The Contemporaneous Interaction between the Investment and Rental-supply Effects of Higher Land Ownership Security

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Abstract: Securing land ownership is supposed to bring about significant gains in both agricultural output and poverty reduction for an agrarian economy endowed with unequal land ownership distribution. These win-win economic gains rely on the premise that it can simultaneously boost land-attached investments and increase land rental supply to facilitate land access for the poor who have relatively abundant family labor that is more efficient than hired labor due to the agency cost. However, this paper argues that the moral hazard of tenants not taking care of landlords' land-attached capital, resulting from non-security barriers to long-term land rental contracts, can downsize these gains. Theoretically, it induces the bias of the investment effect of higher land ownership security towards the endowed land to be self-cultivated, which tends to attenuate the concurrent rental-supply effect. The attenuated rental-supply effect will limit not only the improvement in labor efficiency but also the size of the investment effect through the complementarity between attached capital and labor inputs in the farm production, leading to smaller welfare gains than expected.

Keywords: land ownership security; moral hazard; land-attached investments; land rental supply.

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1 Introduction

There is a consensus in the economic literature that securing land ownership contributes to agricultural growth by boosting land-attached investments and productive land transfers.[1] On the one hand, higher security enhances landowners' incentives to invest as it lowers the risk of losing the land and thus land-attached investments (e.g., Feder et al., 1988). It will also enhance landowners' ability to invest when the safer land collateral induces lenders to offer more credit (e.g., Carter and Olinto, 2003). On the other hand, higher security enhances landowners' incentives to rent out land to more productive farmers as it reduces the threat of losing the rented-out land (e.g., Macours et al., 2010). This paper studies the contemporaneous interaction between these two effects, which has been ignored in the literature.[2] Importantly, I find that the investment effect can attenuate the concurrent rental-supply effect in the presence of common market failures (see details below).

The foregoing investment and rental-supply effects of securing land ownership have long been supposed to bring about significant gains in both agricultural output and poverty reduction for an agrarian economy endowed with unequal land ownership distribution like many rural areas in Latin America and the Caribbean (LAC) (e.g., Deininger, 2003). These win-win economic gains hinge on the premise that the security improvement facilitates the egalitarian distribution of the operational land by activating the land rental market (e.g., Boucher et al., 2005). However, large landowners may still hesitate to rent out (more) land after the security improvement. For instance, rural Nicaragua only witnessed a mild expansion of the land rental market after salient land titling and registrations in the 1990s, although it had a notable increase in land-attached capital investments (Deininger and Chamorro, 2004; Boucher et al., 2005). This paper argues that this can happen when the investment effect attenuates the concurrent rental-supply effect due to market failures. As a result, the realized economic gains of securing land ownership will be smaller than expected.

[1]For concreteness, this paper focuses on the land tenure system of private ownership. In the communal or collective land tenure system, securing use and transfer rights can also induce agricultural growth by boosting land-attached investments (e.g., Jacoby et al., 2002; Deininger and Jin, 2006) and productive land transfers (e.g., Holden et al., 2011; Chari et al., 2021). For simplicity, this paper will not consider the sectoral occupation choice through which securing land tenure can notably affect agricultural growth, either (e.g., Chen, 2017; Gottlieb and Grobovšek, 2019). See Deininger et al. (2022) for a comprehensive review of this strand of economic literature.

[2]Besley (1995) and Carter and Yao (1999) studied the *intertemporal* interaction between the investment and rental-supply effects. They found that the rental-supply effect can strengthen the investment effect as the option of renting out land in the future helps reap investment fruits in an uncertain world. This paper, however, studies the *contemporaneous* interaction between the investment and rental-supply effects and thus complements their works.

I start the analyses with a novel agricultural household model that builds on the following three common market failures that are interlinked through land ownership. The first market failure is the agency cost of hired labor, i.e., hired labor tends to shirk and thus is less efficient than family labor without costly supervision (Eswaran and Kotwal, 1986). Holding land-attached investments constant, large landowners who suffer from the agency cost of hired labor will rent out (more) land in response to the improvement in land ownership security as it lowers the risk of losing the rented-out land. The second market failure is the credit rationing of small landowners, i.e., they are rationed out of the credit market due to insufficient land endowments for collateral, regardless of land ownership security (Carter, 1988; Carter and Olinto, 2003). Thus, only large landowners will increase land-attached investments, which require upfront monetary outlays, in response to the improvement in land ownership security that lowers the risk of losing land-attached investments.

The third market failure is the moral hazard of tenants who may recklessly use or overexploit long-term attached capital (e.g., irrigation facilities like wells, livestock structures like stables and fences, long-lived tree crops like coffee and citrus, etc.) on the rented land under short-term land rental contracts, which induces landlords' preferences for attached capital investments on the self-cultivated land (Bandiera, 2007).[3] Given the lower risk of losing land-attached capital, large landowners will then increase attached capital investments on the endowed land to be self-cultivated more than that on the endowed land to be rented out. This bias of the investment effect favors self-cultivation and thus dampens the concurrent rental-supply effect generated from the improvement in land ownership security that also lowers the risk of losing the rented-out land.

The third market failure is critical for the welfare gains of securing land ownership. Without it, the investment effect would not be biased towards the endowed land to be self-cultivated and thus not attenuate the concurrent rental-supply effect. Importantly, the unattenuated rental-supply effect would get around the other two land-size-sensitive market failures by facilitating both the

[3] In LAC, there have been frequent incidences of tenants abusing landlords' land-attached capital under short-term land leasings (de Janvry et al., 2002). The problem is that landlords lack the commitment to long-term land rental contracts. Unlike de Janvry and Sadoulet (2002) who emphasize insecure land ownership, Bandiera (2007) argues that landlords may not have the commitment simply because they want to have the option of adjusting contract terms or self-cultivating the land to changes in the economic environment. Moreover, legal regulations directly dampen long-term land rental contracts in LAC. For instance, Díaz et al. (2002) find that civil codes in Argentina, Nicaragua, Peru, and Uruguay prohibit land leasing of longer than 10 or 15 years. Other LAC countries, like Chile and Costa Rica, put similar regulations on the indigenous and agrarian reform land. Because of these non-security barriers, landlords will still not commit to long-term land rental contracts even if they have secure land ownership.

egalitarian distribution of the operational land and the even distribution of attached capital investments between the self-cultivated and rented-out land. This will deliver a double-efficiency improvement when attached capital complements labor in the farm production (Carter and Yao, 1999), possibly leading to sizable win-win gains in both agricultural output and poverty reduction.

In the presence of the third market failure, however, the investment effect tends to attenuate the concurrent rental-supply effect due to its bias towards the endowed land to be self-cultivated. The attenuated rental-supply effect will in turn restrict the size of the investment effect as it limits the scope of large landowners to reduce the inefficient hired labor input on the self-cultivated land that dampens attached capital investments through input complementarity. Hence, the moral hazard of tenants not taking care of landlords' land-attached capital will downsize the potential welfare gains for a typical unequal agrarian economy, especially the welfare gain for the poor, as evidenced by the simulated equilibrium welfare impacts of securing land ownership in the follow-up paper.

This paper contributes to the extensive literature on the economic effects of land tenure security by establishing a novel agricultural household model that allows the contemporaneous interaction between the investment and rental-supply effects for the first time. The model predicts that the investment effect will attenuate the concurrent rental-supply effect when the moral hazard of tenants not taking care of landlords' land-attached capital is present, leading to smaller welfare gains of securing land ownership than expected for an agrarian economy endowed with unequal land ownership distribution. These unintended consequences deepen our understanding of how much economic gains can be generated from securing land tenure given multiple market failures.

The most closely-related works are conducted by Besley (1995) and Carter and Yao (1999) who studied the intertemporal interaction between the investment and rental-supply effects of land tenure security. They find that securing land tenure facilitates renting out land to reap investment fruits in the risky future, enlarging the current investment effect. In contrast, I find the moral hazard of tenants not taking care of landlords' land-attached capital discourages renting out land at securer land tenure, which will downsize the current investment effect as explained above.

The rest of the paper proceeds as follows. First, I introduce the new model in section 2. Then, I study land rental choices of landowners given land ownership security in section 3, which facilitates my investigation into the contemporaneous interaction between the investment and rental-supply effects of higher land ownership in section 4. Finally, I conclude the paper in section 5.

2 A New Agricultural Household Model

In this section, I introduce a new agricultural household model that will be used to study the interaction between the investment effect of higher land ownership security and the concurrent rental-supply effect in section 4. First, I outline model assumptions. Then, I set up the utility maximization problem. In section 3, I study land rental choices of households endowed with different sizes of land given the same land ownership security, which facilitates my analyses in section 4.

2.1 Model assumptions

The agrarian economy considered below consists of heterogeneous households in land endowment. They engage in the same C.R.S. agricultural production that involves complementary inputs of land, attached capital, and labor. They allocate land, credit, and labor to maximize discounted incomes in the presence of multiple market failures. The detailed assumptions are outlined below.

Preferences: Each agent has the same risk-neutral preferences for the income flow over infinite production periods and shares the same discount factor β.[4]

Endowments: labor and land.

(i) *Labor*: Each agent, either landed or landless, is endowed with one unit of labor that is divisible between two usages—family labor on their own farms and hired labor on others' farms.

(ii) *Land*: Each landed agent is endowed with the land of size A_e and security level $S_e \in [0, 1]$. Larger S_e means a lower risk of losing the endowed land and its attached capital investments, and $S_e = 1$ means no risk. Landed agents are heterogeneous in the size and security level of land endowment, although the same intensity of natural capital k_n is embedded in their endowed land.

[4] Unlike Eswaran and Kotwal (1986), I do not consider the utility of leisure except income. It will become clear later that incorporating the utility of leisure will not alter the model predictions of interest in sections 3 and 4.

Technologies: farm production and the extraction of effective labor.

(i) *Farm production*: Each agent has access to the same C.R.S. production technology $F(A, K, L)$ that is strictly increasing, concave, and twice-continuously differentiable in its three inputs—raw land A, attached capital K, and effective labor L.[5] Attached capital consists of the embedded natural capital (endowments like rainfalls) and the invested artificial capital (investments like irrigation installments), and they are perfect substitutes.[6] All the inputs are ordinary and strictly gross complements for each other (e.g., Carter and Yao, 1999).[7] Also, the marginal output of each input, evaluated at zero, goes to positive infinity, given nonzero other inputs.[8]

(ii) *The extraction of effective labor under the agency cost of hired labor (the first market failure)*: Hired labor is an imperfect substitute for family labor as hired labor tends to shirk without costly supervision (e.g., Eswaran and Kotwal, 1986). When hired workers are employed, family labor will supervise them by working together with them. The resulted amount of effective labor is a function of family labor input L_f and hired labor input L_h, denoted by $L(L_f, L_h)$, with the following regular properties (e.g., Frisvold, 1994): $L(L_f, 0) = L_f, \forall L_f \geq 0$, i.e., family labor is used as the numeraire for effective labor; and $0 < \frac{\partial L}{\partial L_h} \leq 1, \frac{\partial^2 L}{\partial L_h^2} < 0, \forall L_h \geq 0, L_f > 0$, i.e., the first unit of hired labor is as efficient as family labor; but its effectiveness decreases as more hired labor is used or equivalently the supervision intensity, namely $\frac{L_f}{L_h}$, decreases.

Markets: land rental, labor, attached capital, credit, and output.

(i) *Land rental market*: Land rental contracts are of fixed rent.[9] Agents face the same land rental rate schedule $r(\cdot)$—rental rates for land with different intensities of attached capital—determined in the competitive equilibrium. Landlords provide tenants with full security to cultivate the rented

[5] This technical assumption is a common regularity assumption that simplifies the analytical analyses below. For simplicity, I do not incorporate any intermediate input in the production technology above. Movable capital, like machines and other farming equipment, is not considered, either. See related discussions in section 5.

[6] I introduce natural attached capital to allow the possibility of landlords making zero attached capital investments on the rented-out land, which is not uncommon in reality (e.g., Bandiera, 2007). See details in the follow-up paper.

[7] At the optimum, an ordinary input will decrease as its price increases. That two inputs are strictly gross complements for each other means that at the optimum, one input will decrease as the price of the other increases.

[8] This common technical assumption simplifies the analytical analyses below by ruling out corner solutions with one or more zero optimal inputs in the farm production.

[9] To focus on the inefficiency of labor input caused by the agency cost of hired labor, I do not consider alternative land rental contracts which may introduce additional inefficiency of labor input like the Marshallian inefficiency associated with sharecropping contracts (e.g., Shaban, 1987).

land and collect its fruits during contract periods by protecting land ownership (see details below). However, they may or may not invest attached capital in the rented-out land, depending on its return and cost, while tenants do not invest in the rented-in land.[10]

(ii) *Labor market*: Agents face the same wage rate w determined in the competitive equilibrium.

(iii) *Attached capital market*: Each agent faces the same exogenous price of the artificial attached capital. Such price is normalized to one, i.e., attached capital is the numeraire in this economy.

(iv) *Credit market with rationing of small landowners (the second market failure)*: Credit, the only source of money to make attached capital investments, requires land collateral. Agents endowed with the land of a size below the minimum size of land collateral A_e^m will have no access to credit due to quantity rationing, regardless of land ownership security (e.g., Carter, 1988; Carter and Olinto, 2003).[11] Non-rationed landed agents, however, have access to credit up to $A_e\theta(S_e)$ with the leverage ratio $\theta(S_e) > 0$ and its responsivity to land ownership security $\theta'(S_e) > 0$ at each security level S_e. The accessible credit caps her or his attached capital investments on the self-cultivated and rented-out land $A_o k_o$ and $A_t^{out} k_t^{out}$, i.e., $A_o k_o + A_t^{out} k_t^{out} \leq A_e\theta(S_e)$, where $\{A_o, k_o\}$ denote the size of the self-cultivated land and the intensity of its attached capital investments and $\{A_t^{out}, k_t^{out}\}$ denote the size of the rented-out land and the intensity of its attached capital investments. Nevertheless, each agent faces the same exogenous interest rate i. Following Eswaran and Kotwal (1986), I set the discount factor β equal to $\frac{1}{1+i}$, i.e., $\beta = \frac{1}{1+i}$.

(v) *Output market*: Agents face the same exogenous output price p given by the outside output market like the global agricultural output market.

Depreciation costs: The artificial attached capital depreciates over time while the natural attached capital does not.[12] The depreciation rate of the artificial attached capital invested in the rented-out land d_t may be larger than the depreciation rate of the artificial attached capital invested in the

[10] This ad hoc assumption that tenants do not invest in the rented-in land seems reasonable for an unequal agrarian society of interest in this paper, like rural Nicaragua in Latin America and the Caribbean where it is often the rich landlord who makes attached capital investments on the rented-out land (e.g., Bandiera, 2007). Without this assumption, landed agents who have access to credit would otherwise invest in the rented-in land rather than their endowed land given the full security provided by landlords, which contradicts common sense.

[11] I do not consider the risk rationing (Boucher et al. 2008) given the risk-neutral preferences in this model.

[12] The assumption that the natural attached capital does not depreciate simplifies analyses below, although it is not essential for the model predictions of interest in section 3 and 4.

self-cultivated land d_o, i.e., $d_t \geq d_o > 0$. This capital depreciation rate gap will emerge under the short-term land rental contract that induces the moral hazard of tenants who may recklessly use or overexploit the long-term attached capital invested by landlords (*the third market failure*).[13] Nevertheless, landed agents including landlords conduct regular maintenance to keep the attached capital invested in the endowed land unchanged over time.[14] That is, the per-period depreciation costs facing a landed agent will be $d_o A_o k_o$ and $d_t A_t^{out} k_t^{out}$ for the attached capital invested in the self-cultivated and rented-out land, respectively.

Protection costs: Insecure land ownership induces the risk of losing the endowed land and its attached capital investments. Renting out land raises such risk.[15] To maintain land ownership, landed agents periodically expend money to protect the endowed land and its attached capital investments.[16] These outlays translate into the following periodical protection costs.

(i) *For the self-cultivated land and its attached capital investments*: $c_o(S_e)A_o\left[\frac{r(k_n)}{i} + k_o\right]$.

(ii) *For the rented-out land and its attached capital investments*: $c_t(S_e)A_t^{out}\left[\frac{r(k_n)}{i} + k_t^{out}\right]$.

Here, $c_o(S_e)$ and $c_t(S_e)$ denote the cost rates of protecting the self-cultivated and rented-out land (and their attached capital investments), respectively. The market value of the endowed land is measured by its discounted rents in the land rental market $\frac{r(k_n)}{i}$. We may interpret $c_o(S_e)$ and $c_t(S_e)$ as the per-period probabilities of losing the self-cultivated and rented-out land (and their attached capital investments) under no protection, respectively. The protection costs above may then be interpreted as the expected losses of the endowed land and its attached capital investments

[13]Establishing long-term land rental contracts may be either impossible due to legal regulations on contract durations (e.g., Díaz et al., 2002) or too costly for landlords as they have to give up the option of adjusting terms of the contract or self-cultivating the land to changes in the economic environment (e.g., Bandiera, 2007).

[14]Together with the next assumption that landowners expend costs to protect the endowed land and its attached capital investments, this assumption simplifies the theoretical analyses below by making the problem of maximizing the discounted incomes over the infinite production periods static. See details in subsection 2.2.

[15]The increased land ownership risk comes from either tenants who may squat the rented land or non-tenants for whom it may be easier to occupy the tenant-cultivated land than the owner-cultivated land.

[16]In the conventional way of modeling insecure land ownership, landowners passively lose the endowed land and its attached capital investments cum output with some positive probability (e.g., Feder et al., 1988; Besley, 1995). Here, I deviate from it and introduce this alternative approach in which landowners actively expend resources like money in this model to protect insecure land ownership. This new approach ensures that all land cultivators can collect all their outputs at each harvest. Importantly, this means that insecure land ownership only indirectly affects the variable labor input through the fixed attached capital input that complements labor input in the farm production. Nevertheless, insecure land ownership will still dampen landowners' incentives to invest land-attached capital and rent out land as that in the traditional approach, given the structure of protection cost rates above.

in market values that a landed agent would face if she or he did not protect her or his land ownership.[17] Moreover, we have $c_t(S_e) > c_o(S_e) > 0$ and $c_t'(S_e) < c_o'(S_e) < 0, \forall S_e \in [0,1)$, as renting out land raises the risk of losing the endowed land and its attached capital investments and higher land ownership security reduces such risk. When land ownership is fully secure, namely $S_e = 1$, there will be no risk and thus zero protection cost rates, namely $c_t(1) = c_o(1) = 0$.

No working capital requirement: Agents pay for hiring in labor, renting in land, protecting the endowed land and its attached capital investments, and maintaining the attached capital invested in the endowed land after each harvest, i.e., no working capital is required.

2.2 The utility maximization problem

To proceed, let me revisit existing notations and introduce several new ones for the resource allocation possibly made by an individual agent, namely *choice variables* listed below:

A_o—*the size of the endowed land to be self-cultivated;*

k_o—*the intensity of the attached capital to be invested in the self-cultivated land;*

L_o—*the amount of the effective labor to cultivate the self-cultivated land;*

A_t^{out}—*the size of the endowed land to be rented out;*

k_t^{out}—*the intensity of the attached capital to be invested in the rented-out land;*

A_t^{in}—*the size of the land to be rented in;*

k_t^{in}—*the intensity of the attached capital investments on the rented-in land made by the landlord;*

L_t^{in}—*the amount of the effective labor to cultivate the rented-in land;*

L_f—*the amount of the endowed labor to produce the effective labor input* $L(L_f, L_h^{in})$ *on her or his own farm (including the self-cultivated and rented-in land) as family labor;*

L_h^{in}—*the amount of labor to hire in and produce the effective labor input* $L(L_f, L_h^{in})$ *on her or his own farm (including the self-cultivated and rented-in land); and*

L_h^{out}—*the amount of the endowed labor to hire out and work on others' farms.*

[17] It is inappropriate to simply use $\frac{r(k_n+k_o)}{i}$ or $\frac{r(k_n+k_t^{out})}{i}$ for the gross market value of the endowed land and its attached capital investments as it does not incorporate future capital depreciation costs. In fact, doing so will further complicate the already-sophisticated theoretical analyses below without bringing us additional insights.

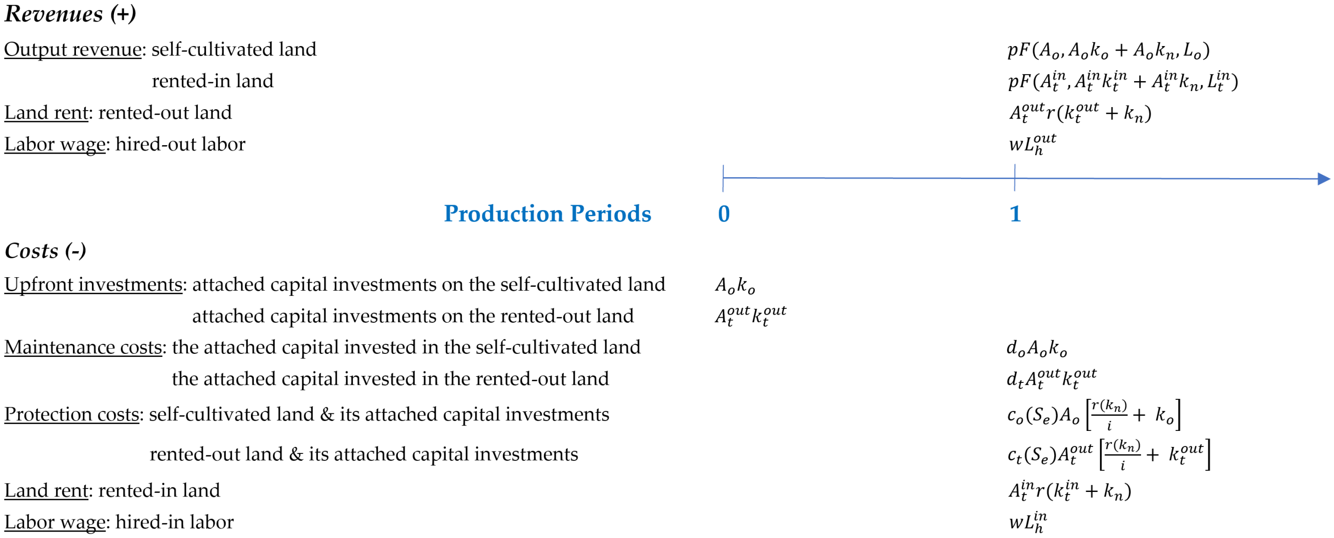

Figure 1: The General Structure of Revenues and Costs.

Under the model assumptions in subsection 2.1, we have the general structure of revenues and costs as outlined above in Figure 1. Here, the blue integer "0" denotes the initial production period when the *upfront attached capital investments* on the self-cultivated and rented-out land, namely $A_o k_o + A_t^{out} k_t^{out}$, occur. The blue integer "1" denotes the first harvest when the periodical revenues and costs occur for the first time, which deliver the following *four sources of income.*

(i) *The pseudo-profit of cultivating the self-cultivated land* $\pi_o(A_o, k_o, L_o)$:[18]

$pF(A_o, A_o k_o + A_o k_n, L_o) - [d_o + c_o(S_e)]A_o k_o - c_o(S_e) A_o \frac{r(k_n)}{i}$.

(ii) *The pseudo-return of renting out land* $\pi_t^{out}(A_t^{out}, k_t^{out})$:[19]

$A_t^{out} r(k_t^{out} + k_n) - [d_t + c_t(S_e)]A_t^{out} k_t^{out} - c_t(S_e) A_t^{out} \frac{r(k_n)}{i}$.

(iii) *The pseudo-profit of cultivating the rented-in land* $\pi_t^{in}(A_t^{in}, k_t^{in}, L_t^{in})$:[20]

$pF(A_t^{in}, A_t^{in} k_t^{in} + A_t^{in} k_n, L_t^{in}) - A_t^{in} r(k_t^{in} + k_n)$.

(iv) *The net wage income of hiring out and in labor*: $wL_h^{out} - wL_h^{in}$.

[18] This profit is pseudo as it does not include the credit and labor costs. The upfront cost of attached capital investments $A_o k_o + A_t^{out} k_t^{out}$ equals the present value of credit interests and its principal given the discount factor $\beta = \frac{1}{1+i}$, although I do not specify the repayment structure. The labor cost shared across the farm production on the self-cultivated and rented-in land is embedded in the net wage income of hiring out and in labor defined above.

[19] This return is pseudo as it does not include the credit cost that is embedded in the upfront cost of attached capital investments $A_o k_o + A_t^{out} k_t^{out}$ as the pseudo-profit of cultivating the self-cultivated.

[20] This profit is pseudo as it does not include the labor cost that is embedded in the net wage income of hiring out and in labor defined above as the pseudo-profit of cultivating the self-cultivated.

These incomes will repeatedly occur in later harvests as no agent will change resource allocation, holding prices and land ownership security constant.[21] The reason is that attached capital on any land will remain unchanged after initial investments thanks to the periodical maintenance made by landowners. Hence, we have the following utility maximization problem (UMP) facing an arbitrary agent, given the risk-neutral preferences over incomes and the discount factor $\beta = \frac{1}{1+i}$:

$$
\begin{aligned}
max_{\{choice\ variables\}} \frac{1}{i} \Big\{ & \pi_o(A_o, k_o, L_o) + \pi_t^{out}(A_t^{out}, k_t^{out}) + \pi_t^{in}(A_t^{in}, k_t^{in}, L_t^{in}) + (wL_h^{out} - wL_h^{in}) \Big\} \\
& - (A_o k_o + A_t^{out} k_t^{out}) \\
& s.t. \quad A_o + A_t^{out} \leq A_e; && (1) \\
& \qquad A_o k_o + A_t^{out} k_t^{out} \leq I_{\{A_e \geq A_e^m\}} A_e \theta(S_e); && (2) \\
& \qquad L_o + L_t^{in} \leq L(L_f, L_h^{in}); && (3) \\
& \qquad L_f + L_h^{out} \leq 1; and && (4) \\
& \qquad \{A_o, A_t^{out}, A_t^{in}, k_o, k_t^{out}, k_t^{in}, L_o, L_t^{in}, L_f, L_h^{out}, L_h^{in}\} \geq 0, && (5)
\end{aligned}
$$

where *choice variables* are A_o, A_t^{out}, A_t^{in}, k_o, k_t^{out}, k_t^{in}, L_o, L_t^{in}, L_f, L_h^{out}, and L_h^{in}, as defined above.

The land constraint (1) says that the gross size of the endowed land to be self-cultivated and rented out should not exceed the size of land endowment A_e. The credit constraint (2) says that the gross attached capital investments on the self-cultivated and rented-out land should not exceed the accessible credit $A_e\theta(S_e)$ for an agent who has access to credit. An agent endowed with land of size below the minimum size of land collateral required for access to credit A_e^m will be rationed out of the credit market, namely $I_{\{A_e \geq A_e^m\}} = 0$, and thus have no accessible credit to make attached capital investments. The effective labor constraint (3) says that the total amount of the effective labor to cultivate the self-cultivated and rented-in land should not exceed the amount of the effective labor extracted from family and hired-in labor. Constraint (4), on the other hand, says that the total amount of the endowed labor to work on her or his own farm as family labor and work on

[21]For instance, a landlord or a tenant will keep renting out or renting in land by consecutively renewing the same contract, although her or his tenant or landlord may change. Nevertheless, the depreciation rate of the attached capital invested in the rented-out land or the rented-in land by its landowner should remain unchanged since it is the contract duration but not the duration of the rental relationship that matters for attached capital investments on the land in rental as shown in the empirical literature (Bandiera, 2007; Jacoby and Mansuri, 2008).

others' farms as hired labor should not exceed the amount of labor endowment. Finally, constraint (5) simply says that all the allocations of land, credit, and labor should be nonnegative.

For readability, I put the first-order optimality conditions for the UMP above in Appendix A, which will be used in later sections. Concerning the complex nature of this problem, I study the interaction between the investment effect of higher land ownership security and the concurrent rental-supply effect in the following two steps. In section 3, I explain how the three market failures introduced in the previous subsection will affect the land rental choices of agents endowed with different sizes of land endowment given the same land ownership security. Building on that, I examine the contemporaneous interaction between the investment and rental-supply effects of higher land ownership security through the lens of land rental supply in section 4.

3 Land Rental Choices given Land Ownership Security

In this section, I study when landed agents will rent in and rent out land in terms of the size of land endowment at a given security level of land endowment, holding prices constant.[22] Studying this helps us understand how the three market failures—the agency cost of hired labor, the credit rationing of small landowners, and the moral hazard of tenants not taking care of landlords' land-attached capital—will affect agents' renting choices. This analysis prepares us for the investigation into the interaction between the investment effect of higher land ownership security and the concurrent rental-supply effect in the next section. In the following, let us focus on the general case when the given security of land endowment is not at the highest level, i.e., landed agents need to expend costs to protect the endowed land and its attached capital investments. To proceed, let me introduce Lemma 1 below.

Lemma 1*: Under the C.R.S. production technology and the competitive land rental and labor markets, the unit return of the effective labor input on the rented land equals wage rate, regardless of the intensity of attached capital investments made by the landlord.*

[22] Admittedly, landed agents are also heterogeneous in the security level of land endowment. See their land rental choices at different security levels of land endowment in section 4.

Lemma 1 comes from the following two facts: (i) under the C.R.S. production technology, tenants earn the same unit return of the effective labor input on the rented land in the competitive land rental market, regardless of the intensity of attached capital investments made by landlords; and (ii) tenants and laborers are indifferent between the two usages of the endowed labor—cultivating the rented land as family labor and working on others' farms as hired labor—in the competitive land rental and labor markets (see details in Appendix B). Lemma 1 implies that tenants will not use any hired labor but family labor to cultivate the rented land as one unit of hired labor produces less than one unit of effective labor due to the agency cost while one unit of family labor just produces one unit of effective labor. As a corollary, a landed agent will not rent in land if she or he opts to use all the endowed labor to self-cultivate all or part of the endowed land.

Note that a landed agent will not rent out land if self-cultivating all the endowed land does not consume all the endowed labor at its opportunity cost wage rate. Under this condition, renting out land will not improve the efficiency of the labor input on the endowed land as self-cultivating all the endowed land does not involve the usage of the inefficient hired labor. In fact, renting out land will only raise the protection and capital depreciation cost rates resulting from the higher risk of losing the rented-out land cum its attached capital investments and the moral hazard of tenants not taking care of landlords' land-attached capital. More generally, landed agents will use the endowed labor to self-cultivate the endowed land up to the point where the marginal return of the family labor input on the self-cultivated land equals wage rate and use the remaining endowed labor (if any) to cultivate the land to be rented in or others' farms.[23] Based on this fact, I obtain the following proposition about the threshold of renting in land, denoted by A_e^{in}.

Proposition I*: There exists a unique size of land endowment A_e^{in} above which landed agents will stop renting in land at a given security level of land endowment.*

As shown below in Figure 2, the solid lines represent the marginal return of the endowed land under self-cultivation at different sizes of land endowment. It is defined as the marginal output revenue of the endowed land (including its natural attached capital) under self-cultivation minus

[23] Agents are indifferent between the latter two usages of the endowed labor as they deliver the same unit return.

the unit cost of protecting the endowed land under self-cultivation.[24] At a given security level of land endowment S_e, the protection cost part is constant, whereas the output revenue part depends on the size of land endowment A_e. That is, the size of land endowment affects the marginal return of the endowed land under self-cultivation only through the output revenue part.

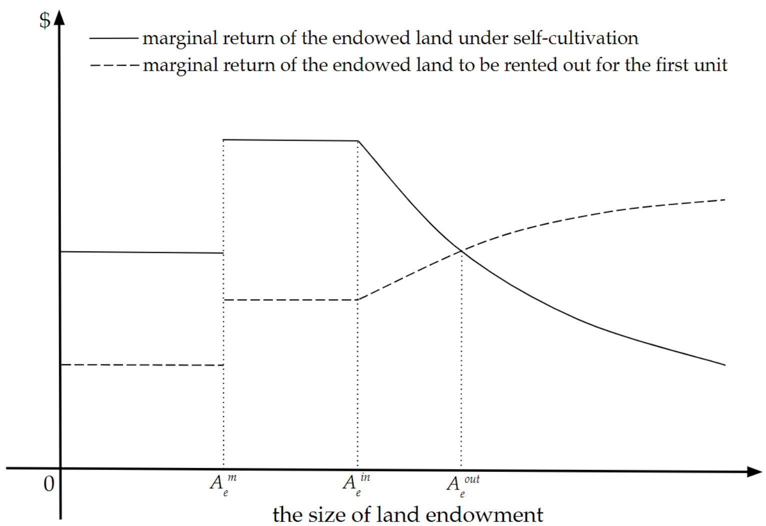

Figure 2: Thresholds of Renting in and out Land at a given Security Level of Land Endowment.

Note: (i) The marginal return of the endowed land is defined as the marginal output revenue of the endowed land minus its unit protection cost, where the unit protection cost only depends on the security level of land endowment. Thus, the patterns of the two marginal returns of the endowed land listed above capture the effects of the size of land endowment on these marginal returns. (ii) A_e^m is the minimum size of land collateral required for access to credit, i.e., an agent endowed with land of size below A_e^m will have no accessible credit to make attached capital investments. This leads to jump-ups in both marginal returns of the endowed land right at the size of land endowment equal to A_e^m and their changes at larger sizes of land endowment. See the text below for detailed explanations. (iii) A_e^{in} is the threshold of renting in land, the size of land endowment above which landed agents stop renting in land. (iv) A_e^{out} is the threshold of renting out land, the size of land endowment above which landed agents start renting out land.

When A_e is smaller than the minimum size of land collateral required for access to credit A_e^m, self-cultivating all the endowed land will not involve attached capital investments as landed agents of this category have no accessible credit to do investments. Nevertheless, self-cultivating all the endowed land will always involve the usage of family labor. It will not consume all the endowed labor at its opportunity cost wage rate though, since the size of land endowment is small, namely $A_e < A_e^m$ where A_e^m is usually small (Carter and Olinto, 2003). Under the C.R.S. production

[24]In the farm production, the endowed land provides two inputs—raw land and attached capital. The latter comes from the natural attached capital embedded in the endowed land. Hence, the marginal output revenue of the endowed land equals the marginal output revenue of the raw land plus the marginal output revenue of attached capital times the intensity of the natural attached capital. See the mathematical formula below in subsection 4.2.

technology, landed agents of this category will have the same intensity of the effective labor input on the endowed land under self-cultivation as they face the same marginal cost of the effective labor input extracted from family labor, namely wage rate. Hence, the marginal output revenue of the endowed land under self-cultivation will be the same for them as well. So will the marginal return of the endowed land under self-cultivation.

For $A_e \geq A_e^m$, landed agents have accessible credit to make attached capital investments. *Assume that they will invest attached capital in the endowed land under self-cultivation.* Then, the marginal return of the endowed land under self-cultivation will become larger right at $A_e = A_e^m$ than that at $A_e < A_e^m$ as attached capital investments raise the marginal output revenue of the endowed land under self-cultivation through the complementarity between attached capital and land in the farm production.[25] Although attached capital also complements labor in the farm production, self-cultivating all the endowed land of size A_e equal to A_e^m will still not consume all the endowed labor at its opportunity cost wage rate given that A_e^m is small.

As the size of land endowment increases, however, self-cultivating all the endowed land will consume more endowed labor. Hence, there exists a unique size of land endowment, namely the threshold of renting in land A_e^{in}, at which self-cultivating all the endowed land will just consume all the endowed labor at its opportunity cost wage rate. This means that agents endowed with land of size above A_e^{in} will not use any endowed labor to cultivate any land to be rented in as they will use all the endowed labor to self-cultivate all or part of the endowed land.[26]

For $A_e \in [A_e^m, A_e^{in}]$, the marginal return of the endowed land under self-cultivation will be invariant with respect to the size of land endowment. Note that landed agents of this category face the same marginal cost of the effective labor input extracted from family labor, namely wage rate. Under the C.R.S. production technology, they will then demand the same intensity of attached capital investments on the endowed land under self-cultivation. Hence, they will invest the same intensity of attached capital in the endowed land under self-cultivation, regardless of the credit

[25] Admittedly, attached capital investments at $A_e = A_e^m$ will reduce the output revenue of the natural attached capital per unit of the endowed land—the marginal output revenue of attached capital times the intensity of the natural attached capital—if the marginal output revenue of attached capital becomes smaller than that at $A_e < A_e^m$. Nevertheless, the marginal output revenue of the endowed land under self-cultivation will increase right at $A_e = A_e^m$ where a landed agent just becomes able to make attached capital investments to maximize the profit of cultivating all the endowed land. So will the marginal output revenue of the endowed land to be rented out for the first unit.

[26] As explained before, renting out land without using out all the endowed labor for self-cultivation is unprofitable.

constraint status, since they face the same leverage ratio of the accessible credit over the size of land endowment as collateral at a given security level of land ownership (*one of model assumptions*).[27] At the same time, they will have the same intensity of the effective labor input on the endowed land under self-cultivation as they face the same marginal cost of the effective labor input. These constant input intensities will deliver a constant marginal output revenue of the endowed land under self-cultivation given the C.R.S. production technology. Thus, the marginal return of the endowed land under self-cultivation will remain unchanged for $A_e \in [A_e^m, A_e^{in}]$.

For $A_e > A_e^{in}$, however, the marginal return of the endowed land under self-cultivation will decrease as the size of land endowment increases. The reason is that self-cultivating all the endowed land now will involve the usage of the inefficient hired labor that raises the marginal cost of the effective labor input above wage rate due to the agency cost of hired labor. Moreover, a larger size of land endowment requires more hired labor input, although family labor input is fixed. Then, the marginal cost of the effective labor input on the endowed land under self-cultivation will keep increasing as one unit of hired labor will produce less and less effective labor due to the rising agency cost resulting from the decreasing supervision intensity. Therefore, the marginal output revenue of the endowed land under self-cultivation will keep decreasing as the size of land endowment increases. So will the marginal return of the endowed land under self-cultivation.

The increasing marginal cost of the effective labor input will also dampen the intensity of attached capital investments demanded on the endowed land under self-cultivation. Then, the intensity of the attached capital invested in the endowed land under self-cultivation will decrease after the credit constraint becomes not binding at a sufficiently large size of land endowment, contributing to the decrease in the marginal return of the endowed land under self-cultivation as well.[28] Nevertheless, the credit constraint is usually binding for agents endowed with medium sizes

[27]Under this assumption, they will be either all credit constrained or all credit unconstrained. If the constant intensity of attached capital investments demanded on the endowed land under self-cultivation is larger than the constant leverage ratio, then they will be all credit constrained and invest the same intensity of attached capital investments on the endowed land under self-cultivation, which equals the constant leverage ratio that they face. Otherwise, they will be all credit unconstrained and invest the same intensity of attached capital investments on the endowed land under self-cultivation as they demand.

[28]For a given security level of land endowment, the decreasing intensity of attached capital investments demanded on the endowed land under self-cultivation will eventually equal the constant leverage ratio, i.e., the credit constraint will turn to be not binding at a sufficiently large size of land endowment. Then, the intensity of the attached capital invested in the endowed land under self-cultivation will equal the intensity of attached capital investments demanded

of land (Carter and Olinto, 2003). For them, however, the decreasing intensity of attached capital investments demanded on the endowed land under self-cultivation means a decreasing shadow price of the accessible credit. Importantly, this also means a decreasing marginal cost of attached capital investments on the first unit of the endowed land to be rented out. *Assume that they will invest attached capital in the endowed land to be rented out.*[29] Then, the marginal output revenue of the endowed land to be rented out for the first unit will increase as the size of land endowment increases.[30] So will the marginal return of the endowed land to be rented out for the first unit, as shown above by the long-dashed lines in Figure 2.[31] Of course, it will eventually plateau out as the credit constraint becomes not binding at a sufficiently large size of land endowment.

For $A_e \in [A_e^m, A_e^{in}]$, however, the intensity of attached capital investments demanded on the endowed land under self-cultivation will be invariant to the size of land endowment as landed agents of this category face the same constant marginal cost of the effective labor input, namely wage rate. Given the constant leverage ratio of the accessible credit for attached capital investments, the shadow price of the accessible credit will be invariant to the size of land endowment as well. So will the marginal cost of attached capital investments on the first unit of the endowed land to be rented out. Under the C.R.S. production technology, the marginal output revenue of the endowed land to be rented out for the first unit will then be a positive constant for $A_e \in [A_e^m, A_e^{in}]$, regardless of the size of land endowment. So will the marginal return of the endowed land to be rented out for the first unit. This constant pattern also applies to the case of $A_e < A_e^m$ when landed agents have no accessible credit to make attached capital investments, although the return level will be lower.

Put everything together, both the marginal return of the endowed land under self-cultivation and the marginal return of the endowed land to be rented out for the first unit will follow the same constant patterns for $A_e \leq A_e^{in}$. But the former will be always higher than the latter as renting out land will only increase the protection and capital depreciation cost rates but not the efficiency of the labor input on the endowed land when self-cultivating all the endowed land does

on the endowed land under self-cultivation and thus keep decreasing afterwards.

[29] It will become clear later that this assumption is not essential for the main findings in this paper.

[30] The marginal cost of the effective labor input on the rented-out land always equals wage rate. See Lemma 1.

[31] Like the marginal return of the endowed land under self-cultivation, the marginal return of the endowed land to be rented out for the first unit is defined as the marginal output revenue of the endowed land to be rented out for the first unit minus its unit protection cost. Again, the unit protection cost is fixed at a given security level of land endowment, although it is higher than that for the endowed land under self-cultivation.

not consume all the endowed labor. For $A_e > A_e^{in}$, however, self-cultivating all the endowed land will consume all the endowed labor and involve the usage of the inefficient hired labor. Then, the marginal cost of the effective labor input will keep increasing due to the rising agency cost of hired labor caused by the decreasing supervision intensity. As a result, the marginal return of the endowed land under self-cultivation will keep decreasing. In contrast, the marginal return of the endowed land to be rented out for the first unit will keep increasing until the shadow price of the accessible credit for attached capital investments stops decreasing after the credit constraint becomes not binding at a sufficiently large size of land endowment.[32] Based on these opposite patterns, I obtain the following proposition about the threshold of renting out land, denoted by A_e^{out}.

Proposition II*: There exists a unique size of land endowment A_e^{out} above which agents will start renting out land at a given security level of land endowment.*

Fundamentally, renting out land brings both gain and loss in the marginal return of the endowed land to large landed agents who have the accessible credit for attached capital investments but suffer from the agency cost of hired labor. The gain comes from the relatively lower marginal cost of the effective labor input on the rented-out land as tenants only use family labor but not the less efficient hired labor to cultivate the rented land. The loss comes from the relatively higher unit cost of protecting the rented-out land and its attached capital investments as renting out land raises the risk of losing the endowed land and its attached capital investments. The moral hazard of tenants not taking care of landlords' land-attached capital also contributes to the loss in the marginal return of the endowed land as it raises the capital depreciation rate.

The analyses before Proposition II show that the larger the size of land endowment is, the larger the gain will be relative to the loss at a given security level of land endowment. As a result, a landed agent will rent out land if her or his size of land endowment exceeds the threshold of renting out land A_e^{out} at which the gain just equals the loss. In the next section, I will build on this

[32] When landed agents do not invest attached capital in the endowed land to be rented out due to a super high capital depreciation rate, the marginal return of the endowed land to be rented out for the first unit will instead stay constant for $A_e > A_e^{in}$. Nevertheless, Proposition II above still holds true as the marginal return of the endowed land under self-cultivation will always keep decreasing for $A_e > A_e^{in}$ as the size of land endowment increases, even if landed agents do not invest attached capital in the endowed land under self-cultivation, either.

equality condition to study the interaction between the investment effect of higher land ownership security and the concurrent rental-supply effect through the lens of individual land rental supply.

4 Land Rental Supply at Higher Land Ownership Security

In this section, I study land rental supply at higher land ownership security, holding prices constant. First of all, I present the main results using the threshold of renting out land defined above in section 3. Then, I use the first-order condition for the optimal land allocation made by a landlord to explain the economics behind them. These analyses help us understand to what extent securing land ownership can increase land rental supply in the presence of multiple market failures, especially the moral hazard of tenants not taking care of landlords' land-attached capital.

4.1 Main Results

As shown below in Figure 3, both the marginal return of the endowed land under self-cultivation and the marginal return of the endowed land to be rented out for the first unit will become higher at any given size of land endowment for a higher security level of land endowment, holding prices constant. Higher land ownership security raises these marginal returns as it reduces the unit cost of protecting the endowed land and its attached capital investments. Agents endowed with land of size below the minimum size of land collateral required for access to credit A_e^m will only capture the benefit of a lower unit cost of protecting the endowed land as they do not have accessible credit to make attached capital investments. Agents endowed with land of size above A_e^m, however, will additionally capture the benefit of a lower unit cost of protecting attached capital investments by using the increased accessible credit to make more investments. Hence, they witness larger gains in these marginal returns than the other landed agents who have no access to credit.

The higher intensity of attached capital investments will demand a higher intensity of labor input due to their complementarity in the farm production. Then, self-cultivating all the endowed land at higher land ownership security will consume all the endowed labor at a smaller size of land endowment for landed agents having access to credit, holding prices constant, i.e., the threshold of renting in land A_e^{in} will become smaller at a higher security level of land endowment, as shown below in Figure 3.[33] However, whether the threshold of renting out land A_e^{out} will also become smaller or not and to what extent depend on the increase in the marginal return of the endowed land to be rented out for the first unit relative to the increase in the marginal return of the endowed land under self-cultivation. As formally studied in the next subsection, the moral hazard of tenants not taking care of landlords' land-attached capital, resulting from non-security barriers to long-term land rental contracts, plays a critical role in modulating the relative increase in these marginal returns through the investment effect of higher land ownership security.

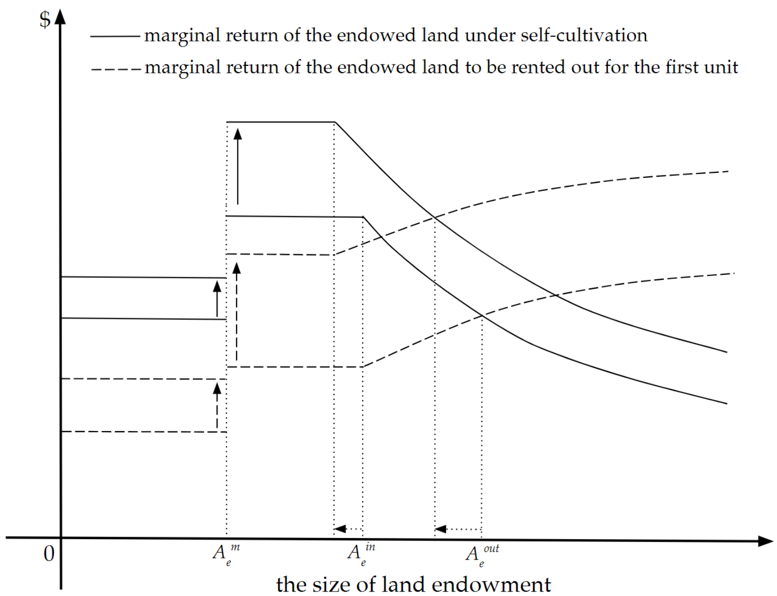

Figure 3: Thresholds of Renting in and out Land at a Higher Security Level of Land Endowment.

Note: (i) The marginal return of the endowed land is defined as the marginal output revenue of the endowed land minus its unit protection cost, where the unit protection cost only depends on the security level of land endowment. For all landed agents, higher land ownership security will reduce the unit cost of protecting the endowed land. For landed agents having access to credit, it will also raise the marginal output revenue of the endowed land by increasing their attached capital investments. Thus, they will witness relatively larger increases in the two marginal returns of the endowed land listed above in the figure. See the text for detailed discussions about the relative increases of these two marginal returns. (ii) A_e^m is the minimum size of land collateral required for access to credit, i.e., an agent endowed with land of size below A_e^m will have no accessible credit to make investments. (iii) A_e^{in} is the threshold of renting in land, the size of land endowment above which landed agents stop renting in land. (iv) A_e^{out} is the threshold of renting out land, the size of land endowment above which landed agents start renting out land.

[33] As shown in the previous section, the marginal return of the endowed land to be rented out for the first unit is always smaller than the marginal return of the endowed land under self-cultivation at any size of land endowment below the threshold of renting in land A_e^{in} where self-cultivating all the endowed land just consumes all the endowed labor at its opportunity cost wage rate. That is, landed agents will always use the endowed labor to self-cultivate the endowed land before using it to cultivate any rented-in land.

As shown below in Figure 4, there are two types of barriers to the even distribution of attached capital investments between the self-cultivated and rented-out land, represented by the protection cost rate gap and the capital depreciation rate gap. On the one hand, renting out land raises the risk of losing the insecure endowed land and its attached capital investments and thus the unit cost of protecting them. Higher land ownership security will reduce this protection cost rate gap between the rented-out and self-cultivated land. On the other hand, the moral hazard of tenants not taking care of landlords' land-attached capital generates the capital depreciation rate gap between the rented-out and self-cultivated land. Higher land ownership security, however, does not help close this gap as it comes from non-security barriers to long-term land rental contracts.

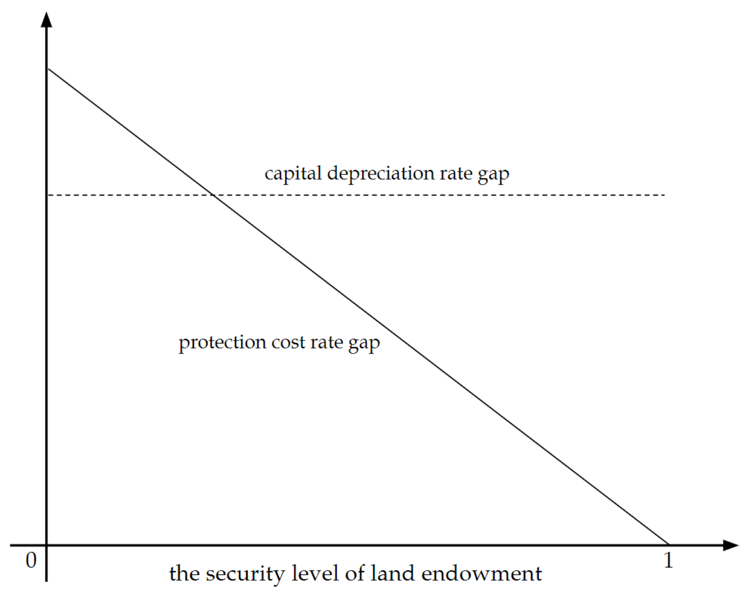

Figure 4: The Two Types of Barriers to the Even Distribution of Attached Capital Investments between the Rented-out and Self-cultivated Land.

Note: (i) The protection rate gap between the rented-out and self-cultivated land captures the security barrier to the even distribution of attached capital investments, namely insecure land ownership. (ii) The capital depreciation rate gap between the rented-out and self-cultivated land captures the non-security barrier to the even distribution of attached capital investments, namely the moral hazard of tenants not taking care of landlords' land-attached capital.

The economic analyses in the next subsection show that the invariant capital depreciation rate gap induces landed agents having access to credit to increase attached capital investments on the self-cultivated land more than that on the rented-out land at higher land ownership security, which tends to surpass the opposite investment effect induced by the smaller protection cost rate gap. This bias of the investment effect of higher land ownership security favors self-cultivation. In contrast, the smaller protection cost rate gap reduces the unit cost of protecting the rented-out land relatively more and thus favors renting out land (the rental-supply effect of higher land ownership security). Hence, the marginal return of the endowed land under self-cultivation may not necessarily witness a smaller increase than the marginal return of the endowed land to be rented out for the first unit. Then, the threshold of renting out land A_e^{out} may not decrease at a higher security level of land endowment as expected.

Nevertheless, the threshold of renting out land A_e^{out} will decrease at a higher security level of land endowment if the moral hazard of tenants not taking care of landlords' land-attached capital is not severe so that the marginal return of the endowed land to be rented out for the first unit witnesses a larger increase than the marginal return of the endowed land under self-cultivation. In the ideal case when the moral hazard of tenants not taking care of landlords' land-attached capital is absent, the threshold of renting out land A_e^{out} will witness a larger reduction than the threshold of renting in land A_e^{in}, as shown above in Figure 3. Eventually, A_e^{out} will coincide with A_e^{in} at the highest security level of land endowment (fully secure) where renting out land will neither raise the unit cost of protecting the endowed land and its attached capital investments nor increase the depreciation rate of the attached capital invested in the endowed land. This means that each agent endowed with land of size above A_e^{in} will rent out land of an enough size to get around the agency cost of hired labor and invest the same intensity of attached capital in the rented-out land as that in the self-cultivated land if land ownership is fully secure.

The moral hazard of tenants not taking care of landlords' land-attached capital, however, will dampen the foregoing pro-egalitarian improvement in the distribution of complementary production factors (land, attached capital, and labor). First of all, it will discourage agents endowed with land of size above the threshold of renting in land from renting out land, regardless of land ownership security, as it lowers the marginal return of the endowed land to be rented out by raising the capital depreciation rate. As shown below in Figure 5, thresholds of renting out land at different security levels of land endowment (the short-dashed lines) will become larger than those (the long-dashed line) in the ideal case when the moral hazard of tenants not taking care of landlords' land-attached capital is not present, holding prices constant. That is, less landed agents will rent out land.

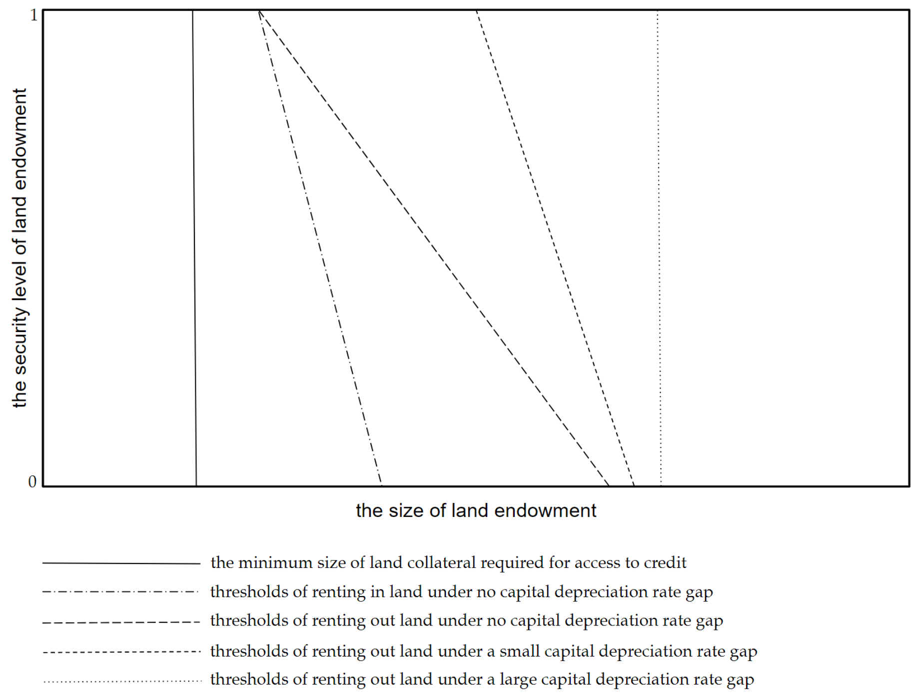

Figure 5: The Role of the Moral Hazard of Tenants not Taking Care of Landlords' Land-attached Capital in the Threshold of Renting out Land.

Note: (i) On the left of the figure, "0" means the lowest land ownership security, whereas "1" means the highest, namely no risk of losing the endowed land and its attached capital investments. (ii) The size of the capital depreciation rate gap between the rented-out and self-cultivated land captures the severity of the moral hazard of tenants not taking care of landlords' land-attached capital. (iii) The long-dashed line collates the thresholds of renting out land at different security levels of land endowment in the case when the moral hazard of tenants not taking care of landlords' land-attached capital is not present. (iv) The inclined short-dashed line represents the case when the moral hazard of tenants not taking care of landlords' land-attached capital is moderate so that the threshold of renting out land still decreases but less at a higher security level of land endowment. (v) The vertical short-dashed line represents the case when the moral hazard of tenants not taking care of landlords' land-attached capital is severe such that the threshold of renting out land remains unchanged at a higher security level of land endowment.

More importantly, the threshold of renting out land may decrease less at a higher security level of land endowment (on the inclined short-dashed line) as the moral hazard of tenants not taking care of landlords' land-attached capital induces the bias of the investment effect towards the endowed land to be self-cultivated. It may even not decrease at all (on the vertical short-dashed line) if the moral hazard of tenants not taking care of landlords' land-attached capital is severe enough. This means that higher land ownership security may not necessarily induce more landed agents to rent out land, holding prices constant. The next subsection shows that it may not necessarily encourage preexisting landlords to rent out more land, either. In sum, the moral hazard of tenants not taking care of landlords' land-attached capital tends to attenuate the rental-supply effect of higher land ownership security through the concurrent investment effect that favors self-cultivation.

4.2 Economic Analyses

In this subsection, I demonstrate how the moral hazard of tenants not taking care of landlords' land-attached capital can attenuate the rental-supply effect of higher land ownership security by inducing the bias of the concurrent investment effect towards the endowed land to be self-cultivated. For readability, I only present economic reasoning here and put all the math in Appendix C and D. There are two variables of interest: (i) the threshold of renting out land (the size of land endowment above which landed agents start renting out land); and (ii) the optimal size of the self-cultivated land (the size of the endowed land minus the optimal size of the rented-out land). Their responsivenesses to land ownership security tell us how higher land ownership security will affect the renting-out behaviors of landed agents at the extensive and intensive margins, respectively.

To proceed, let me introduce Lemma 2 below. It says that the moral hazard of tenants not taking care of landlords' land-attached capital induces the bias of the investment effect of higher land ownership security towards the endowed land to be self-cultivated. As shown later, this bias of the investment effect tends to attenuate the concurrent rental-supply effect.

Lemma 2*: When the moral hazard of tenants not taking care of landlords' land-attached capital is present, landed agents at the extensive and intensive margins of renting out land tend to increase the intensity of attached capital investments on the self-cultivated land more than that on the rented-out land at higher land ownership security, holding other things constant.*

In section 3, I have shown that landlords are among landed agents who have access to credit. *As before, I assume that they invest attached capital in the self-cultivated and rented-out land.*[34] However, as shown below in Figure 6, a landlord will invest a relatively lower intensity of attached capital in the rented-out land at a given security level of land ownership $S_e < 1$ (insecure), namely $k_t^{out} < k_o$, since the (per-period) marginal cost of attached capital investments on the rented-out land $d_t + c_t(S_e) + i(1+\mu)$ is higher than that on the self-cultivated land $d_o + c_o(S_e) + i(1+\mu)$.[35]

[34] Lemma 2 will mechanically hold true if landlords do not invest attached capital in the rented-out land.

[35] I assume that the relatively higher marginal return or output revenue of attached capital investments on the rented-out land, resulting from the relatively higher efficiency of the labor input on the rented-out land, does not alter the incentives of a landlord to invest a relatively lower intensity of attached capital in the rented-out land.

Renting out land invokes the moral hazard of tenants not taking care of landlords' land-attached capital, which induces a higher capital depreciation rate, namely $d_t > d_o$. Renting out land also raises the risk of losing the endowed land and its attached capital investments, which induces a higher protection cost rate, namely $c_t(S_e) > c_o(S_e)$. Nevertheless, attached capital investments on the rented-out and self-cultivated land share the same shadow price of the accessible credit $i(1+\mu)$, where μ denotes the shadow value of relaxing the credit constraint.

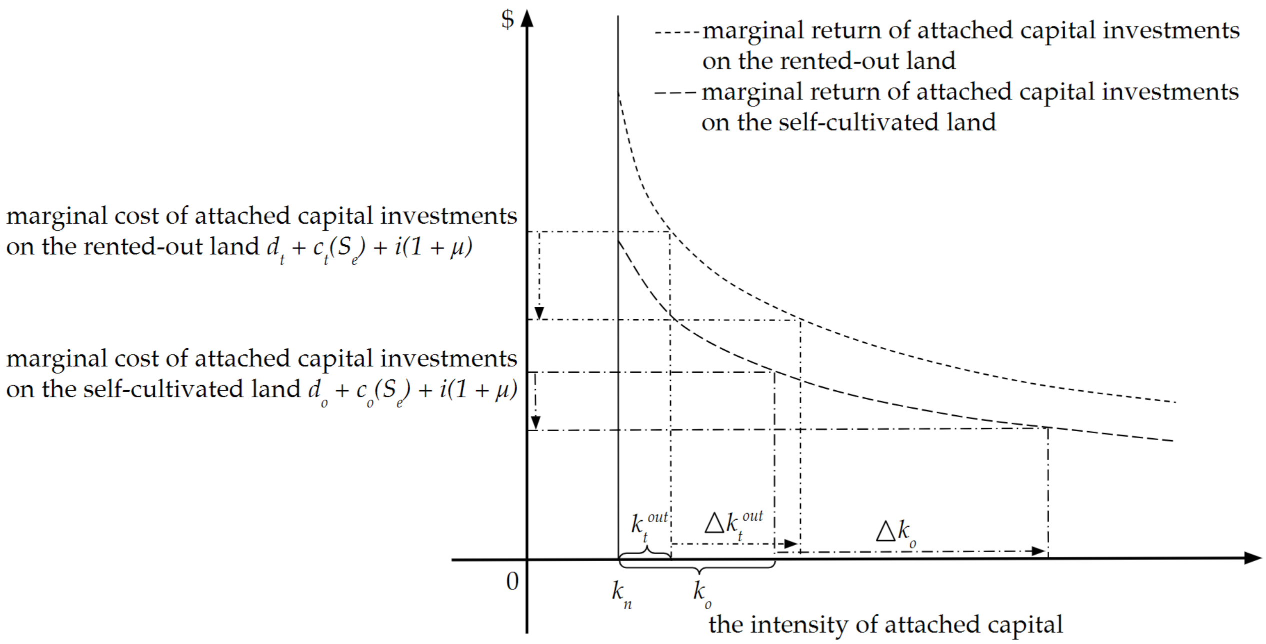

Figure 6: The Bias of the Investment Effect of Higher Land Ownership Security.

Note: Here, k_n denotes the intensity of the natural attached capital embedded in the endowed land, which is small. For illustration purposes, I assume that landed agents at the extensive and intensive margins of renting out land invest attached capital in both the self-cultivated and rented-out land, i.e., the marginal returns of attached capital investments on both the self-cultivated and rented-out land, evaluated at k_n, are larger than their marginal costs. Hence, we have positive intensities of attached capital investments on both the self-cultivated and rented-out land before the security improvement, namely $k_o > 0$ and $k_t^{out} > 0$. At a given intensity of attached capital, the marginal return or output revenue of attached capital investments on the rented-out land is higher than that on the self-cultivated land. This results from the relatively higher efficiency of the labor input on the rented-out land and the complementarity between attached capital and labor in the farm production. The arrows above show the effects of higher land ownership security on attached capital investments and their marginal costs. See detailed explanations about these effects in the main text above.

Holding other things constant, higher land ownership security will decrease the marginal costs of attached capital investments on the self-cultivated and rented-out land as it lowers their protection cost rates, namely $c_t'(S_e) < 0$ and $c_o'(S_e) < 0$. The increase in the accessible credit resulting from a higher leverage ratio, namely $\theta'(S_e) > 0$, will also lower these marginal costs of attached capital investments by reducing the shadow value of relaxing the credit constraint μ. Then, as shown above in Figure 6, a landlord tends to increase attached capital investments on the self-cultivated land more than that on the rented-out land, namely $\Delta k_o > \Delta k_t^{out}$, given $k_o > k_t^{out}$ and the diminishing marginal return of attached capital investments. This is particularly true when the decrease in the protection cost rate gap between the rented-out and self-cultivated land $c_t'(S_e) - c_o'(S_e)$ is not too large, the capital depreciation rate gap between the rented-out and self-cultivated land $d_t - d_o$ is not too small, and the increase in the accessible credit is nontrivial. Based on this bias of the investment effect of higher land ownership security, I obtain the following two propositions.

Proposition III*: Higher land ownership security may not necessarily decrease the threshold of renting out land A_e^{out} when the moral hazard of tenants not taking care of landlords' land-attached capital is present, holding prices constant.*

Proposition IV*: Higher land ownership security may not necessarily decrease the optimal size of the self-cultivated land A_o^* for a preexisting landlord when the moral hazard of tenants not taking care of landlords' land-attached capital is present, holding prices constant.*

Propositions III and IV are about the effect of higher land ownership security on the land rental supply at the extensive and intensive margins, respectively. At these margins, the marginal return of the endowed land to be self-cultivated should equal the marginal return of the endowed land to be rented out. The associated first-order condition for the optimal land allocation is as follows:[36]

$$p\frac{\partial F^o}{\partial A} + p\frac{\partial F^o}{\partial K}k_n - c_o(S_e)\frac{r(k_n)}{i} = p\frac{\partial F^t}{\partial A} + p\frac{\partial F^t}{\partial K}k_n - c_t(S_e)\frac{r(k_n)}{i}, \qquad (6)$$

where F^o denotes the output produced on the self-cultivated land, F^t denotes the output produced on the rented-out land, A and K denote raw land and attached capital, respectively.[37] On each side, the first two terms represent the marginal output revenue of the endowed land (raw land plus its natural attached capital) while the third term represents the unit cost of protecting the endowed land.

[36] See the corresponding first-order conditions for the optimal allocations of credit and labor in Appendix C.

[37] Specifically, we have $F^o = F(A_o, A_o k_o + A_o k_n, L_o)$ and $F^t = F(A_t^{out}, A_t^{out} k_t^{out} + A_t^{out} k_n, L_f^t)$ with L_f^t denoting the family labor input provided by the tenant.

To simplify notations, I denote MR^o and MR^t as the marginal output revenues of the self-cultivated and rented-out land, respectively, i.e., $MR^o = p\frac{\partial F^o}{\partial A} + p\frac{\partial F^o}{\partial K}k_n$ and $MR^t = p\frac{\partial F^t}{\partial A} + p\frac{\partial F^t}{\partial K}k_n$.

On the one hand, higher land ownership security reduces the risk of losing the endowed land, either self-cultivated or rented out, and thus the associated protection cost rates, namely $c_o'(S_e) < 0$ and $c_t'(S_e) < 0$. Importantly, renting out land will raise the unit cost of protecting the endowed land by a smaller amount than before, namely $c_t'(S_e)\frac{r(k_n)}{i} - c_o'(S_e)\frac{r(k_n)}{i} < 0$. This will incentivize a landed agent to rent out (more) land, holding other things constant, given that renting out (more) land will help her or him reduce the inefficient hired labor input on the endowed land.

On the other hand, higher land ownership security also reduces the risk of losing attached capital investments and raises the accessible credit. As explained before, these improvements will incentivize a landed agent to increase attached capital investments on the endowed land, either self-cultivated or rented out, by lowering the associated marginal costs, holding other things constant. However, Lemma 2 tells us that this investment effect of higher land ownership security will be biased towards the self-cultivated land when the moral hazard of tenants not taking care of landlords' land-attached capital is present. Then, the marginal output revenue of the self-cultivated land may witness a larger increase than the marginal output revenue of the rented-out land, namely $\frac{\partial MR^o}{\partial S_e} > \frac{\partial MR^t}{\partial S_e}$, as attached capital complements land in the farm production.[38]

In sum, higher land ownership security may bring about two offsetting effects on land rental supply when the moral hazard of tenants not taking care of landlords' land-attached capital is present.[39] The investment effect tends to attenuate the concurrent rental-supply effect as it is biased towards the endowed land to be self-cultivated. The more severe the moral hazard of tenants not taking care of landlords' land-attached capital is, the larger the bias of the investment effect will be, leading to a larger attenuation of the concurrent rental-supply effect.

[38]Admittedly, whether a relatively larger increase in attached capital investments on the self-cultivated land will lead to a relatively larger increase in the marginal output revenue of the self-cultivated land largely depends on the easiness of credit access. For instance, the self-cultivated land might not necessarily witness a relatively larger increase in its marginal output revenue if its relatively larger increase in attached capital investments is small in the absolute amount due to limited credit access or equivalently a small leverage ratio in the model. The reason is that the relatively lower efficiency of the labor input on the self-cultivated land, resulting from the agency cost of hired labor, downsizes the contribution of attached capital investments to the marginal output revenue of the self-cultivated land relative to the marginal output revenue of the rented-out land as labor, attached capital and land complement each other in the farm production. See the numerical evidence in the follow-up paper (*forthcoming*).

[39]See the associated comparative statics of renting out land at the extensive and intensive margins in Appendix D.

5 Conclusion

This paper studies the contemporaneous interaction between the investment and rental-supply effects of higher land ownership security, which has long been ignored in the economic literature. Based on a novel agricultural household model, I find that the moral hazard of tenants not taking care of landlords' land-attached capital, resulting from non-security barriers to long-term land rental contracts, can attenuate the rental-supply effect as it induces the bias of the concurrent investment effect towards the endowed land to be self-cultivated. The attenuated rental-supply effect will limit the improvement in land access for the poor. It will also limit the scope of large landowners to reduce the inefficient hired labor input on the self-cultivated land, which tends to restrict the increase in attached capital investments as labor complements attached capital in the farm production. Hence, securing land ownership may not generate sizable gains in both agricultural output and poverty reduction for an unequal agrarian economy as expected.

The new theory proposed in this paper deepens our understanding of how securing land ownership will affect resource allocation and social welfare in the presence of multiple market failures. Without the moral hazard of tenants not taking care of landlords' land-attached capital, securing land ownership would help get around the agency cost of hired labor and the credit rationing of small landowners by facilitating the egalitarian distribution of the operational land among heterogeneous agents in land endowment and the even distribution of attached capital investments between the self-cultivated and rented-out land. But the moral hazard of tenants not taking care of landlords' land-attached capital will dampen these double-efficiency improvements in resource allocation, which will downsize the welfare gains for an agrarian economy endowed with unequal land ownership distribution, especially the welfare gain for the poor, as evidenced by the simulated equilibrium welfare impacts of securing land ownership in the follow-up paper.

Admittedly, the new agricultural household model introduced here does not incorporate several relevant features of modern agriculture. For instance, machine, a salient agricultural input even in developing countries, which often substitutes labor and favors large farms due to economies of scale (e.g., Sheng et al., 2019; Foster and Rosenzweig, 2022), is completely missing in the current model. It may induce a U-shape relationship between the unit return of land and farm size and thus change the donor pool of landlords, e.g., landlords may be only among landowners with medium sizes of land endowment. Then, securing land ownership may only mildly increase land rental supply even without the moral hazard of tenants not taking care of landlords' land-attached capital, as the set of landowners who may rent out (more) land at higher land ownership security is small.[40]

However, adding the input of machine into the model will not alter the attenuation of the rental-supply effect from the concurrent investment effect of higher land ownership security. This is because the latter effect will still be biased towards the endowed land to be self-cultivated as long as the moral hazard of tenants not taking care of landlords' land-attached capital is present. The same argument also applies to the modern value chain through which larger farms receive higher output prices (e.g., Henderson and Isaac, 2017).

Last but not least, I do not consider the sectoral labor allocation, either, through which securing land ownership can notably affect agricultural output and labor income in an agrarian economy or the agriculture sector (e.g., de Janvry et al., 2015; Chen, 2017; Gottlieb and Grobovšek, 2019). However, how it will interact with land and capital allocations within the agriculture sector remains unclear. So does how their interactions will affect the welfare gains of securing land ownership for an unequal economy as a whole, which I leave for future research.[41]

[40] On the other hand, landowners endowed with super large sizes of land may even consolidate land through land rental or sales markets if it is profitable to expand the farm size beyond land endowment due to economies of scale in machines or other movable capital inputs. Then, the land-poor including the landless may only be able to rent in land of smaller sizes, further limiting their income gains.

[41] The existing literature mostly focuses on the interaction of land and labor allocations and its effect on the output and income gains generated from the improvement in land tenure security. See a comprehensive review conducted by Deininger et al. (2022). Recently, Adamopoulos et al. (2022) found that the idiosyncratic friction in the rural capital market reduces the aggregate agricultural productivity in China by causing resource misallocation across farmers and labor misallocation across sectors under insecure land tenure. Unlike rural China, land ownership distributions in rural areas of LAC are highly unequal. Importantly, the friction in the rural capital market there tends to be systematic, given the land collateral requirement for credit access.

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Appendices

Appendix A. The first-order conditions for the optimal resource allocation made by an arbitrary agent

The first-order optimality conditions below will be used in later appendices, which supplement the analyses above in the main text. To proceed, I obtain the following Lagrangian for the UMP above in subsection 2.2.

$$\begin{aligned}
\mathcal{L} = \frac{1}{i}\Big\{&\pi_o(A_o, k_o, L_o) + \pi_t^{out}(A_t^{out}, k_t^{out}) + \pi_t^{in}(A_t^{in}, k_t^{in}, L_t^{in}) + (wL_h^{out} - wL_h^{in})\Big\} - (A_o k_o + A_t^{out} k_t^{out}) \\
&- \lambda(A_o + A_t^{out} - A_e) \\
&- \mu[A_o k_o + A_t^{out} k_t^{out} - I_{\{A_e \geq A_e^m\}} A_e \theta(S_e)] \\
&- \nu[L_o + L_t^{in} - L(L_f, L_h^{in})] \\
&- \xi(L_f + L_h^{out} - 1) \\
&+ \zeta_o A_o + \zeta_t^{out} A_t^{out} + \zeta_t^{in} A_t^{in} \\
&+ \delta_o k_o + \delta_t^{out} k_t^{out} + \delta_t^{in} k_t^{in} \\
&+ \chi_o L_o + \chi_t^{in} L_t^{in} + \psi L_f + \phi L_h^{out} + \eta L_h^{in},
\end{aligned}$$

where λ, μ, ν, and ξ are the Lagrangian multipliers for constraints (1)-(4), respectively, while ζ's, δ's, χ's, ψ, ϕ, and η are the Lagrangian multipliers for the nonnegativity requirement on the eleven choice variables summarized in constraint (5). Then, the first-order conditions for the optimal resource allocation are:

(7) $\frac{\partial \mathcal{L}}{\partial A_o} : \frac{1}{i}\frac{\partial \pi_o}{\partial A_o} - \lambda - (1+\mu)k_o + \zeta_o = 0;$

(8) $\frac{\partial \mathcal{L}}{\partial k_o} : \frac{1}{i}\frac{\partial \pi_o}{\partial k_o} - (1+\mu)A_o + \delta_o = 0;$

(9) $\frac{\partial \mathcal{L}}{\partial L_o} : \frac{1}{i}\frac{\partial \pi_o}{\partial L_o} - \nu + \chi_o = 0;$

(10) $\frac{\partial \mathcal{L}}{\partial A_t^{out}} : \frac{1}{i}\frac{\partial \pi_t^{out}}{\partial A_t^{out}} - \lambda - (1+\mu)k_t^{out} + \zeta_t^{out} = 0;$

(11) $\frac{\partial \mathcal{L}}{\partial k_t^{out}} : \frac{1}{i}\frac{\partial \pi_t^{out}}{\partial k_t^{out}} - (1+\mu)A_t^{out} + \delta_t^{out} = 0;$

(12) $\frac{\partial \mathcal{L}}{\partial A_t^{in}}: \frac{1}{i}\frac{\partial \pi_t^{in}}{\partial A_t^{in}} + \zeta_t^{in} = 0;$

(13) $\frac{\partial \mathcal{L}}{\partial k_t^{in}}: \frac{1}{i}\frac{\partial \pi_t^{in}}{\partial k_t^{in}} + \delta_t^{in} = 0;$

(14) $\frac{\partial \mathcal{L}}{\partial L_t^{in}}: \frac{1}{i}\frac{\partial \pi_t^{in}}{\partial L_t^{in}} - \nu + \chi_t^{in} = 0;$

(15) $\frac{\partial \mathcal{L}}{\partial L_f}: \nu\frac{\partial L}{\partial L_f} - \xi + \psi = 0;$

(16) $\frac{\partial \mathcal{L}}{\partial L_h^{out}}: \frac{1}{i}w - \xi + \phi = 0;$

(17) $\frac{\partial \mathcal{L}}{\partial L_h^{in}}: -\frac{1}{i}w + \nu\frac{\partial L}{\partial L_h^{in}} + \eta = 0;$

(18) $\lambda \geq 0,\ A_o + A_t^{out} \leq A_e,\ \lambda(A_o + A_t^{out} - A_e) = 0;$

(19) $\mu \geq 0,\ A_o k_o + A_t^{out}k_t^{out} \leq I_{\{A_e > A_e^m\}}A_e\theta(S_e),\ \mu[A_o k_o + A_t^{out}k_t^{out} - I_{\{A_e > A_e^m\}}A_e\theta(S_e)] = 0;$

(20) $\nu \geq 0,\ L_o + L_t^{in} \leq L(L_f, L_h^{in}),\ \nu[L_o + L_t^{in} - L(L_f, L_h^{in})] = 0;$

(21) $\xi \geq 0,\ L_f + L_h^{out} \leq 1,\ \xi(L_f + L_h^{out} - 1) = 0; and$

(22)$\{\zeta_o, A_o, \zeta_t^{out}, A_t^{out}, \zeta_t^{in}, A_t^{in}, \delta_o, k_o, \delta_t^{out}, k_t^{out}, \delta_t^{in}, k_t^{in}, \chi_o, L_o, \chi_t^{in}, L_t^{in}, \psi, L_f, \phi, L_h^{out}, \eta, L_h^{in}\} \geq 0,$

$\{\zeta_o A_o, \zeta_t^{out}A_t^{out}, \zeta_t^{in}A_t^{in}, \delta_o k_o, \delta_t^{out}k_t^{out}, \delta_t^{in}k_t^{in}, \chi_o L_o, \chi_t^{in}L_t^{in}, \psi L_f, \phi L_h^{out}, \eta L_h^{in}\} = 0.$

Appendix B. Properties of the land rental rate schedule

In this appendix, I derive properties of the land rental rate schedule based on the first-order conditions above, which have been used to prove Lemma 1 in section 3. Note that the properties outlined below do not pin down the land rental rate schedule which exact value also depends on the wage rate in the labor market, although I use some necessary equilibrium conditions to derive these properties. In other words, the properties derived here tell us the relationship between the land rental rate schedule and wage rate but not their exact values in equilibrium.

First of all, we always have the size of the land to be rented in $A_t^{in} > 0$ at the optimum for a tenant. Thus, we have the associated Lagrangian multiplier $\zeta_t^{in} = 0$ in the first-order condition (12) above. Also, we always have $L_t^{in} > 0$ for a tenant and thus its associated Lagrangian multiplier $\chi_t^{in} = 0$ in the first-order condition (14) above. The reason is that it is always profitable to have the first unit of the effective labor input on the rented-in land at a finite wage rate w given the infinite marginal return of the effective labor input on the rented-in land for the first unit. Now, let us rewrite the first-order conditions (12)-(14) above as follows, given $\pi_t^{in}(A_t^{in}, k_t^{in}, L_t^{in}) = pF(A_t^{in}, A_t^{in}k_t^{in} + A_t^{in}k_n, L_t^{in}) - A_t^{in}r(k_t^{in} + k_n)$.

(23) $\frac{1}{i}\frac{\partial \pi_t^{in}}{\partial A_t^{in}} = 0$: $p\frac{\partial F}{\partial A}|_{A=A_t^{in}} + p\frac{\partial F}{\partial K}|_{K=A_t^{in}k_t^{in}+A_t^{in}k_n}(k_t^{in}+k_n) = r(k_t^{in}+k_n)$;

(24) $\frac{1}{i}\frac{\partial \pi_t^{in}}{\partial k_t^{in}} + \delta_t^{in} = 0$: $p\frac{\partial F}{\partial K}|_{K=A_t^{in}k_t^{in}+A_t^{in}k_n} \leq \frac{dr}{dk_t^{in}} = r'(k_t^{in}+k_n)$ with the equality for $k_t^{in} > 0$;

(25) $\frac{1}{i}\frac{\partial \pi_t^{in}}{\partial L_t^{in}} - \nu = 0$: $p\frac{\partial F}{\partial L}|_{L=L_t^{in}} = i\nu$.

Condition (23) says that the marginal return of the land to be rented in (including its attached capital investments made by its owner) equals the rental rate for that land (during each production period). Under the C.R.S. production technology, it means that a tenant will just earn the return of the effective labor input on the rented-in land as they only provide the effective labor input, i.e.,

$$\pi_t^{in}(A_t^{in}, k_t^{in}, L_t^{in}) = p\frac{\partial F}{\partial A}A_t^{in} + p\frac{\partial F}{\partial K}[A_t^{in}(k_t^{in}+k_n)] + p\frac{\partial F}{\partial L}L_t^{in} - r(k_t^{in}+k_n)A_t^{in} = p\frac{\partial F}{\partial L}L_t^{in}.$$

In the following, I will show that the marginal return of the effective labor input on the rented-in land, namely $p\frac{\partial F}{\partial L}|_{L=L_t^{in}}$, should always equal wage rate w in the competitive equilibrium of land rental and labor markets. Note that condition (23) is equivalent to the following equality condition under the C.R.S. production technology:

$$pF(1, k_t^{in}+k_n, l_t^{in}) - pF_l(1, k_t^{in}+k_n, l_t^{in})l_t^{in} = r(k_t^{in}+k_n),$$

where l_t^{in} denotes the intensity of the effective labor input and $F_l(1, k_t^{in}+k_n, l_t^{in})$ denotes the marginal return of the effective labor input $p\frac{\partial F}{\partial L}|_{L=L_t^{in}}$.[42]

For a given type of the land to be rented in, measured by the intensity of attached capital investments made by its owner k_t^{in}, the marginal return of the land to be rented in on the left-hand side increases at a higher intensity of the effective labor input l_t^{in} due to the diminishing marginal return of the effective labor input. The rental rate for that type of land on the right-hand side, however, is a positive constant. Hence, there exists a unique intensity of the effective labor input l_t^{in}

[42]Under the C.R.S. production technology, we have:

$$F(A_t^{in}, A_t^{in}k_t^{in}+A_t^{in}k_n, L_t^{in}) = A_t^{in}F(1, k_t^{in}+k_n, l_t^{in}) = A_t^{in}\Big[\frac{\partial F}{\partial A}|_{A=A_t^{in}} + F_k(1, k_t^{in}+k_n, l_t^{in})(k_t^{in}+k_n) + F_l(1, k_t^{in}+k_n, l_t^{in})l_t^{in}\Big],$$

where $F_k(1, k_t^{in}+k_n, l_t^{in})$ denotes the marginal return of attached capital investments.

such that the left-hand side equals the right-hand side. That is, the intensity of the effective labor input l_t^{in} will be the same at the optimum for all the tenants who rent in the same type of land. So will the marginal return of the effective labor input on that type of land $pF_l(1, k_t^{in} + k_n, l_t^{in})$ or equivalently $p\frac{\partial F}{\partial L}|_{L=L_t^{in}}$.

Next, I will show that the marginal return of the effective labor input on any type of the land to be rented in should equal wage rate at the optimum in the competitive equilibrium, i.e., $p\frac{\partial F}{\partial L}|_{L=L_t^{in}} = w, \forall k_t^{in} \geq 0$. Without loss of generality, suppose that both land rental and labor markets are active in the competitive equilibrium. That is, both markets have positive supply and demand and they equal each other at some wage rate w and land rental rate schedule $r(\cdot)$.

On the one hand, if the marginal return of the effective labor input on some type of the land to be rented in is smaller than wage rate w, then tenants who rent in that type of land will either change to rent in another type of land instead or hire out labor in the labor market. The reason is that the marginal cost of the effective labor input, namely $i\nu$ in condition (25), is no less than wage rate w as one unit of labor, either family labor or hired labor, can only produce one unit of effective labor at most. This contradicts the premise that the land rental market is in equilibrium.

On the other hand, if the marginal return of the effective labor input on some type of the land to be rented in is larger than wage rate w, then all laborers in the labor market will change to rent in that type of land in the land rental market instead of hiring out labor. For instance, by using family labor to cultivate that type of the land to be rented in, they can earn a higher labor return than wage rate as one unit of family labor produces one unit of effective labor. This contradicts the premise that the labor market is in equilibrium.

In sum, the marginal return of the effective labor input on any type of the land to be rented in should equal wage rate w in the competitive equilibrium where both land rental and labor markets are active. This property, namely $p\frac{\partial F}{\partial L}|_{L=L_t^{in}} = w, \forall k_t^{in} \geq 0$, also holds true for any other competitive equilibria where either the land rental market or the labor market is inactive.[43] For instance, we can define wage rate w as the marginal return of family labor input on the rented-in land when the labor market is inactive while the land rental market is active.[44] Similarly, we can

[43]Land rental and labor markets cannot be simultaneously inactive in a competitive equilibrium as landless agents in an agrarian economy will either hire out the endowed labor or use it to cultivate the land to be rented in.

[44]The inactive labor market means that agents will neither hire in nor hire out labor at wage rate w, i.e., they

define the land rental rate schedule $r(\cdot)$ such that it satisfies the properties (23)-(25) above when the land rental market is inactive while the labor market is active.[45]

Importantly, the property that the marginal return of the effective labor input on any type of the land to be rented in equals wage rate means that tenants will use family labor but not hired labor to cultivate the land to be rented in due to the agency cost of hired labor. This is why renting out land will improve the efficiency of labor input on the endowed land when self-cultivating all the endowed land involves the usage of the relatively inefficient hired labor.

Back to condition (24), we have:

$$p\frac{\partial F}{\partial K}|_{K=A_t^{in}k_n+A_t^{in}k_t^{in}} = r'(k_t^{in}+k_n)$$

for $k_t^{in} > 0$. It says that the marginal return of the attached capital investments on the land to be rented in made by its owner equals the associated marginal increment of the rental rate for that land. That is, landlords will recoup all the returns of their attached capital investments on the rented-out land through land rental rates. This reconfirms that tenants will only earn market returns on their labor inputs on the rented-in land.

use all the endowed labor as family labor to cultivate land, either the self-cultivated land or the rented-in land or both. Note that the marginal return of family labor input on the rented-in land should be the same across tenants. Otherwise, a tenant who obtains a lower marginal return of family labor input will switch to renting in another type of land that delivers a higher marginal return of family labor input, which contradicts the premise that the land rental market is in equilibrium. At the same time, the marginal return of hired labor input on the self-cultivated land for the first unit should be no higher than the marginal return of family labor input on the rented-in land. Otherwise, self-cultivators will hire in labor and tenants will hire out labor, which contradicts the premise that the labor market is inactive. Of course, the marginal return of hired labor input on the rented-in land for the first unit is also no higher than the marginal return of family labor input on the rented-in land due to the agency cost of hired labor. Last but not least, the marginal return of family labor input on the self-cultivated land is no lower than that on the rented-in land. Otherwise, some landed agents will rent out more land, which contradicts the premise that the land rental market is in equilibrium. In sum, no agent will have any incentives to either hire in or hire out labor when wage rate is set equal to the marginal return of family labor input on the rented-in land. Hence, introducing this specific wage rate will not alter the original competitive equilibrium.

[45]The inactive land rental market means that no landed agent will rent out land and no agent will rent in land at the land rental rate schedule $r(\cdot)$, i.e., all the endowed land will be self-cultivated by owners. Note that the properties of the land rental rate schedule $r(\cdot)$ derived above simply say that landlords will recoup all the returns of the endowed land to be rented out and its attached capital investments through land rental rates and tenants will just earn wage rate for family labor input on the land to be rented in. Under this land rental rate schedule, using the endowed labor to cultivate the land to be rented in will deliver the same labor return as hiring out the endowed labor in the labor market. Thus, no laborer will have any incentives to rent in land and thus no landed agent will rent out land. Hence, introducing this specific land rental rate schedule will not alter the original competitive equilibrium.

Appendix C. The first-order conditions for the optimal resource allocation at the extensive or intensive margin of renting out land

In this appendix, I establish the first-order optimality conditions for when a landed agent will rent out land (the extensive margin) and by how much (the intensive margin). These conditions have been used to investigate the interaction between the investment effect of higher land ownership security and the concurrent rental-supply effect in section 4. As shown above in the main text, landlords are among landed agents who have the accessible credit to make attached capital investments. Also, I assume that they will invest attached capital in the endowed land to be self-cultivated at least, although they may not invest attached capital in the endowed land to be rented out if the moral hazard of tenants not taking care of landlords' land-attached capital is severe (see details below).

Before moving to the first-order optimality conditions derived below, let us look at the general picture about the labor input on the endowed land made by landed agents at the extensive and intensive margins of renting out land first. The previous appendix shows that cultivating the rented-in land delivers the same unit return of the endowed labor as working on others' farms, namely wage rate. Thus, the opportunity cost of using the endowed labor to cultivate the endowed land equals wage rate. At this opportunity cost, a landed agent will not rent out land if self-cultivating all the endowed land does not consume all the endowed labor. Otherwise, renting out land would not improve the efficiency of the labor input on the endowed land but raise the protection cost rate and the capital depreciation cost rate resulting from the higher risk of losing the rented-out land cum its attached capital investments and the moral hazard of tenants not taking care of landlords' land-attached capital. As a corollary, a landed agent at the extensive or intensive margin of renting out land will always use all the endowed labor to cultivate all or part of the endowed land.

With all that being said above, I obtain the following first-order conditions for the optimal resource allocation made by a landed agent at the extensive and intensive margins of renting out land. These refined conditions are derived from properties of the land rental rate schedule and other first-order conditions in the previous appendices and the definitions of π_o and π_t^{out} in section 2.2. For readability, I omit the detailed derivations.

(26) $p\frac{\partial F^o}{\partial A} + p\frac{\partial F^o}{\partial K}k_n - c_o(S_e)\frac{r(k_n)}{i} = p\frac{\partial F^t}{\partial A} + p\frac{\partial F^t}{\partial K}k_n - c_t(S_e)\frac{r(k_n)}{i}$;

(27) $p\frac{\partial F^o}{\partial K} = d_o + c_o(S_e) + i(1+\mu)$ with $k_o > 0$;

(28) $p\frac{\partial F^o}{\partial L} = w\Big/\frac{\partial L}{\partial L_h^{in}}|_{L=L(L_f,L_h^{in}),L_f=1,L_h^{in}>0}$;

(29) $p\frac{\partial F^t}{\partial K} \leq d_t + c_t(S_e) + i(1+\mu)$ with the equality for $k_t^{out} > 0$;

(30) $p\frac{\partial F^t}{\partial L} = w$;

(31) $A_o > 0,\ A_t^{out} \geq 0,\ A_o + A_t^{out} = A_e$;

(32) $\mu \geq 0,\ A_o k_o + A_t^{out}k_t^{out} \leq A_e\theta(S_e),\ \mu[A_o k_o + A_t^{out}k_t^{out} - A_e\theta(S_e)] = 0$.

Here, F^o denotes the output produced on the self-cultivated land $F(A_o, A_o k_o + A_o k_n, L_o)$; and F^t denotes the output produced on the rented-out land $F(A_t^{out}, A_t^{out}k_t^{out} + A_t^{out}k_n, L_f^t)$ with L_f^t denoting the family labor input provided by the tenant who rents in the land of size equal to A_t^{out} and intensity of attached capital investments equal to k_t^{out}.

Condition (26) says that the marginal return of the endowed land to be self-cultivated—the marginal output revenue of the endowed land to be self-cultivated (including the natural attached capital) minus its unit protection cost—should equal the marginal return of the endowed land to be rented out—the marginal output revenue of the endowed land to be rented out (including the natural attached capital) minus its unit protection cost at the extensive or intensive margin of renting out land. This equality condition tells us whether a landed agent will rent out land or not and by how much depend on the difference between the marginal output revenue of the endowed land to be rented out and the marginal output revenue of the endowed land to be self-cultivated, namely $\left(p\frac{\partial F^t}{\partial A} + p\frac{\partial F^t}{\partial K}k_n\right) - \left(p\frac{\partial F^o}{\partial A} + p\frac{\partial F^o}{\partial K}k_n\right)$, relative to the difference between the unit cost of protecting the endowed land to be rented out and the unit cost of protecting the endowed land to be self-cultivated, namely $c_t(S_e)\frac{r(k_n)}{i} - c_o(S_e)\frac{r(k_n)}{i}$. Sections 3 and 4 examine this from the perspectives of the size and security level of land endowment, respectively.

Conditions (27) and (28) state that the marginal return or output revenue of an input on the self-cultivated land, either attached capital or effective labor, equals its marginal cost. We have the intensity of attached capital investments $k_o > 0$ as I assume that it is always profitable to invest attached capital in the self-cultivated land. We have the amount of family labor input $L_f = 1$ as a landed agent at the extensive or intensive margin of renting out land will use all the endowed labor to cultivate all or part of the endowed land. Moreover, cultivating the self-cultivated land will involve the usage of the inefficient hired labor, namely $L_h^{in} > 0$. Otherwise, a landed agent will not rent out land as explained above. Hence, the marginal effective labor extracted from family labor cum hired labor, namely $\frac{\partial L}{\partial L_h^{in}}$, is smaller than 1 and will decrease as more hired labor is employed due to the agency cost. This means that the marginal cost of the effective labor input on the self-cultivated land is higher than wage rate w.

In contrast, the marginal cost of the effective labor input, provided by a tenant, on the rented-out land always equals wage rate w since tenants only use family labor to cultivate the rented-in land, as shown in Appendix B. Thus, we have condition (30) for the optimal effective labor input on the rented-out land. The lower marginal cost of the effective labor input favors renting out land. However, attached capital investments on the rented-out land satisfy condition (29), which says that investing attached capital in the rented-out land may be unprofitable. The reason is that renting out land induces a higher protection cost rate and a higher depreciation cost rate, namely $c_t(S_e) > c_o(S_e)$ and $d_t > d_o$, leading to a higher marginal cost of attached capital investments, namely $d_t + c_t(S_e) + i(1+\mu) > d_o + c_o(S_e) + i(1+\mu)$, although the self-cultivated and rented-out land share the shadow price of the accessible credit $i(1+\mu)$ with μ denoting the shadow value of relaxing the credit constraint (if any).[46]

Finally, conditions (31) and (32) capture constraints on the land allocation and attached capital investments, respectively. Condition (31) says that a landed agent may or may not rent out part of the endowed land. In terms of renting out land, we have $A_t^{out} = 0$ at the extensive margin and $A_t^{out} > 0$ at the intensive margin. Condition (32) says that the gross attached capital investments on the self-cultivated and rented-out land, namely $A_o k_o + A_t^{out} k_t^{out}$, should not exceed the amount of the accessible credit $A_e \theta(S_e)$.

[46] Because of the positive intensity of the natural attached capital k_n, the marginal return of attached capital investments on the rented-out land $p\frac{\partial F^t}{\partial K}$ evaluated at $k_t^{out} = 0$ is finite and thus can be lower than the associated marginal cost $d_t + c_t(S_e) + i(1+\mu)$, i.e., no attached capital should be invested in the rented-out land at the optimum.

Appendix D. Comparative statics of renting out land

In section 4, I have explained why the moral hazard of tenants not taking care of landlords' land-attached capital tends to attenuate the rental-supply effect of higher land ownership security by inducing the bias of the concurrent investment effect towards the endowed land to be self-cultivated. Here, I present the associated comparative statics based on the first-order conditions above in Appendix C. Specifically, table 1 below shows the comparative statics of the threshold of renting out land A_e^{out} with respect to land ownership security S_e, namely $\frac{\partial A_e^{out}}{\partial S_e}$, which demonstrates the attenuation that may happen at the extensive margin. Table 2 below shows the comparative statics of the optimal size of the self-cultivated land A_o^* with respect to land ownership security S_e, namely $\frac{\partial A_o^*}{\partial S_e}$, which demonstrates the attenuation that may happen at the intensive margin.

Table 1: Marginal Effects of Land Ownership Security on the Threshold of Renting out Land.

credit constrained	credit unconstrained
$I_{e,1}^c\theta'(S_e) - R_e^c\{-[c_t'(S_e) - c_o'(S_e)]\frac{r(k_n)}{i}\}$ $-I_{e,2}^c k_t^{out}\theta'(S_e)$ $-I_{e,3}^c k_t^{out}\{-[c_t'(S_e) - c_o'(S_e)]\}$,	$I_{e,1}^{uc}[-c_o'(S_e)] - R_e^{uc}\{-[c_t'(S_e) - c_o'(S_e)]\frac{r(k_n)}{i}\}$ $-I_{e,2}^{uc} k_t^{out}[-c_t'(S_e)]$,
$I_{e,1}^c > 0, I_{e,2}^c > 0, I_{e,3}^c = R_e^c > 0.$	$I_{e,1}^{uc} > 0,\ I_{e,2}^{uc} = R_e^{uc} > 0.$

Note: (i) The marginal effects of land ownership security on the threshold of renting out land $\frac{\partial A_e^{out}}{\partial S_e}$ are obtained under the assumption that a landed agent at the extensive margin of renting out land will use the accessible credit to invest attached capital in the endowed land to be self-cultivated at least. I obtain all the I's and R's above from the first-order conditions (26)-(32) using the implicit function theorem. Here, I stands for the investment effect while R stands for the rental-supply effect. (ii) She or he will not invest attached capital in the endowed land to be rented out when the marginal cost of attached capital investments on the endowed land to be rented out is sufficiently higher than that on the endowed land to be self-cultivated, e.g., the capital depreciation rate is much higher for the rented-out land than the self-cultivated land due to the severe moral hazard of tenants not taking care of landlords' land-attached capital. (iii) She or he will be credit constrained when her or his demand for attached capital investments exceeds the accessible credit. (iv) The protection cost rate for the rented-out land and its attached capital investments $c_t(S_e)$ will decrease more than that for the self-cultivated land and its attached capital investments $c_o(S_e)$ given higher land ownership security. This will reduce both their difference in the unit cost of protecting the endowed land and their gap in the marginal cost of attached capital investments.

In both tables, we clearly see that the size of the investment effect of higher land ownership security on the endowed land to be rented out is increasing in its initial intensity of attached capital investments, namely k_t^{out}. Note that the moral hazard of tenants not taking care of landlords' attached capital dampens attached capital investments on the endowed land to be rented out.

Hence, it induces the bias of the investment effect towards the endowed land to be self-cultivated, which tends to attenuate the concurrent rental supply effect of higher land ownership security as shown by these comparative statics.

Table 2: Marginal Effects of Land Ownership Security on the Size of the Self-cultivated Land.

	credit constrained	credit unconstrained
$k_t^{out} = 0$	$I_o^c \theta'(S_e) - R_o^c\{-[c_t'(S_e) - c_o'(S_e)]\frac{r(k_n)}{i}\}$, $I_o^c > 0, R_o^c > 0.$	$I_o^{uc}[-c_o'(S_e)] - R_o^{uc}\{-[c_t'(S_e) - c_o'(S_e)]\frac{r(k_n)}{i}\}$, $I_o^{uc} > 0, R_o^{uc} > 0.$
$k_t^{out} > 0$	$\tilde{I}_{o,1}^c \theta'(S_e) - \tilde{R}_o^c\{-[c_t'(S_e) - c_o'(S_e)]\frac{r(k_n)}{i}\}$ $-\tilde{I}_{o,2}^c k_t^{out}\theta'(S_e)$ $-\tilde{I}_{o,3}^c\{-[c_t'(S_e) - c_o'(S_e)]\}$, $\tilde{I}_{o,1}^c > 0, \tilde{I}_{o,2}^c > 0, \tilde{I}_{o,3}^c > 0, \tilde{R}_o^c > 0.$	$\tilde{I}_{o,1}^{uc}[-c_o'(S_e)] - \tilde{R}_o^{uc}\{-[c_t'(S_e) - c_o'(S_e)]\frac{r(k_n)}{i}\}$ $-\tilde{I}_{o,2}^{uc} k_t^{out}[-c_t'(S_e)]$, $\tilde{I}_{o,1}^{uc} > 0, \tilde{I}_{o,2}^{uc} = \tilde{R}_o^{uc} > 0.$

Note: (i) The marginal effects of land ownership security on the size of the self-cultivated land $\frac{\partial A_o^*}{\partial S_e}$ are obtained under the assumption that a landed agent at the intensive margin of renting out land will use the accessible credit to invest attached capital in the self-cultivated land at least. I obtain all the I's, R's, $\tilde{I}$'s, and $\tilde{R}$'s above from the first-order conditions (26)-(32) using the implicit function theorem. Here, I and $\tilde{I}$ stand for the investment effects while R and $\tilde{R}$ stand for the rental-supply effects. (ii) She or he will not invest attached capital in the rented-out land when the marginal cost of attached capital investments on the rented-out land is sufficiently higher than that on the self-cultivated land, e.g., the capital depreciation rate is much higher for the rented-out land than the self-cultivated land due to the severe moral hazard of tenants not taking care of landlords' land-attached capital. (iii) She or he will be credit constrained when her or his demand for attached capital investments exceeds the accessible credit. (iv) The protection cost rate for the rented-out land and its attached capital investments $c_t(S_e)$ will decrease more than that for the self-cultivated land and its attached capital investments $c_o(S_e)$ at higher land ownership security. This will reduce both their difference in the unit cost of protecting the endowed land and their gap in the marginal cost of attached capital investments.