered households are operating businesses in the off-farm economy. Furthermore, households with land certificates tend to supply more labour to the non-agricultural economy (0.55 members relative to 0.41 members for households with unregistered land). Descriptive statistics therefore illustrate the linkages between land certification, land market participation, and off-farm economic activity. One interpretation of the summary evidence is that the owners of registered land experience greater tenure security and possess credible documentation to convey their secure ownership. The market for certified land should therefore be more active than the market for untitled land, allowing farmers with land certificates to lease out land and accept off-farm employment more readily.

5.3 Empirical Analysis

To investigate the effect of land certificates on supply side land market participation, a difference-in-difference methodology is applied to the IFLS data. In addition to land registration, one would expect a household's demographic characteristics to affect the decision to participate in the land market. The age, gender, and educational attainment of the household head are included as independent variables. To account for market imperfections for non-land factors of production, the number of adult males and females in the household are included, as well as the market value of livestock and farm equipment. If land market transactions are driven by off-farm labour market opportunities as in the theoretical model, supplying land in the lease market should also be related to the participation of household members in non-agricultural sectors and the value of non-farm assets. Off-farm economic variables are therefore included as well. Market transactions might correct for an unequal distribution of land by transferring land from households with large landholdings to house-

(Deininger and Jin, 2005), where land market frictions affect both the participation decision and the amount of land to rent in or out.

Table 1: Summary Statistics

	landowners with certificates			landowners without certificates			t test
VARIABLE	mean	std. error	obs.	mean	std. error	obs.	H_A: diff > 0
supply side land market participation rates							
rental market	0.131	0.0102	1094	0.0961	0.00590	2498	3.099***
lease market	0.121	0.00985	1094	0.0673	0.00501	2497	5.340***
both markets	0.251	0.0131	1100	0.165	0.00742	2506	6.0529***
size and value of household farmland endowments							
size (in hectares)	2.184	0.780	1084	1.697	0.418	2473	0.597
value (in Rupiah) per hectare	4.92e+08	5.39e+07	1077	2.87e+08	2.18e+07	2441	4.226***
size (in hectares) of land rented out	0.683	0.0905	143	2.888	1.917	240	-0.887
non-agricultural economic activity							
participation in off-farm business	0.411	0.0148	1100	0.337	0.00944	2507	4.289***
members earning off-farm wages	0.552	0.0232	1100	0.405	0.0136	2507	5.722***

Notes: The sample is restricted to Indonesian households that owned farmland in 2007. Single asterisk denotes statistical significance at the 90% level of confidence, double 95%, triple 99%.
Source: 2007 Indonesian Family Life Survey (IFLS4), calculations by author.

holds lacking sufficient acreage. Accordingly, the area of owned land per household member is a included among the explanatory variables. Finally, provincial dummy variables are included to account for differences in population densities and the possibility that off-farm economic opportunities differ across regions. The probit model to be estimated is therefore

$$\Pr\big(y_i = 1\big) = \Phi\big(\beta_0 + \beta_1(c_i \times d_{2007}) + \beta_2 c_i + \beta_3 d_{2007} + \boldsymbol{\beta}_4 \boldsymbol{X}_i + \boldsymbol{\beta}_5 \boldsymbol{Y}_i + \boldsymbol{\beta}_6 \boldsymbol{Z}_i + \boldsymbol{\beta}_7 \boldsymbol{P}_i\big), \quad (6)$$

where i indexes households, y_i is an indicator variable for supply side land market participation, the βs are coefficients or vectors of coefficients, c_i indicates possession of a land certificate, d_{2007} is an indicator for the 2007 survey, $\boldsymbol{X}_i$ is a vector of household demographic characteristics, $\boldsymbol{Y}_i$ is a vector of farm-related variables, $\boldsymbol{Z}_i$ is a vector of off-farm economic variables, $\boldsymbol{P}_i$ is a vector of provincial dummies, and Φ is the standard normal distribution function.

The variable of interest is c_i, which indicates the ownership of registered land. More specifically, c_i is a dummy variable for the possession of a land certificate securing the *Hak Milik* title. This type of land right is intended to increase tenure security by providing perpetual ownership, user rights, and transferability. In the context of the theory, land certification and the presence of an accessible land registry reduce the asymmetric information problem and eliminate the need for illiquidity as a screening mechanism. Therefore, the market for registered land should be more active than the market for unregistered land, since unregistered land is subject to the inefficiencies associated with tenure insecurity and private information.

Rental and profit-sharing arrangements can be long lasting, and past participation in the land lease market is likely related to the current participation decision. To account for this, I estimate probit models for the binary decision to lease out land in 2007 (y_i in IFLS4, or $y2007_i$) including the land variable from 2000 (y_i in IFLS3, or $y2000_i$) on the right-hand side. The probability of supplying land to the lease market in 2007 is represented by the probit equation

$$\Pr\big(y2007_i = 1\big) = \Phi\big(\beta_0 + \beta_1 c_i + \beta_2 y2000_i + \boldsymbol{\beta_3 X}_i + \boldsymbol{\beta_4 Y}_i + \boldsymbol{\beta_5 Z}_i + \boldsymbol{\beta_6 P}_i\big), \tag{7}$$

where i indexes households; $\boldsymbol{X}_i$, $\boldsymbol{Y}_i$, $\boldsymbol{Z}_i$, and $\boldsymbol{P}_i$ are defined as before; and Φ is the standard normal distribution function.

5.4 Empirical Findings

The Impact of Land Certification

The land market participation difference-in-difference estimation is presented in Table 2. Since equation (6) is a nonlinear model, the interaction effect can be computed according to Ai and Norton (2003) so as to avoid misinterpreting the difference in the land market outcomes of registered versus unregistered landowners and the statistical significance of the result. Applying their method of estimating the magnitude and standard errors of the interaction effects for the first specification yields a mean interaction effect of 0.0732 with a mean z-statistic of 2.46 (significant at the 95 percent confidence level). For the remaining specifications, the estimated mean interaction term is similar in magnitude (between 0.0610 and 0.0675), and the mean z-statistics establish significance at the 95 percent confidence level. Moreover, for all four specifications, the interaction effect is positive for the entire sample; that is, for all combinations of independent variables that exist in the sample.

The implication of the above is that a household having acquired a legal land title between the IFLS3 and IFLS4 surveys has a higher propensity to lease out land. This empirical trend is robust to the inclusion of farm variables (columns (2) and (4)) and non-farm economic variables (columns (3) and (4)). Proponents of land certification programs argue that registered land offers greater tenure security and reduces the asymmetry of information in land market transactions. The findings are therefore consistent with the idea that tenure insecurity and asymmetric information reduce liquidity in land markets. There is no attempt to control for the possibility that landowners acquire certificates in anticipation of supply side land market participation. This would be important if the objective was to evaluate the impact of exogenous land titling initiatives, as in Holden, Deininger, and Ghebru (2007). Regardless of the direction of causation, the fact that land certificates are associated with more active land markets supports the notion that tenure insecurity and asymmetric information affect how easily land transactions can be carried out.

As expected, farm asset ownership is negatively related to land market participation on the supply side, although household labour endowments are not significant predictors of land market participation, except for the number of adult males in column (4). Off-farm business activity, off-farm employment, and non-farm asset ownership are positively related to leasing out land. These results are in line with the presupposition that the demand for land market transactions is stimulated by off-farm economic opportunities, as in the theoretical framework. The size of owned farmland is important in the participation decision, as households with greater per capita land endowments are more likely to rent out land.

Table 3 presents the comparable estimates from probit regressions for the most recent cross section of the IFLS, using a binary variable indicating land market participation on the supply side in 2007. Some of the land rental and profit-sharing arrangements in the IFLS4 could simply be the continuation of prior arrangements. To account for this, the land market variable from 2000 (i.e., supply side land market participation in the IFLS3) is included as an explanatory variable. Past participation is a significant predictor of current participation in all four specifications. Focusing again on the variable of interest, the probit results reinforce the findings from the difference-in-difference analysis. Possession of a land certificate increases the propensity to supply land by 3.3 to 4.3 percentage points.

The difference-in-difference and probit results have established a clear link between land certificates and land market activity. Tenure insecurity, unclear boundary definitions, and the complexity of the customary system of property rights are preventing unregistered land from being readily transferred in the rental and sales markets. Acquiring a formal legal title improves the liquidity of farmland. Further analysis of unregistered land is required to establish whether the theoretical model presented in Section 2 is a reasonable representation of land markets with uncertainty and private information about tenure security.

Tenure Insecurity in the Market for Unregistered Land

The degree of tenure security associated with a particular plot is unobservable. It is precisely this hidden information that renders land illiquid in order for potential buyers to distinguish the ownership rights associated with a vendor's plot. Although private information makes it difficult for econometric analysis, a proxy variable can be backed out of the IFLS data which, according to the theory, is correlated with the parameters λ_i, for all i. Appendix C provides the details for the construction of the proxy variable, *lambda*. Essentially, land tenure is assumed to be insecure if annual farm output is high relative to the value of the plot. This is based on the premise that owners of insecure land discount future farm profit at a higher rate, which lowers their self-assessed valuation of their land. Taking the ratio of land rent to land value is one way of backing out the degree of ownership insecurity.

Proposition 4.1 can be tested empirically using *lambda* as a proxy variable for unobservable tenure insecurity. Proposition 4.1(i) describes the negative relationship between average tenure insecurity and land market activity, while Proposition 4.1(ii) characterizes a negative relationship between the dispersion of the λ_is and the thickness of the land market. These implications of the theory can be verified in the IFLS data by exploiting differences in the distributions of *lambda* across regions. Figure 1 displays the disparities between two Indonesian regions for unregistered land. Land in Java is relatively secure, while the distribution of *lproxy* in Sumatra suggests that land is more insecure.

Table 4 contains the first and second moments of the distributions of *lambda*, as well as the share of landowners participating on the supply side of the market for five geographical regions. It is easy to detect a pattern of high land market participation in regions where tenure is on average more secure. Land markets are most active in Java, Nusa Tenggara, and Sulawesi, where land is secure (low average *lambda*) and the information problem is limited

Table 2: Difference-in-Difference Results for Supply Side Land Market Participation

VARIABLES	(1)	(2)	(3)	(4)
land certificate × 2007 indicator	0.297**	0.300**	0.269**	0.279*
	(0.130)	(0.137)	(0.136)	(0.142)
land certificate	-0.0991	-0.119	-0.101	-0.118
	(0.117)	(0.122)	(0.123)	(0.128)
2007 indicator	0.0754	0.0328	0.0874	0.0401
	(0.0569)	(0.0598)	(0.0591)	(0.0619)
per capita farmland (log)	0.0293**	0.0496***	0.0404***	0.0571***
	(0.0145)	(0.0156)	(0.0151)	(0.0163)
head's age	0.0237**	0.0274**	0.0162	0.0243*
	(0.0118)	(0.0129)	(0.0121)	(0.0132)
head's age squared	-0.000165	-0.000218*	-9.10e-05	-0.000185
	(0.000121)	(0.000131)	(0.000123)	(0.000133)
head's gender (female = 1)	0.387***	0.199**	0.452***	0.238***
	(0.0756)	(0.0852)	(0.0771)	(0.0867)
head's years of schooling	0.0596***	0.0439***	0.0492***	0.0367***
	(0.00552)	(0.00591)	(0.00602)	(0.00640)
household males 15-60 years		-0.0557		-0.0783**
		(0.0357)		(0.0370)
household females 15-60 years		0.0628*		0.0378
		(0.0370)		(0.0383)
indicator for ownership of		-1.211***		-1.172***
livestock or farm assets		(0.0823)		(0.0851)
value of farm assets (log)		-0.0220*		-0.0167
		(0.0127)		(0.0131)
non-farm business indicator			0.312***	0.250***
			(0.0505)	(0.0535)
value of non-farm assets (log)			0.0540***	0.0456***
			(0.0146)	(0.0157)
share of household members			0.365***	0.287***
with off-farm employment			(0.0830)	(0.0874)
provincial indicators	yes	yes	yes	yes
observations	4,219	4,066	4,053	3,911

Notes: Parameter estimates from the probit estimation of equation (6). Standard errors in parentheses. Single asterisk denotes statistical significance at the 90% level of confidence, double 95%, triple 99%. Source: Indonesian Family Life Survey (IFLS), calculations by author.

Table 3: Probit Results for Supply Side Land Market Participation in 2007

VARIABLES	(1)	(2)	(3)	(4)
land certificate	0.169**	0.152**	0.145**	0.136*
	(0.0720)	(0.0758)	(0.0740)	(0.0776)
supply side land market	0.645***	0.569***	0.640***	0.578***
participation in 2000	(0.0831)	(0.0886)	(0.0848)	(0.0901)
per capita farmland (log)	0.0414*	0.0653**	0.0427*	0.0603**
	(0.0229)	(0.0255)	(0.0237)	(0.0261)
head's age	0.00686**	0.00527*	0.00615**	0.00506*
	(0.00269)	(0.00286)	(0.00277)	(0.00293)
head's gender (female = 1)	0.409***	0.260**	0.467***	0.293**
	(0.103)	(0.116)	(0.105)	(0.117)
head's years of schooling	0.0594***	0.0386***	0.0492***	0.0318***
	(0.00776)	(0.00842)	(0.00837)	(0.00900)
household males 15-60 years		-0.00525		-0.0347
		(0.0484)		(0.0502)
household females 15-60 years		0.0651		0.0443
		(0.0522)		(0.0533)
indicator for ownership of		-1.311***		-1.259***
livestock or farm assets		(0.120)		(0.124)
value of farm assets (log)		-0.0302*		-0.0218
		(0.0182)		(0.0186)
non-farm business indicator			0.295***	0.222***
			(0.0704)	(0.0746)
value of non-farm assets (log)			0.0584***	0.0462**
			(0.0214)	(0.0233)
share of household members			0.345***	0.255**
with off-farm employment			(0.116)	(0.123)
provincial indicators	yes	yes	yes	yes
observations	2,218	2,146	2,160	2,094

Notes: Parameter estimates from the probit estimation of equation (7). Standard errors in parentheses. Single asterisk denotes statistical significance at the 90% level of confidence, double 95%, triple 99%.
Source: Indonesian Family Life Survey (IFLS), calculations by author.

(small standard deviation of *lambda*). The two regions with the least active land markets among unregistered landowners, Kalimantan and Sumatra, have the most severe average tenure insecurity as well as the distributions with the most dispersion.

To investigate further, variables can be generated by computing the mean and standard deviation of *lambda* in the household's province of residence. The distributions are highly skewed, and the first two moments are highly sensitive to outliers. To circumvent this issue, a transformation of *lambda* is computed in order to derive a proxy variable for land tenure security $LTSproxy \equiv -\log(lambda)$. The distribution of *LTSproxy* has nicer properties than the distribution of *lambda*. The variables *LTSproxyMEAN*, *LTSproxySD*, and *LTSproxyCV* are generated by computing the mean, standard deviation, and coefficient of variation of *LTSproxy* in the household's province of residence. Including average tenure security, and the dispersion of tenure security across plots within each province in the probit models of land market participation allows Proposition 4.1 to be tested formally. While the coefficients have the appropriate signs (not shown), the significance levels are low (significant only at the 10 percent level) when both variables are included. This is likely because provinces with low tenure security also tend to suffer from high degrees of heterogeneity in land rights. Instead of including both the mean and the standard deviation, only the coefficient of variation, *LTSproxyCV*, is included in the probit models. In a given province, heterogeneity of ownership rights across plots (high *LTSproxySD*) implies a high *LTSproxyCV*, and should limit land market participation according to Proposition 4.1(i). Low average tenure security (low *LTSproxyMEAN*) also implies a high *LTSproxyCV*, and should curb participation in the land rental and lease markets according to Proposition 4.1(ii).

The probability of supplying unregistered land to the lease market in 2007 is represented by the probit equation

$$\Pr\big(y2007_i = 1\big) = \Phi\big(\beta_0 + \beta_1 LTSproxyCV_j + \beta_2 y2000_i + \boldsymbol{\beta}_3 \boldsymbol{X}_i + \boldsymbol{\beta}_4 \mathbf{Y}_i + \boldsymbol{\beta}_5 \mathbf{Z}_i\big), \qquad (8)$$

where i indexes households; j indexes provinces; $y2007_i$, $y2000_i$, $\mathbf{X}_i$, $\mathbf{Y}_i$, and $\mathbf{Z}_i$ are defined as before; and Φ is the standard normal distribution function. Table 5 presents the results for the sample of landowners without legal documentation of ownership. The standard errors are adjusted to allow for clustering based on the 13 provinces included in the IFLS sample. Households living in provinces with high *LTSproxyCV* are much less likely to be conducting land market transactions. For example, a decrease in the coefficient of variation from the highest to the lowest provincial statistic is associated with an increase in the probability of supply side land market participation of roughly 8 or 9 percentage points. This is highly significant even with farm and non-farm related variables included on the right-hand side. Since *LTSproxyCV* is proportional to the standard deviation of the proxy variable and negatively related to the provincial average degree of tenure security, this result supports both parts of Proposition 4.1.

Finally, it is of interest to examine the effect of individual tenure security on landowners' ability to supply land within a regional land market. In the absence of private information regarding heterogeneous degrees tenure security, one would expect the relationship between supply side land market participation and the proxy variable *lambda* to be monotonically decreasing. To see this, recall that the proxy variable can be broadly interpreted as the ratio of land productivity to market value. When the price of land is high (*lambda* is low), landowners with off-farm economic opportunities are willing to transact. On the other hand, when the market value of land is too low (*lambda* is high), households are more likely to switch from renting out land to autarky. In contrast, if the equilibrium of the model in Section 2 accurately reflects the market for farmland in rural Indonesia, then the most insecure plots should be more readily sold or rented out. This is because illiquidity is used as a screening mechanism to identify secure land, since only sellers experiencing a low risk of land confiscation and without unresolved land conflicts are willing to accept a low probability of trade. This is an implication of the theory that is not shared by conventional transaction cost models of land market liquidity.

Table 4: Land Market Activity and *lambda* by Region

REGION	share of landowners supplying land (%)	*lambda* mean	*lambda* std. dev.
Sumatra	14.267	0.238	0.234
Java	18.182	0.162	0.181
Nusa Tenggara	15.194	0.142	0.152
Kalimantan	12.935	0.410	0.296
Sulawesi	22.283	0.204	0.191
All Regions	16.394	0.206	0.204

Source: 2007 Indonesian Family Life Survey (IFLS4), calculations by author.

Table 5: Probit Results for Supplying Unregistered Land in 2007

VARIABLES	(1)	(2)	(3)	(4)
LTSproxyCV	-1.150***	-1.103***	-1.029**	-1.025***
	(0.434)	(0.404)	(0.418)	(0.367)
per capita farmland (log)	0.0333	0.0446**	0.0434*	0.0477*
	(0.0209)	(0.0194)	(0.0260)	(0.0252)
supply side land market participation in 2000	0.704***	0.611***	0.697***	0.624***
	(0.0851)	(0.116)	(0.0931)	(0.122)
household variables	yes	yes	yes	yes
farm variables	no	yes	no	yes
non-farm variables	no	no	yes	yes
provincial indicators	no	no	no	no
observations	1,533	1,479	1,495	1,446

Notes: Parameter estimates from the probit estimation of equation (8). Standard errors in parentheses. Single asterisk denotes statistical significance at the 90% level of confidence, double 95%, triple 99%. Household variables include head's age, head's gender, and head's years of schooling. Farm variables include household males and females 15-60 years, indicator for ownership of livestock or farm assets, and value of farm assets (log). Non-farm variables include non-farm business indicator, value of non-farm assets (log), and share of household members with off-farm employment.
Source: Indonesian Family Life Survey (IFLS), calculations by author.

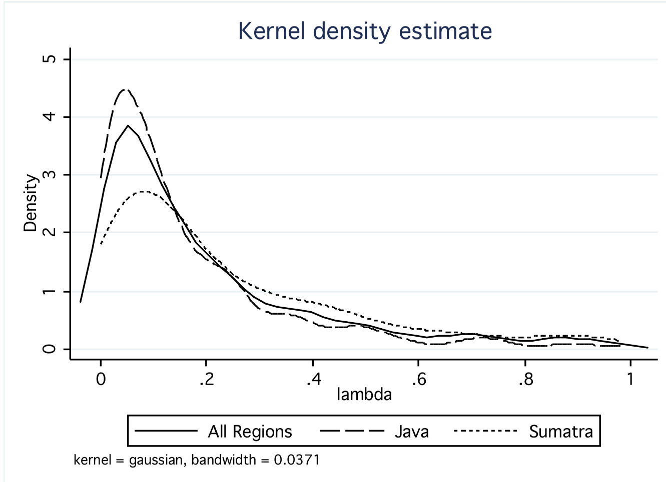

Figure 1: The kernel density estimation of *lambda* by region for unregistered land

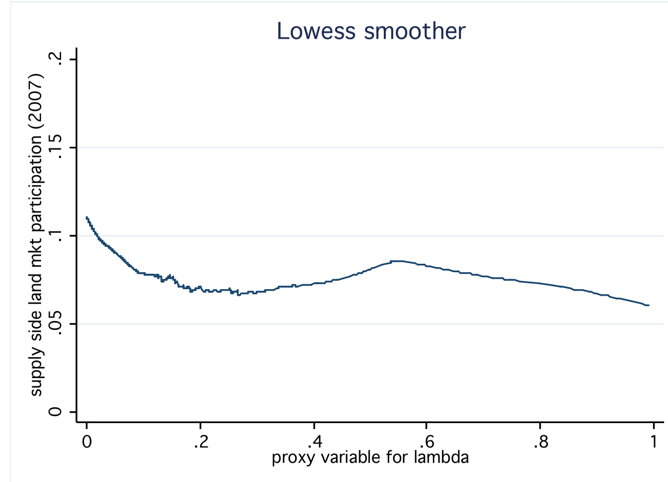

Figure 2: Supply side land market participation and the proxy variable for tenure insecurity, *lambda*

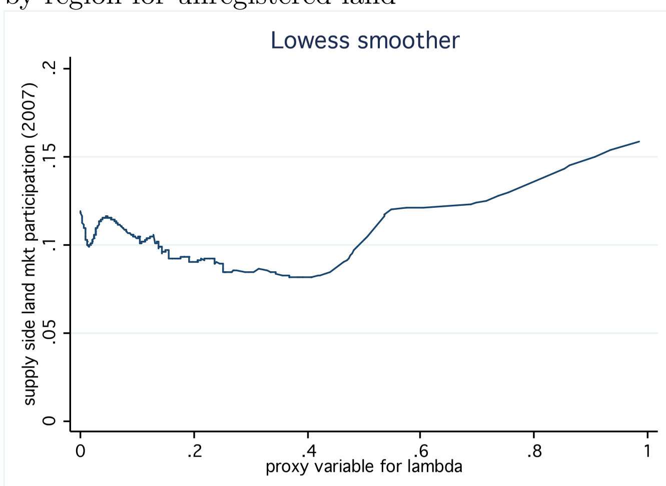

Figure 3: Supply side land market participation in Java

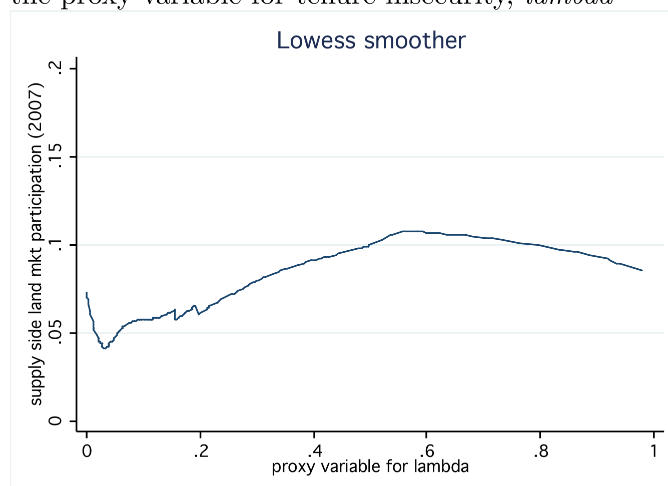

Figure 4: Supply side land market participation in Sumatra

Locally weighted scatterplot smoothing, or LOWESS, is applied to the data to describe this relationship. LOWESS is a technique that uses polynomial regressions to summarize a bivariate relationship. Figure 2 plots the smoothed probability of supply side land market participation by the proxy variable for tenure insecurity, *lambda*, for farming households in the IFLS sample without land ownership certificates. To remove the effect of long-term rental contracts, households that leased out land in IFLS3 (2000) are excluded. To account for differences in land endowments, the double residual method proposed by Robinson (1988) is used to control for (log) per capita farmland.

At first glance, the LOWESS estimation does not appear to support the theory's prediction that the most insecure plots are the most liquid. The theoretical model implies that, in equilibrium, the relationship between supplying land in the market and *lambda* should be positive and monotonic. As Figure 2 shows, this is only the case over some range of *lambda*, and there are households at the low end of the distribution that exhibit higher rates of land market participation. It is worth remarking that the LOWESS modelling technique does not control for other household characteristics and economic variables that contribute to a household's ability and willingness to conduct land market transactions. Moreover, there could be methods[11] other than formal land titles by which the owners of secure land can credibly advertise the security of their ownership. This would explain the higher probability of land market participation in Figure 2 among landowners with *lambda* close to zero, while the screening mechanism proposed here explains the increasing part for $lambda \in [0.2, 0.6]$.

Note that Figure 2 displays the estimation for unregistered landowners from all regions. Since the results of the probit models with provincial variables suggest that the differences in land tenure systems across regions is important in understanding land market activity, it makes more sense to investigate the relationship between land market participation and *lambda* for specific regions. Figures 3 and 4 display the LOWESS smoother for the two

[11]For example, Besley (1995) suggests that investments in the land, such as planting trees, can enhance tenure security. It could be that owners with relatively secure property rights find it worthwhile to invest in their land as a way of signalling the quality of their ownership rights to potential buyers. Future work will investigate signalling and screening in land markets where tenure is insecure.

geographic regions with the highest sample sizes in the IFLS: Java and Sumatra. The evidence no longer appears to falsify the model's mechanism, as the propensity to supply land increases for high values of the proxy variable *lambda*.

This evidence supports illiquidity as a screening mechanism over other theories of land market inactivity. The proxy variable is roughly the ratio of farm output to market value. High values of *lambda* therefore imply highly productive land but with low market value. In a conventional model of land markets, these are the last people one would expect on the supply side of a land transaction. The LOWESS estimation reveals that it is precisely these households at the high end of the *lambda* distribution that have the highest probability of supply side land market participation. This empirical trend is difficult to reconcile with other models, but the theory presented here offers an answer: a landowner would be willing to sell or lease a productive plot of land for a low market price if tenure is insecure. Moreover, illiquidity as a screening device explains why a Sumatran plot with $lambda = 0.6$ is more likely to be leased out than a plot with $lambda = 0.2$.

6 Conclusions

This paper proposes a theory to explain the varied levels of activity across land markets in developing countries in terms of the security of property rights over land. Despite the discussion of land market thinness in the literature, tenure insecurity in most land market models either affects the price of land (Feder and Onchan, 1987) or the presence of transaction costs (Besley, 1995; Deininger and Jin, 2005). In contrast, I construct a model that allows one to explicitly characterize important aspects of the land market such as the volume of trade and the likelihood of selling a particular plot. The results show how the number of land transactions in an economy with an emerging off-farm labour market can be hindered by tenure insecurity: a characteristic of many property rights regimes over land. Moreover, when ownership security becomes more varied across plots, the adverse selection problem worsens and land market activity declines.

Enhancing tenure security is often cited as a motivation for land titling programs in developing countries. Land titles allow for the verification of ownership, which reduces the incidence of land disputes as well as land market transaction costs in general. The availability of records reduces asymmetric information about ownership and the quality of the land title. In smallholder farming communities in Indonesia, land registration has endowed land users with more secure rights and triggered a higher volume of land transfers. The result that landowners without legal documentation cannot transact land as readily as certified owners is evidence that tenure insecurity and private information about property rights lead to thin land markets. Empirically, a novel contribution of this study is the derivation of a proxy variable for land tenure insecurity, which has traditionally been difficult to measure. This widened the scope of the study to include parametric and nonparametric analyses of supply side land participation among unregistered farming households.

Future work could extend the theoretical model to a dynamic setting. Instead of affecting the probability of a transaction, inefficiencies of the land market will affect the time required to sell or lease. These endogenous transaction frictions will slow down the flow of labour from agricultural to off-farm activities. Further empirical work could investigate the link between tenure security, land market activity and the migration patterns of household members in Indonesia. The IFLS tracked and interviewed individuals who moved or separated from their original household between surveys. This feature of the IFLS along with the high household recontact rates make it a promising data source to study the link between land markets and migration decisions. Finally, in light of the LOWESS estimation results, extending the framework to investigate both signalling and screening technologies in a land market with tenure insecurity might explain the high participation rates at both tails of the λ distribution.

References

Ai, Chunrong and Edward C. Norton. 2003. "Interaction terms in logit and probit models." *Economic Letters* 80 (1):123–129.

Akerlof, George A. 1970. "The market for "lemons": quality uncertainty and the market mechanism." *The Quarterly Journal of Economics* 84 (3):488–500.

Besley, Timothy. 1995. "Property rights and investment incentives: theory and evidence from Ghana." *Journal of Political Economy* 103 (5):903–937.

Brasselle, Anne-Sophie, Frédéric Gaspart, and Jean-Philippe Platteau. 2002. "Land tenure security and investment incentives: puzzling evidence from Burkina Faso." *Journal of Development Economics* 67 (2):373–418.

Carter, Michael R. and Yang Yao. 2002. "Local versus global separability in agricultural household models: the factor price equalization effect of land transfer rights." *American Journal of Agricultural Economics* 84 (3):702–715.

Chiu, Jonathan and Thorsten V. Koeppl. 2010. "Market freeze and recovery: trading dynamics under optimal intervention by a market-maker-of-last-resort." *manuscript, Bank of Canada* .

Deaton, Angus. 2010a. "Instruments, randomization, and learning about development." *Journal of Economic Literature* 48 (2):424–455.

———. 2010b. "Understanding the mechanisms of economic development." *Journal of Economic Perspectives* 24 (3):3–16.

Deininger, Klaus and Raffaella Castagnini. 2006. "Incidence and impact of land conflict in Uganda." *Journal of Economic Behavior and Organization* 60 (3):321–345.

Deininger, Klaus and Songking Jin. 2005. "The potential of land rental markets in the process of economic development: evidence from China." *Journal of Development Economics* 78 (1):241–270.

Deininger, Klaus and Songqing Jin. 2006. "Tenure security and land-related investment: evidence from Ethiopia." *European Economic Review* 50 (5):1245–1277.

———. 2009. "Land rental markets in the process of rural structural transformation: productivity and equity impacts from China." *Journal of Comparative Economics* 37 (4):629–646.

Deininger, Klaus, Eduardo Zegarra, and Isabel Lavadenz. 2003. "Determinants and impacts of rural land market activity: evidence from Nicaragua." *World Development* 31 (8):1385–1404.

Feder, Gershon and Tongroj Onchan. 1987. "Land ownership security and farm investment in Thailand." *American Journal of Agricultural Economics* 69 (2):311–320.

Fenske, James. 2010. "Land tenure and investment incentives: evidence from West Africa." *Journal of Development Economics* In Press, Corrected Proof.

Firmin-Sellers, Kathryn and Patrick Sellers. 1999. "Expected failures and unexpected successes of land titling in Africa." *World Development* 27 (7):1115–1128.

Guerrieri, Veronica, Robert Shimer, and Randall Wright. 2010. "Adverse selection in competitive search equilibrium." *Econometrica* 78 (6):1823–1862.

Holden, Stein T., Klaus Deininger, and Hosa'ena Ghebru. 2007. "Impact of land certification on land rental market participation in Tigray region, Northern Ethiopia." *MPRA Paper 5211* .

Holden, Stein T., Keijiro Otsuka, and Frank M. Place, editors. 2009. *The emergence of land markets in Africa: assessing the impacts on poverty, equity, and efficiency.* Washington, DC, USA: Resources for the Future.

Jacoby, Hanan G., Guo Li, and Scott Rozelle. 2002. "Hazards of expropriation: tenure insecurity and investment in rural China." *American Economic Review* 92 (5):1420–1447.

Kung, James Kai-sing. 2002. "Off-farm labor markets and the emergence of land rental markets in rural China." *Journal of Comparative Economics* 30 (2):395–414.

Lester, Benjamin, Andrew Postlewaite, and Randall Wright. 2009. "Information and liquidity." *manuscript, University of Pennsylvania* .

Li, Guo, Scott Rozelle, and Loren Brandt. 1998. "Tenure, land rights, and farmer investment incentives in China." *Agricultural Economics* 19 (1-2):63–71.

Liu, Shouying, Michael R. Carter, and Yang Yao. 1998. "Dimensions and diversity of property rights in rural China: dilemmas on the road to further reform." *World Development* 26 (10):1789–1806.

Moen, Espen R. 1997. "Competitive search equilibrium." *Journal of Political Economy* 105 (2):385–411.

Place, Frank and S. E. Migot-Adholla. 1998. "The economic effects of land registration on smallholder farms in Kenya: evidence from Nyeri and Kakamega districts." *Land Ecomomics* 74 (3):360–373.

Risnarto. 2009. "Impact of land certification on land market and small-scale landholders." In *Land and household economy 1970-2005: changing road for poverty reduction*, edited by I. Wayan Rusastra, Sahat M. Pasaribu, and Yusmichad Yusdja. Indonesian Center for Agriculture Socio Economic and Policy Studies (ICASEPS), 37–60.

Robinson, P. M. 1988. "Root-n-consistent semiparametric regression." *Econometrica* 56 (4):931–954.

Skoufias, Emmanuel. 1995. "Household resources, transaction costs, and adjustment through land tenancy." *Land Economics* 71 (1):42–56.

Vranken, Liesbet and Johan Swinnen. 2006. "Land rental markets in transition: theory and evidence from Hungary." *World Development* 34 (3):481–500.

Walijatun, Djoko and Chris Grant. 1996. "Land registration reform in Indonesia." Jakarta, Indonesia: International Conference on Land Tenure and Administration in Developing Countries.

Yang, Dennis Tao. 1997. "China's land arrangements and rural labor mobility." *China Economic Review* 8 (2):101–116.

Yao, Yang. 2000. "The development of the land lease market in rural China." *Land Economics* 76 (2):252–266.

A Proof of Proposition 3.1

It is straightforward to check that these prices and allocations satisfy the equilibrium conditions 1, 2, and 3. Claim 1 establishes that the proposed prices, allocations, and utilities satisfy the equilibrium refinement. Lemma 1 shows that there cannot exist a pooling submarket. Finally, Claims 2, 3, and 4 establish uniqueness.

Claim 1 *The prices, allocations, and utilities in Proposition 3.1 satisfy the equilibrium refinement.*

Proof. Consider all possible deviations, $p' \in \mathbb{R}_+ \backslash \mathbb{P}$. If $p' > (1-\lambda_H)\pi - c = p_H$, the payoff to the buyer in a land transaction is negative. If $p' < (1-\lambda_L)\pi - c = p_L$, no seller will enter the new submarket since submarket p_L is strictly preferred. Finally, consider $p' \in ((1-\lambda_L)\pi - c, (1-\lambda_H)\pi - c)$. Let θ denote the buyer-seller ratio in the new submarket p'. Type L sellers are attracted to the new submarket if

$$\min\{\theta, 1\}(p' - \xi_L) \geq (1-\lambda_L)\pi - \xi_L - c = \bar{U}_L$$
$$\Rightarrow \quad \theta \geq \frac{(1-\lambda_L)\pi - \xi_L - c}{p' - \xi_L} \equiv \theta_L$$

Similarly, type H sellers are attracted to the new submarket if

$$\min\{\theta, 1\}(p' - \xi_H) \geq \frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c}\left[(1-\lambda_H)\pi - \xi_H - c\right]$$
$$\Rightarrow \quad \theta \geq \frac{\left[(1-\lambda_L)\pi - \xi_L - c\right]\left[(1-\lambda_H)\pi - \xi_H - c\right]}{\left[(1-\lambda_H)\pi - \xi_L - c\right]\left[p' - \xi_H\right]} \equiv \theta_H$$

One can rank the cut-offs θ_L and θ_H defined above for any $p' \in ((1-\lambda_L)\pi - c, (1-\lambda_H)\pi - c)$.

$$\theta_L = \frac{(1-\lambda_L)\pi - \xi_L - c}{p' - \xi_L} \gtrless \frac{\left[(1-\lambda_L)\pi - \xi_L - c\right]\left[(1-\lambda_H)\pi - \xi_H - c\right]}{\left[(1-\lambda_H)\pi - \xi_L - c\right]\left[p' - \xi_H\right]} = \theta_H$$
$$\frac{p' - \xi_H}{p' - \xi_L} \gtrless \frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_L - c}$$

Let $p' = \mu[(1-\lambda_L)\pi - c] + (1-\mu)[(1-\lambda_H)\pi - c] \Rightarrow p' = (1-\lambda_H)\pi - c - \mu(\lambda_L - \lambda_H)\pi$,

$\mu \in (0, 1)$. The inequality from above becomes

$$\frac{(1-\lambda_H)\pi - \xi_H - c - \mu(\lambda_L - \lambda_H)\pi}{(1-\lambda_H)\pi - \xi_L - c - \mu(\lambda_L - \lambda_H)\pi} < \frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_L - c}$$

and the inequality is strict for any $\mu \in (0, 1)$. This establishes $\theta_L < \theta_H$ for any new submarket $p' \in ((1-\lambda_L)\pi - c, (1-\lambda_H)\pi - c)$. Since type H sellers correctly anticipate that type L sellers will enter submarket p' until the buyer-seller ratio is θ_L, the type H sellers choose not to enter. Since the deviation $p' > (1-\lambda_L)\pi - c$ attracts only sellers of insecure land, the deviation is not profitable. □

Lemma 1 *There are no submarkets that attract both type L and type H sellers in any competitive land market equilibrium.*

Proof. Suppose (for the sake of contradiction) that there exists a submarket with price p that attracts $s_L(p)$ type L sellers and $s_H(p)$ type H sellers. The type-dependent utilities are

$$\bar{U}_L = \min\left\{\frac{b(p)}{s_L(p) + s_H(p)}, 1\right\}(p - \xi_L)$$
$$\bar{U}_H = \min\left\{\frac{b(p)}{s_L(p) + s_H(p)}, 1\right\}(p - \xi_H)$$

and buyers in submarket p earn a payoff of zero in expectation because of the free entry condition, which requires $p \leq \left[1 - \frac{s_L(p)}{s_L(p)+s_H(p)}\lambda_L - \frac{s_H(p)}{s_L(p)+s_H(p)}\lambda_H\right]\pi - c$. Consider a deviation to $p' \in (p, (1-\lambda_H)\pi - c)$. Let θ again denote the buyer-seller ratio in the new submarket. A type L seller prefers the new submarket if

$$\min\{\theta, 1\}(p' - \xi_L) \geq \min\left\{\frac{b(p)}{s_L(p) + s_H(p)}, 1\right\}(p - \xi_L)$$
$$\Rightarrow \quad \min\{\theta, 1\} \geq \min\left\{\frac{b(p)}{s_L(p) + s_H(p)}, 1\right\}\left(\frac{p - \xi_L}{p' - \xi_L}\right)$$

Similarly, a type H seller prefers the new submarket if

$$\min\{\theta, 1\} \geq \min\left\{\frac{b(p)}{s_L(p) + s_H(p)}, 1\right\}\left(\frac{p - \xi_H}{p' - \xi_H}\right)$$

Since

$$\frac{p - \xi_H}{p' - \xi_H} < \frac{p - \xi_L}{p' - \xi_L}$$

type H sellers enter the new submarket until the buyer-seller ratio is

$$\theta = \min\left\{\frac{b(p)}{s_L(p) + s_H(p)}, 1\right\}\left(\frac{p - \xi_H}{p' - \xi_H}\right) \in (0, 1)$$

which is low enough that the new submarket makes type L sellers worse off. Consequently, the deviation attracts only type H sellers, which yields a positive payoff to the buyer since $p' < (1 - \lambda_H)\pi + c$ and $\theta < 1$. □

Lemma 2 *In any competitive land market equilibrium, there is a submarket $p_L \in \mathbb{P}$ with $s_L(p_L) > 0$.*

Proof. Suppose (for the sake of contradiction) that there is no such submarket, and therefore $s_L(p) = 0$ for all $p \in \mathbb{P}$ and $\bar{U}_L = 0$. A subset of buyers can offer $p_L = \xi_L + \delta$ with $\delta > 0$ close to zero. All potential type L sellers will choose to enter the market since $p_L - \xi_L > 0$. The expected payoff to buyers in the new submarket is at least $(1 - \lambda_L)\pi - \xi_L - \delta - c$ (even higher if H types enter the submarket as well). With δ small enough, this payoff becomes arbitrarily close to $(1 - \lambda_L)\pi - \xi_L - c$, which is strictly positive by Assumption 2. □

Claim 2 *In any competitive land market equilibrium, $\bar{U}_L = (1 - \lambda_L)\pi - \xi_L - c$, and there is a submarket with price $p_L = (1 - \lambda_L)\pi - c$.*

Proof. By Lemma 2, there is some $p_L \in \mathbb{P}$ with $s_L(p_L) > 0$ such that

$$\bar{U}_L = \min\left\{\frac{b(p_L)}{s_L(p_L)}, 1\right\}(p_L - \xi_L) \geq 0$$

Suppose (for the sake of contradiction) that $\bar{U}_L \neq (1 - \lambda_L)\pi - \xi_L - c$. First, suppose $\bar{U}_L > (1 - \lambda_L)\pi - \xi_L - c$. Since

$$\min\left\{\frac{b(p_L)}{s_L(p_L)}, 1\right\}(p_L - \xi_L) \leq (p_L - \xi_L)$$

this can only occur if $p_L > (1-\lambda_L)\pi - c$. Any transaction involving type L land in a submarket with price $p_L > (1-\lambda_L)\pi - c$ will yield a negative payoff to the buyer. This is a contradiction since, according to Lemma 1, there can only be one type of seller in an equilibrium submarket.

Suppose then that $\bar{U}_L < (1-\lambda_L)\pi - \xi_L - c$. Since it's already been established that $p_L \leq (1-\lambda_L)\pi - c$, then either $b(p_L)/s_L(p_L) < 1$ or $p_L < (1-\lambda_L)\pi - c$. If $b(p_L)/s_L(p_L) < 1$, then the buyers' free entry condition implies $p_L = (1-\lambda_L)\pi - c$. A buyer can post a deviating offer $p = p_L - \delta$, with $\delta > 0$ small enough that some type L sellers prefer the new offer:

$$p_L - \delta - \xi_L > \frac{b(p_L)}{s_L(p_L)}(p_L - \xi_L)$$
$$\Rightarrow \quad \delta < \left[1 - \frac{b(p_L)}{s_L(p_L)}\right](p_L - \xi_L)$$

Since the deviating offer attracts sellers and involves a smaller payment for land, the deviation is profitable.

If $p_L < (1-\lambda_L)\pi - c$, consider the deviating offer $p \in (p_L, (1-\lambda_L)\pi - c)$. Since

$$p - \xi_L > p_L - \xi_L \geq \bar{U}_L$$

some type L sellers prefer the new submarket. Moreover, since $p < (1-\lambda_L)\pi - c$, the deviation is profitable. This completes the proof that $\bar{U}_L = (1-\lambda_L)\pi - \xi_L - c$. Moreover, the possibility that $p_L \neq (1-\lambda_L)\pi - c$ has been ruled out. □

Lemma 3 *In any competitive land market equilibrium, there is a submarket $p_H \in \mathbb{P}$ with $s_H(p_H) > 0$.*

Proof. Suppose (for the sake of contradiction) that there is no such submarket, and therefore $s_H(p) = 0$ for all $p \in \mathbb{P}$ and $\bar{U}_H = 0$. A subset of buyers can offer any $p_H = (1-\lambda_H)\pi - c - \delta$, with $\delta > 0$ close to zero. Type L sellers will prefer the new submarket if

$$\begin{aligned} \min\{\theta, 1\}(p_H - \xi_L) &\geq (1-\lambda_L)\pi - \xi_L - c = \bar{U}_L \\ \Rightarrow \quad \theta &\geq \frac{(1-\lambda_H)\pi - \xi_L - c}{(1-\lambda_L)\pi - \xi_L - c - \delta} \equiv \theta_L \end{aligned}$$

For δ close to zero, $\theta_L < 1$. Type H sellers will enter the new submarket, since

$$\theta_L(p_H - \xi_H) = \frac{(1-\lambda_H)\pi - \xi_L - c}{(1-\lambda_L)\pi - \xi_L - c - \delta}\left[(1-\lambda_H)\pi - \xi_H - c - \delta\right] > 0$$

where the last inequality follows from Assumption 2 and δ small. Since type L sellers correctly anticipate that type H sellers will enter submarket p_H until the buyer-seller ratio is below θ_L, the type L sellers choose not to enter. Since the deviation attracts only sellers of secure land and $p_H < (1-\lambda_H)\pi - c$, the deviation is profitable. □

Claim 3 *In any competitive land market equilibrium,*

$$\bar{U}_H = \left(\frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c}\right)\left[(1-\lambda_H)\pi - \xi_H - c\right]$$

and there is a submarket with $p_H = (1-\lambda_H)\pi - c$.

Proof. By Lemma 3, there is some $p_H \in \mathbb{P}$ with $s_H(p_H) > 0$ such that

$$\bar{U}_H = \min\left\{\frac{b(p_H)}{s_H(p_H)}, 1\right\}(p_H - \xi_H) \geq 0$$

Suppose (for the sake of contradiction) that $\bar{U}_H \neq \left(\frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c}\right)\left[(1-\lambda_H)\pi - \xi_H - c\right]$. First, suppose $\bar{U}_H > \left(\frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c}\right)\left[(1-\lambda_H)\pi - \xi_H - c\right]$. Then,

$$\begin{aligned} \bar{U}_H &= \min\left\{\frac{b(p_H)}{s_H(p_H)}, 1\right\}(p_H - \xi_H) \\ &> \left(\frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c}\right)\left[(1-\lambda_H)\pi - \xi_H - c\right] \end{aligned}$$

$$\Rightarrow \quad \min\left\{\frac{b(p_H)}{s_H(p_H)},1\right\} > \left(\frac{(1-\lambda_L)\pi-\xi_L-c}{(1-\lambda_H)\pi-\xi_L-c}\right)\left(\frac{(1-\lambda_H)\pi-\xi_H-c}{p_H-\xi_H}\right) \tag{A.1}$$

From Claim 2, $\bar{U}_L = (1-\lambda_L)\pi-\xi_L-c$. Condition 2(ii) of the equilibrium definition requires

$$\bar{U}_L = (1-\lambda_L)\pi-\xi_L-c \geq \min\left\{\frac{b(p_H)}{s_H(p_H)},1\right\}(p_H-\xi_L)$$

$$\Rightarrow \quad \min\left\{\frac{b(p_H)}{s_H(p_H)},1\right\} \leq \frac{(1-\lambda_L)\pi-\xi_L-c}{p_H-\xi_L} \tag{A.2}$$

Combining (A.1) and (A.2) gives

$$\left(\frac{(1-\lambda_L)\pi-\xi_L-c}{(1-\lambda_H)\pi-\xi_L-c}\right)\left(\frac{(1-\lambda_H)\pi-\xi_H-c}{p_H-\xi_H}\right) < \frac{(1-\lambda_L)\pi-\xi_L-c}{p_H-\xi_L}$$

This reduces to

$$p_H > (1-\lambda_H)\pi-c$$

Any transaction at $p_H > (1-\lambda_H)\pi-c$ yields a negative payoff to the buyer, which contradicts the equilibrium free entry condition for buyers.

Suppose then that $\bar{U}_H < \left(\frac{(1-\lambda_L)\pi-\xi_L-c}{(1-\lambda_H)\pi-\xi_L-c}\right)[(1-\lambda_H)\pi-\xi_H-c]$, so either $p_H < (1-\lambda_H)\pi-c$ or $b(p_H)/s_H(p_H) < \frac{(1-\lambda_L)\pi-\xi_L-c}{(1-\lambda_H)\pi-\xi_L-c}$. If $p_H < (1-\lambda_H)\pi-c$, the buyers' free entry condition implies $b(p_H)/s_H(p_H) > 1$. The type L seller's equilibrium condition 2(ii) requires

$$p_H-\xi_L \leq p_L-\xi_L = \bar{U}_L \quad \Rightarrow \quad p_H \leq p_L$$

This is a contradiction since it means either a single submarket for both types, or if the inequality is strict, that type H sellers would prefer the type L submarket.

If $b(p_H)/s_H(p_H) < \frac{(1-\lambda_L)\pi-\xi_L-c}{(1-\lambda_H)\pi-\xi_L-c}$, the buyers' free entry condition implies $p_H = (1-\lambda_H)\pi-c$.

Moreover, condition 2(ii) requires that type H sellers prefer submarket p_H over submarket p_L:

$$\begin{aligned} \bar{U}_H = \frac{b(p_H)}{s_H(p_H)}(p_H - \xi_H) &\geq p_L - \xi_H \\ \frac{b(p_H)}{s_H(p_H)}[(1-\lambda_H)\pi - \xi_H - c] &\geq (1-\lambda_L)\pi - \xi_H - c \\ \Rightarrow \quad \frac{b(p_H)}{s_H(p_H)} &\geq \frac{(1-\lambda_L)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_H - c} \end{aligned} \tag{A.3}$$

Consider the deviating offer $p(\mu) = (1-\mu)p_L + \mu p_H$, $\mu \in (0,1)$. The new offer can be written

$$p(\mu) = (1-\mu)(1-\lambda_L)\pi + \mu(1-\lambda_H)\pi - c = (1-\lambda_L)\pi - c + \mu(\lambda_L - \lambda_H)\pi$$

Type H sellers prefer the new offer as long as

$$\begin{aligned} &\min\{\theta,1\}(p(\mu) - \xi_L) \geq \frac{b(p_H)}{s_H(p_H)}(p_H - \xi_H) \\ &\min\{\theta,1\}[(1-\lambda_L)\pi - \xi_H - c + \mu(\lambda_L - \lambda_H)\pi] \geq \frac{b(p_H)}{s_H(p_H)}[(1-\lambda_H)\pi - \xi_H - c] \\ &\Rightarrow \quad \min\{\theta,1\} \geq \frac{b(p_H)}{s_H(p_H)}\left(\frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_L)\pi - \xi_H - c + \mu(\lambda_L - \lambda_H)\pi}\right) \equiv \theta_H \end{aligned} \tag{A.4}$$

Similarly, type L sellers prefer the new submarket if

$$\begin{aligned} &\min\{\theta,1\}(p(\mu) - \xi_L) \geq p_L - \xi_L = \bar{U}_L \\ &\min\{\theta,1\}[(1-\lambda_L)\pi - \xi_L - c + \mu(\lambda_L - \lambda_H)\pi] \geq (1-\lambda_L)\pi - \xi_L - c \\ &\Rightarrow \quad \min\{\theta,1\} \geq \frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_L)\pi - \xi_L - c + \mu(\lambda_L - \lambda_H)\pi} \equiv \theta_L \end{aligned} \tag{A.5}$$

The new offer $p(\mu)$ yields a positive expected payoff to the deviating buyer if $\theta_H < \theta_L$ and $\theta_H \leq 1$: only type H sellers enter the new market if $\theta_H < \theta_L$; the buyer makes a purchase with probability one if $\theta_H \leq 1$; and since $p(\mu) < p_H = (1-\lambda_H)\pi - c$, there is a strictly positive payoff to the buyer in a transaction. From the definition of θ_L in (A.5), one can see that $\theta_L < 1$. The necessary condition for a contradiction is therefore $\theta_H < \theta_L$. As before, the cut-offs can be ranked for any $p(\mu)$, $\mu \in (0,1)$.

$$\theta_H \gtrless \theta_L$$
$$\frac{b(p_H)}{s_H(p_H)}\left(\frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_L)\pi - \xi_H - c + \mu(\lambda_L - \lambda_H)\pi}\right) \gtrless \frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_L)\pi - \xi_L - c + \mu(\lambda_L - \lambda_H)\pi}$$
$$\frac{b(p_H)}{s_H(p_H)}\left(\frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_L)\pi - \xi_L - c}\right) \gtrless \frac{(1-\lambda_L)\pi - \xi_H - c + \mu(\lambda_L - \lambda_H)\pi}{(1-\lambda_L)\pi - \xi_L - c + \mu(\lambda_L - \lambda_H)\pi}$$

By assumption and from (A.3),

$$\frac{b(p_H)}{s_H(p_H)} \in \left[\frac{(1-\lambda_L)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_H - c}, \frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c}\right)$$

Denote the particular buyer-seller ratio in submarket p_H by the convex combination

$$\theta(\gamma) = (1-\gamma)\left(\frac{(1-\lambda_L)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_H - c}\right) + \gamma\left(\frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c}\right)$$

with $\gamma \in [0,1)$. Substituting this into the inequality above yields

$$(1-\gamma)\left(\frac{(1-\lambda_L)\pi - \xi_H - c}{(1-\lambda_L)\pi - \xi_L - c}\right) + \gamma\left(\frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_L - c}\right) \gtrless \frac{(1-\lambda_L)\pi - \xi_H - c + \mu(\lambda_L - \lambda_H)\pi}{(1-\lambda_L)\pi - \xi_L - c + \mu(\lambda_L - \lambda_H)\pi} \tag{A.6}$$

The left-hand side of (A.6) is a monotonic function of γ,

$$L : [0,1] \rightarrow \left[\frac{(1-\lambda_L)\pi - \xi_H - c}{(1-\lambda_L)\pi - \xi_L - c}, \frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_L - c}\right]$$

Similarly, the right-hand side of (A.6) is a monotonic function of μ,

$$R : [0,1] \rightarrow \left[\frac{(1-\lambda_L)\pi - \xi_H - c}{(1-\lambda_L)\pi - \xi_L - c}, \frac{(1-\lambda_H)\pi - \xi_H - c}{(1-\lambda_H)\pi - \xi_L - c}\right]$$

By the intermediate value theorem, for any left-hand side value evaluated at $\gamma \in [0,1]$, there is a $\mu \in [0,1]$ such that $L(\gamma) = R(\mu)$. Since $R(\cdot)$ is strictly increasing, for any $\gamma \in [0,1)$, there is a $\mu \in (0,1)$ such that $L(\gamma) < R(\mu)$. This means that a profitable deviating offer is always possible. This completes the proof that

$$\bar{U}_H = \left(\frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c} \right) \big[(1-\lambda_H)\pi - \xi_H - c\big]$$

Moreover, the possibility that $p_H \neq (1-\lambda_H)\pi - c$ has been ruled out. □

Claim 4 *In any competitive land market equilibrium,* $s_L(p_L) = S_L$, $b(p_L) = S_L$, $s_H(p_H) = S_H$, *and*

$$b(p_H) = \frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c} S_H$$

Proof. Claim 2 and the definition of $\bar{U}_L$,

$$\bar{U}_L = (1-\lambda_L)\pi - \xi_L - c = \min\left\{ \frac{b(p_L)}{s_L(p_L)}, 1 \right\} (p_L - \xi_L)$$

imply $b(p_L) \geq s_L(p_L)$. However, $b(p_L) > s_L(p_L)$ violates the free entry condition for buyers, so it must be that $b(p_L) = s_L(p_L)$. Since $\bar{U}_L > 0$, equilibrium condition 2(ii) requires that all type L sellers enter the land market, $s_L(p_L) = S_L$.

Claim 3 and the definition of $\bar{U}_H$ imply

$$b(p_H) = \frac{(1-\lambda_L)\pi - \xi_L - c}{(1-\lambda_H)\pi - \xi_L - c} s_H(p_H)$$

With $\bar{U}_H > 0$, all type H sellers enter the land market, $s_H(p_H) = S_H$. □

By Claims 2, 3, and 4, the unique competitive land market equilibrium is characterized by the proposed prices, allocations of buyers and sellers across submarkets, and type-dependent payoffs.

B Comparative Statics and Efficiency Results

It is convenient to introduce some additional notation. Let $\lambda_L = \lambda + \varepsilon$ and $\lambda_H = \lambda - \varepsilon$. Then the system of property rights over land can be summarized by the two parameters: unweighted average tenure insecurity, λ, and a measure of the dispersion with respect to the quality of land titles, ε. Let θ_L and θ_H denote the share of type i sellers trading in equilibrium, $i \in \{L, H\}$. Then $\theta_L(\lambda, \varepsilon) = 1$, and

$$\theta_H(\lambda, \varepsilon) = \left(\frac{(1-\lambda-\varepsilon)\pi - \xi_L(\lambda,\varepsilon) - c}{(1-\lambda+\varepsilon) - \xi_L(\lambda,\varepsilon) - c} \right)$$

where

$$\xi_L(\lambda, \varepsilon) = \max\{\alpha(1-\lambda-\varepsilon)\pi, (1-\lambda-\varepsilon)\pi - (w^U - w^R)\}$$

In order to derive useful comparative statics results, it is useful to first state the following:

Lemma 4 *Let $\lambda_L = \lambda + \varepsilon$ and $\lambda_H = \lambda - \varepsilon$. The fraction of type H sellers trading in equilibrium, θ_H, is continuous in λ and ε.*

Proof of Lemma 4

Let $(\lambda^*, \varepsilon^*)$ be any pair (λ, ε) satisfying $w^U - w^R = (1-\alpha)(1-\lambda^*-\varepsilon^*)\pi$. It is straightforward to check that

$$\lim_{(\lambda,\varepsilon)\to(\lambda^*,\varepsilon^*)^-} \theta_H(\lambda,\varepsilon) = \lim_{(\lambda,\varepsilon)\to(\lambda^*,\varepsilon^*)^+} \theta_H(\lambda,\varepsilon) = \theta_H(\lambda^*,\varepsilon^*)$$

Since $\theta_H(\lambda, \varepsilon)$ is also continuous off the boundary, θ_H is a continuous function.

Proof of Proposition 4.1(i)

Let $\lambda_L = \lambda + \varepsilon$ and $\lambda_H = \lambda - \varepsilon$, and analyze the impact of a change in λ.[12] Proposition 4.1(i) holds if the number of type H land transactions, $\theta_H S_H$, declines with λ. Differentiating θ_H

[12] This is a way of increasing the λ_is in manner that preserves the degree of heterogeneity in the quality of land titles. Otherwise it would be impossible to separate the effect of the land tenure insecurity problem and the the effect of heterogeneity.

with respect to λ yields

$$\frac{\partial \theta_H}{\partial \lambda} = \begin{cases} \dfrac{-2(1-\alpha)\pi^2\varepsilon}{[(1-\lambda+\varepsilon)\pi - \alpha(1-\lambda-\varepsilon)\pi - c]^2} < 0 & \text{if} \quad w^U - w^R \geq (1-\alpha)(1-\lambda-\varepsilon)\pi \\ 0 & \text{if} \quad w^U - w^R < (1-\alpha)(1-\lambda-\varepsilon)\pi \end{cases}$$

Therefore, if $w^U - w^R < (1-\alpha)(1-\lambda-\varepsilon)$, an increase in λ does not affect activity in the land market. The cut-off $(1-\alpha)(1-\lambda-\varepsilon)\pi$ decreasing in λ implies that as λ increases, at some point $w^U - w^R = (1-\alpha)(1-\lambda-\varepsilon)\pi$ and the buyer-seller ratio in the type H submarket declines, reducing the total number of land transactions.

Proof of Proposition 4.1(ii)

Let $\lambda_L = \lambda + \varepsilon$ and $\lambda_H = \lambda - \varepsilon$, with $\varepsilon > 0$, and analyze the effect of ε, since an increase in ε represents greater heterogeneity in the quality of land market titles. Proposition 4.1(iii) holds if the number of type H land transactions, $\theta_H S_H$, declines with ε. Differentiating θ_H with respect to ε yields

$$\frac{\partial \theta_H}{\partial \varepsilon} = \begin{cases} \dfrac{-2\pi\left[(1-\alpha)(1-\lambda)\pi - c\right]}{[(1-\lambda+\varepsilon)\pi - \alpha(1-\lambda-\varepsilon)\pi - c]^2} < 0 & \text{if} \quad w^U - w^R \geq (1-\alpha)(1-\lambda-\varepsilon)\pi \\ \dfrac{-2\pi\left[w^U - w^R - c\right]}{[w^U - w^R + 2\varepsilon\pi - c]^2} < 0 & \text{if} \quad w^U - w^R < (1-\alpha)(1-\lambda-\varepsilon)\pi \end{cases}$$

This establishes the result that the number of type H land transactions declines with ε.

Proof of Proposition 4.2

To determine whether a Pareto improving market intervention is possible given the asymmetric information in the land market, consider an allocation that treats all landowner types identically, regardless of the level tenure security associated with their plot. The number of buyers equals the number of sellers, $b(p) = S_L + S_H$, and the price of land, p, must satisfy a free-entry condition:

$$p = \left(1 - \frac{S_L}{S_L + S_H}\lambda_L - \frac{S_H}{S_L + S_H}\lambda_H\right)\pi - c$$

The expected payoff for a seller of type $i \in \{L, H\}$ is therefore

$$\bar{U}_i^P = \left(1 - \frac{S_L}{S_L + S_H}\lambda_L - \frac{S_H}{S_L + S_H}\lambda_H\right)\pi - \xi_i - c$$

Type L sellers prefer the pooling allocation over the competitive land market equilibrium if $\bar{U}_L^P > \bar{U}_L$, or

$$\left(1 - \frac{S_L}{S_L + S_H}\lambda_L - \frac{S_H}{S_L + S_H}\lambda_H\right)\pi - \xi_L - c > (1 - \lambda_L)\pi - \xi_L - c$$

The inequality is satisfied because $\lambda_L > \lambda_H$. Type L sellers prefer the pooling allocation because the price is higher than the market price for type L land. In addition, there is no trade-off in terms of market liquidity for type L sellers, since type L land is perfectly liquid even in the market equilibrium.

Type H sellers may or may not prefer the pooling allocation. Their preference for the pooling regime requires a low proportion of type L land plots:

$$\begin{aligned} \bar{U}_H^P = \left(1 - \frac{S_L}{S_L + S_H}\lambda_L - \frac{S_H}{S_L + S_H}\lambda_H\right)\pi - \xi_H - c \\ > \left(\frac{(1 - \lambda_L)\pi - \xi_L - c}{(1 - \lambda_H)\pi - \xi_L - c}\right)[(1 - \lambda_H)\pi - \xi_H - c] = \bar{U}_H \\ \Rightarrow \frac{S_L}{S_L + S_H} < \frac{(1 - \lambda_H)\pi - \xi_H - c}{(1 - \lambda_H)\pi - \xi_L - c} \end{aligned}$$

Type H sellers prefer the price of land in the type H equilibrium submarket over the price of land in under the pooling regime. However, type H land is perfectly liquid in the pooling regime, but not in equilibrium. The greater efficiency in trade outweighs the cost of subsidizing type L sellers as long as there is not too much insecure land in the economy.

Proof of Proposition 4.3

Land market transactions take place as long as there are gains from trade, taking into account illiquidity and buyers' cost of entering the land market. With $w^U - w^R$ fixed, an economy starting from a case 3 environment will eventually switch to a case 2 environment as λ increases, and then to a case 1. This is because rural residents develop greater incentives to accept urban job offers as the land tenure problem worsens. Proposition 4.3 then asserts that a case 1 land market will break down as λ increases further.

Te surplus to a seller is $p - \alpha(1-\lambda_i)\pi$, and the surplus to the buyer is $(1-\lambda_i)\pi - p$, $i \in \{L, H\}$. The total surplus of a type i land market transaction, including the entry cost, is therefore $(1-\alpha)(1-\lambda_i)\pi - c$. A land market exists only if $(1-\alpha)(1-\lambda_L)\pi \geq c$. Suppose that $(1-\alpha)(1-\lambda_L)\pi < c$. If $(1-\alpha)(1-\lambda_H)\pi < c$, there are no gains from trading either type of land plot. Instead, if $(1-\alpha)(1-\lambda_H)\pi \geq c > (1-\alpha)(1-\lambda_L)\pi$, the land market shuts down entirely even though there remain gains from trading type H land because buyers can non longer screen for the type L land. Type L sellers will be attracted to the type H market, and potential buyers, anticipating this outcome, choose not to enter. With $\lambda_L = \lambda + \varepsilon$ and $\lambda_H = \lambda - \varepsilon$, the land market shuts down whenever

$$(1-\alpha)(1-\lambda-\varepsilon)\pi < c \quad \Rightarrow \quad \lambda > \frac{(1-\varepsilon)(1-\alpha)\pi - c}{(1-\alpha)\pi}$$

C Deriving the Proxy Variable for Tenure Insecurity

The degree of tenure security associated with a particular plot is unobservable. It is precisely this hidden information that renders land illiquid in order for potential buyers to distinguish the ownership rights associated with a vendor's plot. Although private information makes it difficult for econometric analysis, a proxy variable can be backed out of the IFLS data which, according to the theory, is correlated with tenure insecurity (the λ_is). Recall from the model that the price of a plot of land before transaction costs is

$$p_i = (1 - \lambda_i)\pi \tag{C.1}$$

The analogous pricing equation in an infinite horizon framework is

$$p_{i,t} = \pi + \beta(1 - \lambda_i)\mathrm{E}_t[p_{i,t+1}] \tag{C.2}$$

where t indexes time, and β is the discount factor. Equation (C.2) can be rearranged to express the price of land as the present discounted value of the stream of per period agricultural output.

$$p_i = \sum_{j=0}^{\infty} \beta^j (1 - \lambda_i)^j \pi = \frac{\pi}{1 - \beta(1 - \lambda_i)} \tag{C.3}$$

The value of insecure land (i.e., land with a high λ) is lower because future farm output is discounted according to the risk of expropriation. Figure 5 plots the densities of the log of self-reported value per hectare of household land separately for registered and unregistered land to see if this might be true in the data. On average, the perceived value of unregistered land is less than the value of land when ownership is secured by land certificates.[13]

The π in equations (C.2) and (C.3) is broadly interpreted as land rent. If we assume that $\pi_{i,t}$ for household i at time t is a function of farm assets $k_{i,t}$, labour endowments $n_{i,t}$,

[13] This is not the only interpretation. For example, if land differs in terms of soil quality, it may be that owners of poor quality land do not find it worthwhile to obtain a certificate. However, the property rights explanation becomes more plausible when I compare the ratio of the land value to annual farm output and find that the relationship still holds.

and landholdings $l_{i,t}$, we can express land rent as $\pi(k_{i,t}, n_{i,t}, l_{i,t})$. Moreover, if factor inputs and land rent are relatively stable over time, then

$$p_i = \frac{\pi(k_i, n_i, l_i)}{1 - \beta(1 - \lambda_i)} \tag{C.4}$$

and a proxy variable for λ can be defined as

$$lambda_i \equiv \lambda_i \approx \frac{\pi(k_i, n_i, l_i)}{p_i} \tag{C.5}$$

if the discount factor β is close to one.

In the IFLS, farming households were asked to estimate the market value of their land, and to report their annual farm output. To recover a variable representing land rent, the contributions of farm assets and labour must first be subtracted from farm output. To do so, I first estimate the parameters of an agricultural production function:

$$a_i = \exp(A) k_i^{\alpha_k} n_i^{\alpha_n} l_i^{\alpha_l} \tag{C.6}$$

a_i is farm output for household i; l_i, n_i, and k_i are land, labour, and capital used by household i; and $\exp(A)$ is total factor productivity. Taking the logarithms of both sides of (C.6) gives an equation that can be estimated by ordinary least squares:

$$\log a_i = A + \alpha_k \log k_i + \alpha_n \log n_i + \alpha_l \log l_i + \epsilon_i \tag{C.7}$$

Estimates of the wage rate and rental rate on capital are obtained using marginal products:

$$w = \hat{\alpha}_n \bar{a}/\bar{n} \qquad \text{and} \qquad r_k = \hat{\alpha}_k \bar{a}/\bar{k} \tag{C.8}$$

where $\bar{a}$, $\bar{n}$, and $\bar{k}$ are the average levels of farm output, employment, agricultural capital stock. Land's contribution to farm output can be written

$$\pi(k_i, n_i, l_i) = a_i - wn_i - r_k k_i \tag{C.9}$$

which can be calculated from the data using farm output, farm labour endowment, and farm assets. Plugging this into the numerator of (C.5) and the reported land value into the denominator yields a proxy variable for λ_i. Notice that π is computed using a_i and not the fitted values from the production function estimation since the unexplained part of agricultural output likely reflects undocumented land characteristics such as soil quality and topography. Then, according to equation (C.5), any unobserved characteristics that affect land productivity (the numerator) will also be reflected in the value of the land (the denominator). In the construction of *lambda*, these effects will cancel out, so that the proxy variable is less sensitive to land characteristics such as soil quality and topography. Any factor that influences the perceived value of a plot of land without affecting annual farm output will however generate misleading *lambda* values. I therefore remove the effect of proximity to the provincial capital center on reported land values before constructing the proxy variable.[14]

According to the theory, *lambda* is an estimate of λ_i. If this procedure truly generates a reasonable proxy variable, one would expect *lambda* to be distributed between 0 and 1. Moreover, since even a small probability of losing ownership in a given year reflects a substantial amount of insecurity, most of the mass should be located close to zero. Figure 6 displays the kernel density of the derived proxy variable, *lambda*. The distribution is as expected.

[14] The log of the reported value per hectare of land, $\log v_i$, is regressed on a constant and the distance from the provincial capital center, d_i:

$$\log v_i = \gamma_0 + \gamma_1 d_i + \epsilon_i$$

The estimated coefficient on the distance variable, $\hat{\gamma}_1$ is negative and significant at the 1 percent level. Then, the adjusted total land value used to construct the proxy variable for tenure insecurity is adjusted based on the proximity to the provincial capital center:

$$lambda_i \equiv \frac{y_i - wn_i - r_k k_i}{\exp\left(\log v_i - \hat{\gamma}_1(d_i - \bar{d})\right) \times l_i}$$

where $\bar{d}$ is the average distance between a farm plot and the capital center.

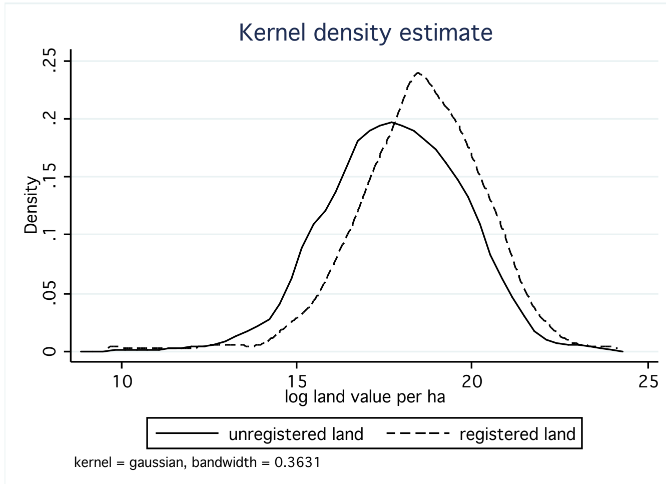

Figure 5: The kernel density estimation of the per hectare value of household land (log)

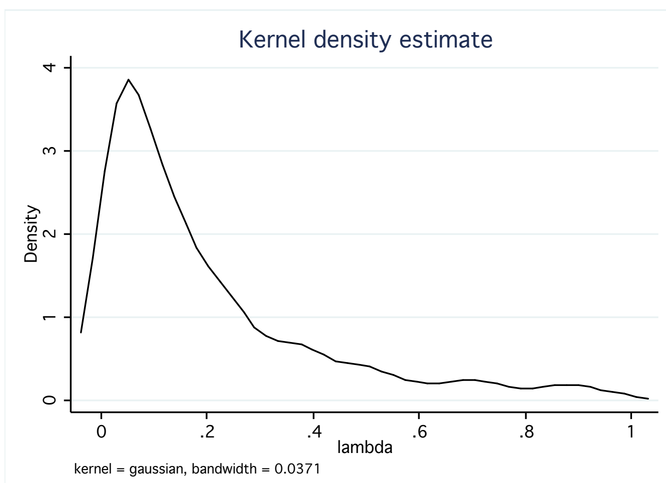

Figure 6: The kernel density estimation of the proxy variable for tenure insecurity, *lambda*

D Model Extension: Heterogeneous Productivity

There are countless potential forces generating the demand for land ownership transferability in rural agricultural economies. In the main part of the paper, I chose to model the land market in an environment where a fraction of landowners receive opportunities to work more productively in a modern sector. The emerging off-farm economy and migration flows spur land market activity. Another possible driver could be heterogeneity in land user productivities, which generates incentives to transfer land to the most productive workers. Instead of an emerging off-farm economy, suppose households are subject to productivity shocks. In particular, assume that with probability q, a household switches from high to low productivity. This interpretation of the model is consistent with some of the land market literature that derives a demand for land transferability from heterogeneous productivity (Besley, 1995; Yao, 2000; Deininger and Jin, 2005) or from heterogeneous household resources and endowments (Skoufias, 1995).

Let $a \in \{a_L, a_H\}$ be the random productivity variable. High productivity landowners earn profit $a_H\pi$, and low productivity households earn $a_L\pi$. Normalize $a_H = 1$ and $a_L = \alpha < 1$. The negative productivity shock can be interpreted, for example, as a shock to a household's labour endowment, or as a health shock that impedes a landowner from making full use of his land. Before agricultural production takes place, there are incentives for land transactions driven by the potential gains from transferring land from low to high productivity owners. A buyer's payoff in a land market transaction involving type i land for price p is $(1 - \lambda_i)\pi - p$. A type i seller's gain from a land transaction is $p - \alpha(1 - \lambda_i)\pi$.

I make the same simplifying assumptions as in the previous sections. There are only two types of land plots, and $\lambda_L > \lambda_H$. The short side of the market matches with probability one. The measure of highly productive landless agents is enough to ensure that the free entry conditions hold in equilibrium. This requires $q < 1 - n_L - n_H$. Finally, assume that the gains from trade are positive for both types of land. A sufficient condition is that the entry cost c is arbitrarily small.

Proposition D.1 *There exists a unique competitive land market equilibrium with*

(i) *land prices:* $p_L = (1-\lambda_L)\pi - c$ *and* $p_H = (1-\lambda_H)\pi - c$

(ii) *seller allocations:* $\{s_L(p_L), s_L(p_H)\} = \{S_L, 0\}$ *and* $\{s_H(p_L), s_H(p_H)\} = \{0, S_H\}$

(iii) *buyer allocation:* $b(p_L) = S_L$ *and* $b(p_H) = \frac{(1-\alpha)(1-\lambda_L)\pi - c}{(1-\lambda_H)\pi - \alpha(1-\lambda_L)\pi - c} S_H.$

(iv) *utilities for type* i *sellers:*

$$\bar{U}_L = (1-\alpha)(1-\lambda_L)\pi - c$$

and

$$\bar{U}_H = \frac{b(p_H)}{S_H}\big[(1-\alpha)(1-\lambda_H)\pi - c\big]$$

There is only one type of equilibrium, which is similar to a case 1 equilibrium in the benchmark model with migration decisions. According to part (iii) of Proposition D.1, the asymmetric information induces illiquidity in the type H land market as a screening mechanism. All of the results from Section 4 apply to the extended model as well. Namely, higher degrees of tenure insecurity reduce the volume of transactions in the land market.

A poor functioning land market affects aggregate farm production. Increased land transferability and reduced tenure insecurity are associated empirically with productivity gains. For example, Holden, Deininger, and Ghebru (2007) find that land rental markets in Ethiopia transfer land to more productive households. There are unexploited productivity gains, however, as they document the existence of barriers that constrain participation in the Ethiopian rental markets, which are likely related to tenure insecurity and the threat of land confiscation. The model extension captures the Ethiopian experience. Land market deficiencies reduce aggregate output because land cannot always be transferred to more productive users. Reducing frictions in the land market improves land allocative efficiency and increases aggregate output.