Risk Rationing and Wealth Effects in Credit Markets: Theory and Implications for Agricultural Development

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We develop a model that shows that asymmetric information can result in two types of credit rationing: conventional quantity rationing, and "risk rationing," whereby farmers are able to borrow but only under high-collateral contracts that offer them lower expected well-being than a safe, subsistence activity. After exploring its incidence with respect to wealth, we show that risk rationing has important policy implications. Specifically, land titling will be only partially effective because it does not enhance producers' willingness to offer up the collateral needed to secure loans under moral hazard constraints. Efforts to enhance agricultural investment and the working of agricultural credit markets must step beyond land titling and also deal with risk.

Key words: asymmetric information, credit rationing, land titling, moral hazard, risk rationing.

In a competitive world of symmetric information and costless enforcement, credit contracts could be written conditional on borrower behavior. Borrowers would then have access to loans under any interest rate-collateral combination that would yield lenders a zero expected profit. However, as a large literature has shown, information asymmetries and enforcement costs make such conditional contracting infeasible and restrict the set of available contracts, eliminating as incentive incompatible high interest rate, low collateral contracts.[1] This contraction of contract space can result in quantity rationing in which potential borrowers who lack the wealth to fully collateralize loans are involuntarily excluded from the credit market and thus prevented from undertaking higher return projects.

This paper theoretically demonstrates that the contraction of contract space induced by asymmetric information can result in another form of nonprice rationing, one that we label "risk rationing." Risk rationing occurs when insurance markets are absent, and lenders, constrained by asymmetric information, shift so much contractual risk to the borrower that the borrower voluntarily withdraws from the credit market even when she has the collateral wealth needed to qualify for a loan contract.[2] According to the model developed here, the private and social costs of risk rationing will be similar to those of more conventional quantity rationing. Like quantity-rationed individuals, risk-rationed individuals will retreat to lower expected return activities and occupations.

Risk rationing is more than a theoretical curiosity. Table 1 presents data from three surveys of farm enterprises in Peru, Honduras, and Nicaragua.[3] Each survey asked a series of questions that made it possible to infer farmers' credit rationing status.[4] The table compares the means of several key variables for price-rationed versus nonprice-rationed

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[1] Recent summaries of this literature include: Ghosh, Mookherjee, and Ray (2000); Udry and Conning (2005); and Dowd (1992).

[2] Like an interest rate increase, an increase in contractual risk will also help equilibrate the loan market by reducing demand, and is thus a form of nonprice rationing.

[3] Boucher (2000) describes the Peru survey, while Boucher, Barham, and Carter (2005) provide an overview of the Honduras and Nicaragua studies.

[4] Households that borrowed and were happy with the amount they received are price rationed. Rejected applicants are quantity rationed. Nonapplicants are the most difficult group to classify as they may not have applied because: (*a*) they knew they would be rejected (quantity rationed); (*b*) they were afraid to lose collateral (risk rationed); or (*c*) they had no need of outside finance (price rationed). Each survey thus asked the reasons why nonapplicants had not sought credit. Boucher, Guirkinger, and Trivelli (2006) provide an in-depth description and discussion of this direct elicitation survey methodology.

Table 1.   Risk- and Quantity-Rationed Farms

| Country | Nonprice Rationed | | Price Rationed |
	Quantity	Risk	
Peru			
Sample frequency (%)	37	19	46
Productive wealth ($)	13,308*	9,634*	23,771
Variable inputs ($/ha)	467*	371*	868
Net income ($/ha)	653*	593*	919
Honduras			
Sample frequency (%)	23	16	62
Productive wealth ($)	10,523*	11,916*	26,580
Variable inputs ($/ha)	128	127	167
Net income ($/ha)	81	98	125
Nicaragua			
Sample frequency (%)	48	12	40
Productive wealth ($)	4,340*	6,283*	12,299
Variable inputs ($/ha)	19*	15*	31
Net income ($/ha)	71	71	76

An asterisk (*) indicates that the mean of the nonprice-rationed group is different from the price-rationed group at the 5% significance level.

farmers. Nonprice-rationed farmers are those that indicated that they would have liked to borrow money at the going rate of interest, but that they either could not qualify for a loan (i.e., were quantity rationed)[5] or were afraid to take one because of the risk of collateral loss (risk rationed). The price-rationed group includes both borrowers and those who chose not to borrow because they did not need capital or found the cost of capital to be too high.[6] As can be seen, risk-rationed farms constitute between 12% and 19% of all surveyed farms, and between 20% and 40% of all nonprice-rationed farms. Risk-rationed farms appear similar to quantity-rationed farms. The value of variable inputs per hectare used by quantity- and risk-rationed farms ranges from 20% less than price-rationed households in Honduras to 50% less in Peru. Net income per hectare is also less for both categories of nonprice-rationed farms than for price-rationed farms.

If these figures are at all indicative of the nature of credit markets in low-income agricul-

ture, then failure to account for risk rationed farms would distort the empirical analysis of the efficiency of rural financial markets. In addition, risk rationing would have important policy implications. Land titling programs are typically put forward as a device to enhance producers' ability to use their assets as collateral, reduce the prevalence of quantity rationing, and raise the productivity of the agricultural economy. However, as this paper's theoretical analysis will show, land titling will be only partially effective at combating nonprice rationing because it does not enhance producers' willingness to offer up the collateral needed to secure loans under moral hazard constraints. The potential for risk rationing thus suggests that even in the presence of well-defined and transferable property rights in land, the development of credit markets will be constrained by weak insurance markets.[7] If correct, this suggestion implies that efforts to enhance agricultural investment and the working of agricultural credit markets must also deal with risk.

The remainder of this paper is organized as follows. The second section lays out the basic model of activity choice by a farmer who faces the choice between a safe (subsistence) reservation activity and a risky commercial activity, where the latter must be financed by an optimally designed credit contract offered by a competitive sector of lenders. The third section contains the paper's key theoretical results

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[5] Most of these firms are what Mushinski (1999) calls preemptively rationed as they do not bother to apply for loans, knowing fully well that they will not receive them.

[6] In the model we develop below, we assume that all households have access to a profitable investment project but lack sufficient liquidity to self-finance. Price rationing in our model is thus equivalent to borrowing. In the real world, the price-rationed group contains a more heterogeneous set of households. This includes both borrowers and nonborrowers. Nonborrowers are themselves a heterogeneous group, made up of those who lack a project that is profitable given the market interest rate and those who have sufficient liquidity to self-finance their project. Unfortunately, in our data these two groups are observationally indistinguishable. Compared to the quantity and risk-rationed groups, this combined group of price-rationed non-borrowers does indeed show greater variability in each of the variables reported in table 1.

[7] Interestingly, the farm surveys, summarized in table 1, all followed major land titling programs.

on quantity and risk rationing. The fourth section sharpens the model's insights regarding the incidence of both forms of nonprice rationing by presenting a numerical analysis of the model. The penultimate section then employs the model to analyze the impact of land titling on the landscape of nonprice rationing, showing that land titling is likely to decrease quantity rationing, but is also likely to increase risk rationing. The final section concludes with reflections on the design of development policies and emphasizes the need to integrate risk mitigation measures into the standard agricultural modernization package.

Key Assumptions and Model Structure

Agents enjoy endowments of financial wealth, W, and land, T. Financial wealth is liquid and can be committed as collateral to secure production loans. For simplicity, we assume that agents earn a certain net rate of return equal to zero on financial wealth. Land can also be used as collateral and sold at price p_T. Land titling increases the market price and collateral value of land. Agents allocate their land between two activities: a safe reservation or subsistence activity, and a higher-returning, but risky, commercial activity.[8] The reservation activity does not require capital and yields a certain return of ω per unit land. The commercial activity requires a fixed investment per unit land, k. Returns to the commercial activity are uncertain, with gross revenues per unit land equal to x_g if the realized state of nature is "good," and x_b if the state of nature is "bad" with $x_g > k > x_b$. In the analysis that follows, we restrict attention to agents with endowments such that $W < Tk$, i.e., to those who must borrow in order to utilize the commercial technology.[9]

The Agent's Preferences and Choices

An agent's well-being in state j depends on her end-of-period consumable wealth, C_j, and the effort exerted in production, e, according to the following additively separable utility function:

$$(1) \qquad U(C_j, e) = u(C_j) - d(e).$$

Consumable wealth is the sum of initial financial wealth (W), the market value of land holdings ($p_T T$), and net income from the chosen activity. We assume that all agents have access to a minimum income level yielding finite utility which is exogenously guaranteed to the agent by social or other mechanisms. The consumption minimum prevents lenders from driving the agent's utility in the bad state of nature below a lower utility bound, thereby limiting their ability to write incentive-compatible contracts. This assumption is required to establish the possibility of quantity rationing but not risk rationing.[10] Effort, in turn, can be either high ($e = H$) or low ($e = L$). The disutility of effort, $d(e)$, is increasing in effort so that $d(H) > d(L)$.

As mentioned above, agents must choose between a subsistence and a commercial activity. We assume that the subsistence activity requires high effort.[11] The agent's utility under this safe, subsistence or reservation activity is thus $U^R = u(W + (p_T + \omega)T) - d(H)$.

If the agent has access to a credit contract, she has the option of farming her land under the risky commercial activity. If she decides to pursue the risky activity, she also must decide how much effort to put into farming. In addition to lowering the agent's utility, high effort raises the probability of the good state of nature. Let ϕ^e be the probability of the good state of nature under effort, e, so that $\phi^H > \phi^L$. We assume that the impact of effort on profitability is sufficiently strong that under high effort the risky commercial activity is more profitable than the safe subsistence activity, while under low effort the risky activity earns a negative rate of return. Any loan contract that is offered will thus need to require, or induce, high effort. Assumptions A.1 and A.2 below formalize these impacts of effort on profitability:

(A.1) $\bar{x}^H - rk > \omega > 0$

(A.2) $\bar{x}^L - rk < 0$

where $\bar{x}^H$ and $\bar{x}^L$ represent expected gross revenues per unit land in the risky activity under high and low effort, respectively, and

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[8] The risky, commercial activity may be thought of, for example, as adopting a new capital intensive technology or a nontraditional export crop.
[9] An earlier version of this paper included agents that could self-finance and showed that some agents that would seek the insurance of the first-best contract instead self-financed under asymmetric information. As this is a secondary point, we exclude those agents that can self-finance from the analysis.

[10] Note that in the absence of this lower utility bound, lenders could offer contracts that drive the agent's utility under the bad state of nature to negative infinity. If the lender could do so, then there would always exist incentive-compatible contracts, and quantity rationing would never occur.
[11] While not necessary for the analysis that follows, this assumption greatly simplifies the results. Formally, this assumption is akin to saying that returns to the subsistence activity diminish so much with low effort that the agents (who bear the full liability of low output) will always choose high effort.

$r \equiv 1 + \tilde{r}$, where $\tilde{r}$ is the opportunity cost of lenders' funds. The first inequality in (A.1), which indicates that the agents have a profitable commercial project available to them, is a vital assumption of the model. As later analysis will show, the magnitude of the difference between $(\bar{x}^H - rk)$ and ω will play a key role in shaping the incidence of risk rationing with respect to changes in land endowment.[12]

Optimal Loan Contracts and the Potential for Nonprice Rationing

While loan contracts are commonly described by an interest rate and a collateral requirement, in this model we can alternatively write a contract in the form (s_g, s_b), where s_g and s_b are the borrower's payoff per unit area financed under the good and bad states of the world. As in Conning (1999), the loan contract specifies how the project returns are divided between the borrower and the lender under each state. Asymmetric information prevents risk-neutral lenders from specifying the borrower's effort level so that, given assumptions A.1 and A.2, lenders must choose payoffs that are incentive compatible and induce the borrower to choose high effort. We further assume that the loan market is competitive and that if the commercial project is financed, the lender provides the entire capital amount, Tk, and the farmer does not use any of her own financial wealth.

Given the assumption of a competitive loan market, the optimal contract maximizes the agent's expected utility subject to the principal's (lender's) participation constraint and the agent's incentive compatibility constraint (ICC).[13] The payoffs of the optimal contract
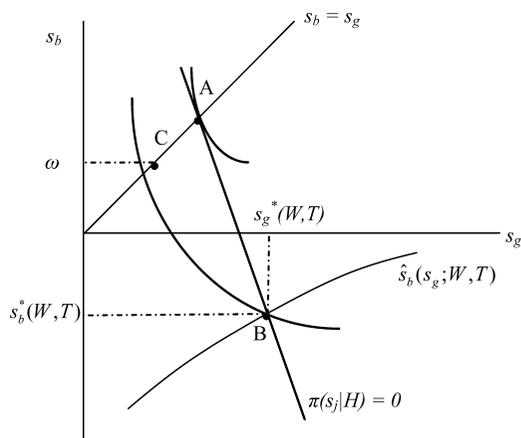
Figure 1. The potential for risk rationing

solve the following program:

$$(2) \quad \underset{s_g, s_b}{Max} \quad Eu(W + (p_T + s_j)T \mid e = H)$$

subject to :

$$(3) \quad \pi(s_j \mid H) \equiv \phi^H(x_g - s_g) \\ + (1 - \phi^H)(x_b - s_b) \\ - rk \geq 0$$

$$(4) \quad [u(W + (p_T + s_g)T) \\ - u(W + (p_T + s_b)T)] \\ \times (\phi^H - \phi^L) \geq d(H) - d(L)$$

$$(5) \quad -s_j \leq W/T + p_T; \quad j = g, b.$$

Equation (3) is the *lender's participation constraint* (LPC) and requires that contracts, conditional on high agent effort, yield nonnegative lender profits. Equation (4) is the agent's ICC. A contract is incentive compatible if the expected utility gain for the borrower outweighs the disutility cost of high effort. Finally, equation (5) gives the agent's wealth or liability constraint. Note that the agent's payoff is not restricted to be nonnegative. A negative payoff requires the borrower to hand over some of her wealth, and thus is equivalent to a collateral requirement.

Much of the intuition behind the rationing results can be gleaned diagrammatically from figure 1. The horizontal and vertical axes represent the borrower's payoff under good and bad states of nature, respectively. Holding constant high effort, the borrower's indifference curves are convex to the origin because the

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[12] Note that our model explictly rules out a land rental option in which agents tempted to pursue the subsistence activity instead rent out their land to commercial farmers. This assumption is quite defensible given the ample evidence that land rental markets are thin in many parts of the developing world, as well as the evidence of the continuing coexistence of commercial and subsistence production. It would be possible to extend the model here to include a land rental option. The land rental rate would fall in the range between $\bar{x}^H - rk$ and ω, with its exact position depending on the aggregate distribution of endowments that would shape the relative supply of and demand for land. With risk averse agents on the demand side of the land market, we would not expect the entire entrepreneurial surplus associated with adopting the commercial activity to be absorbed in a high land rental rate.

[13] We do not explcitly write the agent's participation or reservation utility condition as a constraint on the maximizatoin problem. Approaching the problem this way permits us to first characterize the contract(s) that would be made available by a competitive banking system in conformity with the LPC, the ICC, and the liability constraint. We then ask whether or not any of the available contracts also fulfills the borrower's participation constraint. While appropriate for the questions at hand in this paper, analysis of other constraint configurations would be valuable for answering other questions (e.g., what sort of subsidy would have to be

offered to lenders to induce them to offer a contract that was incentive compatible and meets the borrower's liability and reservation constraints).

rate at which she is willing to trade consumption across states depends on how "smoothed" consumption is. At points like A or C on the 45-degree line, consumption is perfectly smooth across states of nature, and the borrower is willing to marginally trade consumption across states at the rate $\phi^H/(1 - \phi^H)$. In contrast, at a point such as B, consumption in the bad state is relatively scarce so the borrower is only willing to give up a little bit of it in order to increase consumption in the good state. The line labeled $\pi(s_j \mid H) = 0$, also with slope $-\phi^H/(1 - \phi^H)$, is the lender's zero expected profit contour (conditional on high effort). The LPC requires that contracts lie on or to the southwest of this contour. Finally, note that the (risk-free) subsistence reservation activity returns ω irrespective of the state of the world, and thus offers the payoffs at point C in figure 1.

Consider first the solution to this problem ignoring the ICC. Note that if the agent's effort were contractible (i.e., observable and enforceable) then this constraint could be ignored. The first-best contract sets $s_g = s_b$ and equalizes the borrower's consumption across states. In figure 1, the first-best (contractible effort) contract would be at point A, exhibiting the familiar tangency condition between the borrower's indifference curve and the lender's zero-profit contour. In the absence of asymmetric information, credit contracts could serve the dual role of both providing liquidity and efficiently distributing risk. In this case the risk-neutral lender would provide full insurance to the risk-averse borrower.

Suppose now that asymmetric information renders it impossible to enforce loan contracts written conditional on agent effort. In this case, the contract at A will not be available because of moral hazard. With her consumption completely shielded from low outcomes, the agent would have no incentive to apply high effort. Inspection of the ICC (equation (4)) reveals that incentive compatibility requires $s_g > s_b$. The lender motivates the borrower to apply high effort by offering contracts that reward her in the good state and punish her in the bad state.

Let $\hat{s}_b(s_g; W, T)$—which we call the *incentive compatibility boundary* (ICB)—denote, for a given payoff in the good state, the payoff in the bad state such that the ICC binds. Total differentiation of the ICB yields:[14]

(6) $\quad \dfrac{\partial \hat{s}_b}{\partial s_g} = \dfrac{u'(C_g)}{u'(C_b)}.$

The ICB is thus upward sloping with a slope less than unity. More draconian payoff combinations that lie below the ICB are incentive compatible. The ICC thus eliminates low collateral, high interest rate loans from the menu of contracts that competitive lenders will offer. The moral hazard constrained optimal contract is found at point B, the intersection of the LPC and ICC. Let $(s_g^*(W, T), s_b^*(W, T))$ denote the contract at this intersection. Note that this is the lowest collateral (highest insurance) contract that fulfills both the incentive compatibility and the lender's zero-profit conditions.

The contraction of the feasible contract set due to moral hazard creates the potential for two sorts of nonprice rationing. The first is conventional quantity rationing. Quantity rationing occurs when (*a*) the agent would be offered and demand a credit contract in the symmetric information world; but, (*b*) the agent lacks sufficient wealth to collateralize the contract at the LPC-ICB intersection (*i.e.*, $W + p_T T < -T s_b^*(W, T)$). In this case, the feasible contract set will be empty and the lender will not make any contract available to the agent.

The second sort of nonprice rationing that can potentially exist is what we have labeled risk rationing. Risk rationing occurs when (*a*) the agent would be offered and demand a credit contract in the symmetric information world; (*b*) the agent is offered a financially feasible contract in the asymmetric information world (i.e., $W + p_T T \geq -T s_b^*(W, T)$); but, (3) the agent chooses not to accept the offered contract, preferring the reservation subsistence activity. As drawn in figure 1, the agent would be risk rationed because the indifference curve through the best available contract at point B passes to the southwest of the reservation-utility-equivalent contract at point C. While the concept of risk rationing can thus be easily illustrated, the proof of its existence and its incidence with respect to wealth is less straightforward.

Wealth and Nonprice Rationing Under Asymmetric Information

In this section, we formalize the graphical intuitions from the previous section. We begin by establishing necessary and sufficient conditions for the existence of quantity rationing and show that quantity rationing will be unambiguously biased against the poor. We then turn to risk rationing. We extend the results of Thiele and Wambach (1999) by demonstrating that the incidence of risk rationing may depend

on the type of wealth considered; with the financially wealthy but land-poor adversely affected by risk rationing.

Quantity Rationing of the Poor

A necessary and sufficient condition for a positive credit supply is that there exists a contract requiring the agent to pledge her entire wealth as collateral that is both incentive compatible and yields nonnegative lender profits. If there are no "full-wealth-pledge" contracts that satisfy both of these constraints, then the feasible contract set will be empty, and the agent will be quantity rationed. Proposition 1 states the conditions under which quantity rationing will occur and identifies its wealth bias.

PROPOSITION 1 (Wealth-Biased Quantity Rationing). *Assume all agents have financial wealth of at least $\underline{W}$ and define $u(0)$ as the agent's utility when her state-contingent pay-off equals the negative of her collateral wealth $(s_b^*(\underline{W}, T) = -(\frac{\underline{W}}{T} + p_T))$. Consider the following inequality:*

$$(7) \qquad u\left(\frac{T(\bar{x}^H - rk) + \underline{W} + p_T T}{\phi^H}\right)$$
$$< \frac{d(H) - d(L)}{\phi^H - \phi^L} + u(0).$$

For a given value of T, inequality (7) is necessary and sufficient for the following three quantity rationing results: a) There will exist a unique $W^*(T)$ such that agents with financial wealth less than $W^*(T)$ will have an empty feasible contract set and will be quantity rationed. Agents with financial wealth greater than or equal to $W^*(T)$ will have a nonempty feasible contract set. b) Holding W constant at $W^*(T)$, agents with farm size less than T will be quantity rationed while those with greater productive wealth will not. c) $\partial W^*(T)/\partial T < 0$, so that the minimum financial wealth required for access to a contract is decreasing in farm size.

A proof of Proposition 1 is provided in Boucher, Carter, and Guirkinger (2007). The intuition can be explained as follows. Consider whether the agent with the lowest financial wealth can qualify for a loan if she pledges her entire wealth, $\underline{W} + p_T T$, as collateral. Note that under this full-wealth-pledge contract, $s_b = -(\underline{W}/T + p_T)$. For this value of s_b, the LPC then defines the *maximum* payout that can be made to the borrower in the good state of the world without violating the lender's non-negative profit condition. Denote this maximum as $s_g^{\max}(\underline{W} \,|\, T)$. Similarly, the ICC defines

the *minimum* incentive-compatible payout that can be made to the borrower in the good state of the world when $s_b = -(\underline{W}/T + p_T)$. Denote this minimum payout as $s_g^{\min}(\underline{W} | T)$. Payouts below this level will destroy incentives for the borrower to choose high effort.

If $s_g^{\max}(\underline{W} \,|\, T) \geq s_g^{\min}(\underline{W} \,|\, T)$, then there exists at least one full-wealth-pledge contract that is both incentive compatible and provides nonnegative profits to the lender. However, if $s_g^{\max}(\underline{W} \,|\, T) < s_g^{\min}(\underline{W} \,|\, T)$, then the smallest payment that can be made to ensure incentive compatibility of the full-wealth-pledge contract is too high and violates the lender's non-negative profit condition. In this case, the borrower will not be able to secure a loan even when pledging her full wealth as collateral.

The inequality in equation (7) implies that the full-wealth-pledge contract cannot fulfill both the incentive compatibility and the LPC for the financially poorest agent. This inequality can be rewritten as:

$$(8) \qquad u\big(T s_g^{\max}(\underline{W} | T) + \underline{W} + p_T T\big)$$
$$< \frac{d(H) - d(L)}{\phi^H - \phi^L} + u(0)$$

and says that the full-wealth-pledge contract cannot fulfill both the zero profit and ICC if the borrower's utility in the good state of the world (evaluated at $s_g^{\max}(\underline{W} | T)$) is too small to offset the opportunity cost of high effort. Note that whether or not this condition holds depends on the parameters of the problem. For example, if $u(0)$ is infinitely negative, then there will never be quantity rationing. However, as mentioned above, we assume that all agents enjoy a safety net that prevents them from suffering infinite loss in the event that they forfeit all their collateral wealth, meaning that quantity rationing is possible.

It is straightforward to show that, if the lowest wealth agent is quantity rationed, then a large enough increase in financial wealth will always lead to the disappearance of quantity rationing.[15] Let $W^*(T)$ denote the financial wealth level such that quantity rationing just disappears. This threshold level of financial wealth thus satisfies: $u(\frac{T(\bar{x}^H - rk) + W^*(T) + p_T T}{\phi^H}) = \frac{d(H) - d(L)}{\phi^H - \phi^L} + u(0)$. Holding constant farm size,

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[15] As can be seen by inspecting the left-hand side of the inequality in equation (7), greater financial wealth will always increase $u(\frac{T(\bar{x}^H - rk) + W + p_T T}{\phi^H})$, while it leaves the term $\frac{d(H) - d(L)}{\phi^H - \phi^L} + u(0)$ unchanged.

agents with financial wealth greater than this threshold level will have at least one contract available to them and will not be quantity rationed. Intuitively, this result holds because the agent's ability to offer more collateral in the bad state of the world allows the lender to offer a higher payoff in the good state of the world without violating the zero profit constraint. As expected, for given T, quantity rationing is thus biased against financially poor agents.

Determining the direction of quantity rationing with respect to land is slightly more complicated. To understand how land wealth and financial wealth are different, consider the special case where land is untitled and $P_T = 0$ so that land can neither be used as collateral nor be sold and converted into end-of-period consumption. For a marginally quantity-rationed agent who enjoys financial endowment $W^*(T)$, an increase in land dilutes the agent's available (financial) collateral per dollar borrowed (recall that production requires k units of borrowing per unit T). Holding financial wealth fixed at $W^*(T)$, the maximum payout to the borrower per unit T that is consistent with non-negative lender profits, $s_g^{\max}(W \mid T)$, decreases with T.[16] This decrease would, other things equal, make it more difficult to ensure incentive compatibility, as can be seen from equation (8).

However, the marginal increase in T also creates an offsetting "incentive augmentation" effect. With more land, high effort in the commercial activity now yields a larger payoff as it affects the payout on more than T units of productive land. Indeed, as can can be seen in the left-hand side of equation (7), this incentive effect always offsets the collateral reduction effect as a larger value of T unambiguously increases the returns to high effort under the full wealth pledge contract.[17] The increase in T has no effect on the right-hand side of equation (7), and hence an increase in T for the marginally quantity-rationed agent will always ensure the availability of a loan contract.

It is easy to see that the same qualitative result holds when land is titled. A unit increase in titled land has the same effect as (*a*) a unit increase in untitled land, plus (*b*) an increase in financial wealth equal to p_T. Since, as we saw above, an increase in financial wealth

tends to relax quantity rationing, an increase in an agent's land endowment, whether it is titled or untitled, will also relax quantity rationing. Taken together, these results imply that $\partial W^*/\partial T < 0$. That is, the minimum financial wealth required to avoid quantity rationing is decreasing in productive wealth.

Risk Rationing and Financial Wealth

Our analysis of risk rationing proceeds along the same lines as that of quantity rationing. We begin by holding productive wealth constant and examining the existence of risk rationing and its incidence with respect to financial wealth. We show that for any given level of land, a sufficient increase in the drudgery of high effort will always suffice to ensure that there will exist a financial wealth level, $\hat{W}(T)$, such that the agent endowed with $\hat{W}(T)$ is just indifferent at the optimal contract between the subsistence and the commercial activities (i.e., that agent is marginally risk-rationed). Assuming that high effort is sufficiently undesirable so that the marginally risk-rationed agent indeed exists, this section then explores the incidence of risk rationing, asking whether it is the agents with financial wealth greater than or less than $\hat{W}(T)$ who will be risk rationed. This question is structurally similar to the one analyzed by Newman (1995), and especially Thiele and Wambach (1999), who examined how a risk-neutral firm owner's cost of hiring a risk-averse manager varies with the manager's financial wealth. Our analytical strategy for examining the wealth bias of risk rationing draws on the approach used by Thiele and Wambach (1999). Like them, we obtain a counterintuitive result about the impact of financial wealth, namely that it is the financially wealthy who will be risk rationed.

Turning first to the existence of risk rationing, it is relatively straightforward to show that we can always find parameter values such that the marginally risk-rationed agent exists. To see this, let $D \equiv d(H) - d(L)$ and $\Phi \equiv \phi^H - \phi^L$ and explicitly write the ICB, $\hat{s}_b(s_g)$ as:

(9)
$$\hat{s}_b = \frac{u^{-1}\left[u(W + T(p_T + s_g)) - \frac{D}{\Phi}\right] - (W + p_T T)}{T}.$$

Since u^{-1} is an increasing function it is easy to see that by increasing or decreasing the term $\frac{D}{\Phi}$, the ICB shifts down or up, respectively. If we make D large, we can drive $\hat{s}_b(s_g)$ to arbitrarily small (large negative) values. Since the

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[16] As defined by the lender's nonnegative profit condition, $s_g^{\max}(W \mid T) = \frac{\bar{x}^H - rK}{\phi^H} + \frac{1 - \phi^H}{\phi^H}\left(\frac{W}{T} + p_T\right)$. Note that this term is strictly decreasing in T due to the collateral-dilution effect.

[17] This result holds because $\bar{x}^H > rK$, meaning that incremental increases in project size create additional surplus beyond capital costs that can be distributed to the agent.

agent's indifference curve is independent of $\frac{D}{\Phi}$, we can always find parameter values to make any agent indifferent between her optimal contract and the reservation activity so that $\hat{W}(T)$ will always exist. In the analysis to follow, we assume that $\underline{W} < \hat{W}(T)$, where $\underline{W}$ is the minimum financial wealth possessed by an agent.

We turn now to the question of incidence: conditional on having access to a contract, will the financially wealthy or financially poor suffer risk rationing? At first glance, it would seem intuitive that those agents who are more sensitive to risk would be more likely to be risk rationed. Thus under decreasing absolute risk aversion (DARA), we might expect the relatively poor agents—given their greater willingness to pay for insurance—to be the first to retreat from the risk of the commercial activity. Indeed, if contract terms were exogenous to borrower wealth, this "risk-aversion effect," which (assuming DARA) gives the increase in the agent's willingness to accept a given contract when her financial wealth is increased, would imply that agents with financial wealth less than $\hat{W}(T)$ would be risk rationed while the wealthier agents would instead accept the contract and undertake the risky activity.

Contract terms are not, however, independent of borrower wealth. Lenders make contracts incentive compatible by driving a wedge between the borrower's payoffs, and thus consumption, across states of nature. Due to decreasing marginal utility of consumption, a constant differential in contractual payoffs,

This incentive-dilution effect, and the riskier contracts it necessitates, works in an opposite direction of the risk-aversion effect and makes it less likely that wealthier agents will accept the risky contract. Whether it is the financially poor or the financially rich that are risk rationed depends on the relative strength of these two opposing effects. Ultimately, the net outcome of these two effects depends on the nature of agent preferences and, more specifically, on the higher order curvature of the utility of consumption.

To explore the incidence of risk rationing with respect to financial wealth, define the utility of the marginally risk rationed agent under the subsistence reservation activity as $V^R(\hat{W};T)$ and the expected utility of that same agent under the commercial activity with the optimal contract as $V(\hat{W};T)$. Since $V(\hat{W};T) = V^R(\hat{W};T)$, the incidence of risk rationing will be determined by the sign of the following expression:

$$(10) \quad \Delta^W(\hat{W};T) \equiv V_W(\hat{W};T) - V_W^R(\hat{W};T).$$

where the W subscripts indicate derivatives taken with respect to financial wealth. If this expression is positive, then expected utility under the endogenous optimal contract exceeds that of the reservation activity as financial wealth increases, and the financially poor will be risk rationed. If instead $\Delta^W(\hat{W};T) < 0$, then the financially wealthy will be risk rationed.

With use of the envelope theorem we can write

$$(11) \qquad V_W = \frac{u'\bigl(W + T\bigl(s_b^* + p_T\bigr)\bigr)u'\bigl(W + T\bigl(s_g^* + p_T\bigr)\bigr)}{\phi^H u'\bigl(W + T\bigl(s_b^* + p_T\bigr)\bigr) + (1 - \phi^H)u'\bigl(W + T\bigl(s_g^* + p_T\bigr)\bigr)}$$

so that $\Delta^W(\hat{W};T)$ becomes

$$(12) \quad \Delta^W(\hat{W};T) \equiv \frac{u'\bigl(\hat{W} + T\bigl(s_b^* + p_T\bigr)\bigr)u'\bigl(\hat{W} + T\bigl(s_g^* + p_T\bigr)\bigr)}{\phi^H u'\bigl(\hat{W} + T\bigl(s_b^* + p_T\bigr)\bigr) + (1 - \phi^H)u'\bigl(\hat{W} + T\bigl(s_g^* + p_T\bigr)\bigr)} - u'((\omega + p_T)T + \hat{W}).$$

$s_g - s_b$, translates into a declining utility differential, $u(W + T(s_g + p_T)) - u(W + T(s_b + p_T))$, as financial wealth increases. Financially wealthier agents—who are less sensitive to a given contractual risk—must then face riskier contracts than poorer agents in order to maintain incentive compatibility. An increase in financial wealth thus implies a second effect, which we call the "incentive-dilution effect."

It turns out that this somewhat forbidding expression can be signed as the following proposition details:

PROPOSITION 2 (Risk Rationing and Financial Wealth). *Hold farm size fixed at T and assume that the agent preferences are described by DARA. Let A and P denote, respectively, the coefficients of absolute risk aversion and*

prudence. If P > 3A, then any agent with financial wealth greater than Ŵ will strictly prefer the risky commercial activity financed with her optimal contract, while agents with financial wealth less than Ŵ will prefer the low-return, certain subsistence activity. Similarly, if P < 3A then any agent with financial wealth greater than Ŵ will strictly prefer the subsistence activity while agents with financial wealth less than Ŵ will prefer the commercial activity under their optimal contract.

A proof of proposition 2 is provided in Boucher, Carter, and Guirking (2007). Under proposition 2, risk rationing can be biased either for or against the financially wealthy. Without additional assumptions about agent preferences, however, it is not clear whether we should expect the rich or the poor to be risk rationed. In general, the relative size of P and A depends on the functional form of $u(.)$ and on the level of income at which they are evaluated. We can gain some insights, however, by considering the class of constant relative risk averse (CRRA) preferences which implies a one-to-one mapping between the degree of relative risk aversion and the ratio P/A. Letting γ denote the coefficient of relative risk aversion, it is straightforward to show that $\gamma < 1/2$ is equivalent to $P > 3A$. If we believe that preferences are adequately described by CRRA preferences, we might be more inclined to expect risk rationing of the rich since most empirical studies, such as those cited in Gollier (2001), suggest that plausible values for γ lie between 1 and 4.

For the remainder of the paper, we restrict attention to these "empirically plausible" preferences such that $P < 3A$. As such, risk rationing will occur independently of the relative size of W^* and $\hat{W}$. If $\hat{W} > W^*$, then all agents with financial wealth greater than $\hat{W}$ will be risk rationed, while if $\hat{W} < W^*$, then only agents with financial wealth greater than W^* will be risk rationed.[18]

Risk Rationing and Productive Wealth

While the analytics behind risk rationing of the financially rich are clear, the result itself feels unsatisfactory. As discussed by Newman (1995), it is rather hard to accept the result that poor workers should undertake risky in-

vestment projects and hire in the wealthy as wage workers, or, in our case, that the rich retreat to low-return subsistence crops while the poor adopt high-return but risky commercial crops. Part of the counterintuitiveness derives from the fact that in the real world, individuals and households hold wealth in multiple forms. It is important to emphasize that the above result regarding the incidence of risk rationing holds constant land (or productive wealth) and defines "rich" and "poor" only with respect to the agent's endowment of financial wealth. With this in mind, it is perhaps not too much of a stretch to imagine that a household with significant nonfarm earnings or wealth could be risk rationed. As farming represents a relatively small portion of their income, the household is relatively insensitive to the risk associated with the commercial activity (and thus is required by lenders to bear significant risk). At the same time, however, the cost in terms of foregone income that results from this financially wealthy household retreating to the low-risk activity is, as a proportion of the total income, relatively small.

The picture changes, however, when we consider changes in the household's endowment of land. While an increase in farm size is accompanied by both the risk-aversion and incentive-dilution effects, it also implies an additional effect not present in the case of financial wealth. Specifically, because exploiting the land with the risky activity yields a higher return, retreating to the safe activity becomes increasingly costly as farm size increases. This "incentive-augmentation" effect, introduced in our discussion of quantity rationing, reinforces the risk-aversion effect and raises the possibility that the incidence of risk rationing with respect to productive wealth (land) may be the opposite of financial wealth.[19]

We now formally explore this possibility. Specifically, we ask: will the relatively land-poor be risk rationed while the land-wealthy choose to participate in the credit market and fully exploit their productive asset (land)? To

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[18] A proof of the existence of economically relevant risk rationing for the less empirically plausible case of $P > 3A$ is available from the authors.

[19] An alternative means of "overturning" the counterintuitive result is to relax the assumption of separability of effort and income in the agent's preferences. In their labor market application, Thiele and Wambach (1999) pursue this strategy numerically and show that—for plausible coefficients of relative risk aversion—risk rationing of the poor can be obtained if the disutility of effort is decreasing in income. In this case, since the "cost" of high effort is decreasing in income, wealthier agents need a smaller utility differential across states to maintain incentive compatibility. In terms of the language used here, an increase in the agent's financial wealth weakens the incentive-dilution effect, making it easier for the risk-aversion effect to dominate.

explore this question, we proceed in a similar fashion as in the previous section. We now hold financial wealth fixed and let $\hat{T}$ denote the land size such that the agent is indifferent between the two activities so that:

$$(13) \quad V^R(\hat{T}; W) = V(\hat{T}; W)$$

where, as before, V^R is the utility of the reservation activity and V is the expected utility of the commercial activity under the optimal loan contract. Analogous to the prior section, the land-poor will be risk rationed if $\Delta^T(\hat{T}; W) \equiv V_T(\hat{T}; W) - V_T^R(\hat{T}; W) > 0$, where the subscripts T now indicate derivatives taken with respect to productive wealth. The land-rich will instead be risk rationed if the opposite sign holds. Following the same logic used in the proof of proposition 2, it can be shown that under the endogenous optimal contract

$$(14) \quad V_T = (\bar{x}^H - rk + p_T) \frac{u'(W + \hat{T}(s_g^* + p_T))u'(W + \hat{T}(s_b^* + p_T))}{(1 - \phi^H)u'(W + \hat{T}(s_g^* + p_T)) + \phi^H u'(W + \hat{T}(s_b^* + p_T))}$$

and that

$$(15)$$

$$V_T^R(\hat{T}; W) = (\omega + p_T)u'((\omega + p_T)\hat{T} + W).$$

Assembling these terms, $\Delta^T(\hat{T}; W)$ can be rewritten as

$$(16) \quad \Delta^T(\hat{T}; W) = \left[\rho \frac{u'(W + \hat{T}(s_g^* + p_T))u'(W + \hat{T}(s_b^* + p_T))}{(1 - \phi^H)u'(W + \hat{T}(s_g^* + p_T)) + \phi^H u'(W + \hat{T}(s_b^* + p_T))} \right.$$

$$\left. - u'((\omega + p_T)\hat{T} + W) \right](\omega + p_T)$$

where $\rho = \frac{\bar{x}^H - rk + p_T}{\omega + p_T}$ is the ratio of the expected marginal returns to land when used in the commercial versus subsistence activities. As before, $\Delta^T(\hat{T}; W) > 0$ will imply risk rationing of the land-poor.

Note that the expression within brackets is identical to equation (12) except that the first term (which captures marginal expected utility returns to the commercial activity) is multiplied by ρ. Under assumption $(A.1)$, $\rho > 1$ and represents the incentive augmentation effect that makes it more likely that the land-rich will choose to use their assets entrepreneurially. This additional term makes it more likely that $\Delta^T(\hat{T}; W)$ from equation (16) will be positive and that the land-poor will be risk rationed. Consistent with the intuition

discussed above, the larger are the relative returns to high effort entrepreneurialism, the more likely it is that the productive asset-rich will have adequate incentives to supply high effort and the less need for high risk, draconian credit terms to induce high effort. However, without imposing additional structure on preferences, we cannot derive a neat analytic condition equivalent to the $P > (<)3A$ conditions of Proposition 2 that are necessary and sufficient for risk rationing of the land rich or the land-poor. From equation (16), however, we do know that the more empirically plausible condition, $P < 3A$, is necessary but not sufficient for risk rationing of the land-rich, while the less plausible condition, $P > 3A$, is sufficient but no longer necessary for risk rationing of the land-poor. Thus under the empirically more plausible assumption that $P < 3A$, both types of risk rationing with respect to productive wealth could occur.

Numerical Analysis of the Incidence of Nonprice Rationing

The analysis in the prior sections has identified conditions under which risk and quantity rationing will exist. The incidence of quantity rationing with respect to financial and productive wealth is clearly identified analytically. Under reasonable assumptions about the nature of preferences, the financially wealthy will be risk rationed. However, the incidence of risk rationing with respect to productive wealth depends on the more subtle interplay of a number of parameters and no simple analytical expression exists that indicates whether it is the land-poor or -rich who will be risk rationed. To gain better purchase on the incidence of risk rationing, and its interaction with quantity rationing, this section uses numerical analysis to map out the regions of endowment space that are subject to different forms of rationing in credit markets.
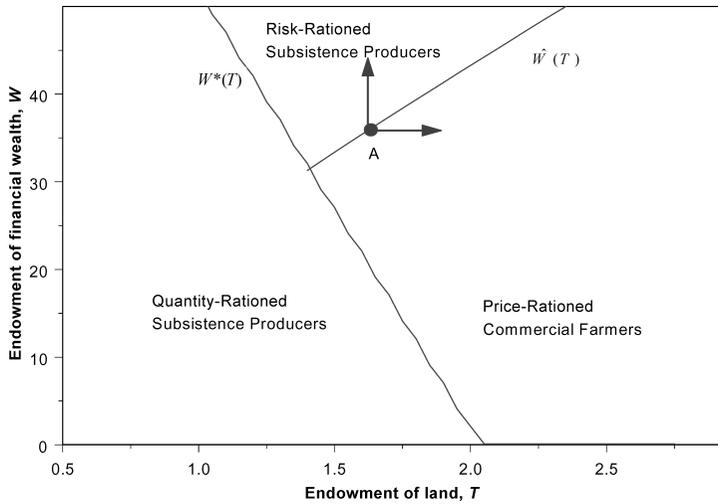
Figure 2. Risk rationing and activity choice

Figure 2 reports the results of a numerical analysis, mapping out the regions of the endowment space that are characterized by the different types of price and nonprice rationing. The appendix reports the full set of parameter values used for the numerical analysis.[20] We assume that agents have constant relative risk aversion and for the analysis, we set the coefficient of relative risk aversion to 1.1 (meaning that $P < 3A$). Note that this value is empirically plausible and is in the range where the financially wealthy will be risk rationed. Other parameters are set such that both risk and quantity rationing occur over the illustrated portion of the endowment space (recall from the earlier analysis that high effort must be sufficiently onerous in order for nonprice rationing to exist). Finally, we assume, for the moment, that all land is untitled and the market price of land, p_T, is set equal to zero. While the assumption of a zero land price is an extreme representation of the impact of tenure insecurity on land marketability, it will permit us, in the next section, to isolate the full impact of land titling.

The solid lines in figure 2 divide the endowment space into credit rationing and activity regimes. The downward sloping line, $W^*(T)$, is the quantity rationing locus. There is no contract available to the agents with endowment locations below that line, and hence that portion of the endowment space is characterized

by quantity rationing. Above that line, competitive loan contracts are available. Under this numerical specification, the incentive effects of the large endowments of productive assets are strong enough that there is no quantity rationing of agents who have at least 2.1 units of land.

The upward sloping solid line, $\hat{W}(T)$, marks the risk rationing boundary for the agents with untitled land. Agents above that line are risk rationed, preferring the safe subsistence activity to the risky commercial activity financed by the optimal contract. Agents below that line are price rationed and accept the optimal contract and undertake the entrepreneurial activity. The arrows emanating from the marginally risk-rationed agent at point A illustrate the different impacts of the two types of wealth on risk rationing. A move straight north from A, representing an increase in financial wealth holding productive wealth fixed, generates risk rationing of the wealthy. In contrast, agents straight east of point A will not be risk rationed and will instead borrow and undertake the risky commercial activity. The positive slope of $\hat{W}(T)$ implies that, for this parameter set, agents with greater productive wealth will become the entrepreneurs. Under our specification, the key parameter, ρ, reflecting the ratio of returns to the commercial versus subsistence activities, is sufficiently large so that the incentive augmentation effect of having an additional unit of productive wealth is strong enough that the optimal contract becomes less onerous for agents with additional productive land. Agents with less productive wealth than

A will undertake the reservation activity of subsistence farming. Together, quantity and risk rationing create a cone of agents who will undertake the risky, entrepreneurial activity. The cone, the area below $\hat{W}(T)$ and to the right of $W^*(T)$, widens as the distance from the origin increases, indicating that it is indeed the wealthy who become the entrepreneurs, fully exploiting their productive asset under the commercial activity.

Land Titling and the Incidence of Nonprice Rationing

Prompted by seminal analytical work such as that by Feder et al. (1988), as well as by the more popular work of De Soto (2000), efforts to securely title land have risen to prominence on the agricultural development policy agenda. Such programs are hypothesized to induce greater investment when land owners become more certain of their ability to fully reap the future gains from the investments sunk into land. By transforming "dead" assets into collateralizable capital, land titling is also hypothesized to restructure access to capital and enhance economic performance. Because untitled or insecurely held land tends to be empirically a more significant problem for poorer households, land titling programs are argued to present a win-win scenario in which they promote both growth and directly reduce poverty and economic inequality.

While a number of studies have tried to evaluate the empirical veracity of these claims (see the summary in World Bank (2003)), few have been able to isolate the capital access effects separately from the investment demand side of the story. One exception is the work of Carter and Olinto (2003) who empirically found that titling only amplifies credit supply for a subset of wealthier producers. They interpret their result to mean that the increase in collateral wealth created by titling is insufficient to relax quantity rationing constraints for the smallest producers. In a similar vein, the empirical studies by Fields and Torero (2005) and Galeana (2005) find that titling programs in urban Peru and the ejido sector of Mexico, respectively have failed to increase beneficiary households' participation in formal credit markets.

While the model put forward in this paper does not permit us to analyze investment demand effects of land titling, it does permit a richer analysis of the impact of titling on both demand and supply in the credit market.

Figure 3 demonstrates this impact. The solid lines repeat the credit rationing regime boundaries from figure 2. These curves are now subscripted with "*nt*" to indicate that these regime boundaries correspond to the no-title scenario. The dashed lines show how these boundaries shift when land is titled and p_T rises.[21] Under this new specification, titled land becomes capital in De Soto's (2000) sense of the word and has collateral value. In addition, because it is marketable, increments of titled land have the same risk-bearing and incentive-dilution effects as financial wealth. Finally, land titling reduces the incentive-augmentation effect as the key parameter $\rho = \frac{\bar{x}^H + p_T - rk}{\omega + p_T}$ is decreasing in the price of land.

As can be seen in figure 3, land titling shifts down the quantity rationing frontier by a vertical distance of $p_T T$ to $W_t^*(T)$.[22] This downward shift represents the hypothesized increase in credit supply resulting from the increased collateralization of agents' assets. Depending on the parameter values, this downward shift may not be sufficient to completely eliminate quantity rationing for the lowest wealth borrowers, a finding that is consistent with the empirical work of Carter and Olinto (2003). In addition, land titling shifts the risk rationing frontier to the southeast to $\hat{W}_t(T)$.[23] The net effect of land titling on the topography of nonprice rationing can thus be summarized as follows. Agents in the portion of the endowment space labeled I are unaffected and are quantity rationed both before and after land titling. Similarly, the agents in zones III and V do not change their status, respectively, remaining as price-rationed commercial farmers and risk-rationed subsistence farmers.

More interesting are the agents located in areas II, IV, and VI of the endowment space. Those in area II receive positive benefits from titling, and move from being quantity-rationed subsistence farmers prior to titling to becoming price-rationed commercial farmers after titling. Agents in area VI shift from being quantity rationed to risk rationed. These agents have an improved access to credit (post-titling,

[21] All other parameters are held at the values underlying the boundaries in figure 2. These values are detailed in the appendix.
[22] Since the acquisition of a title is equivalent to an increase in financial wealth equal to the market value of the agent's land endowment, the marginally quantity-rationed agent with title has exactly $p_T T$ less financial wealth than the marginally quantity-rationed agent without title.
[23] The shift in $\hat{W}(T)$ is not a parallel one as the new wealth effects of titled land increase in magnitude as the amount of titled land increases.
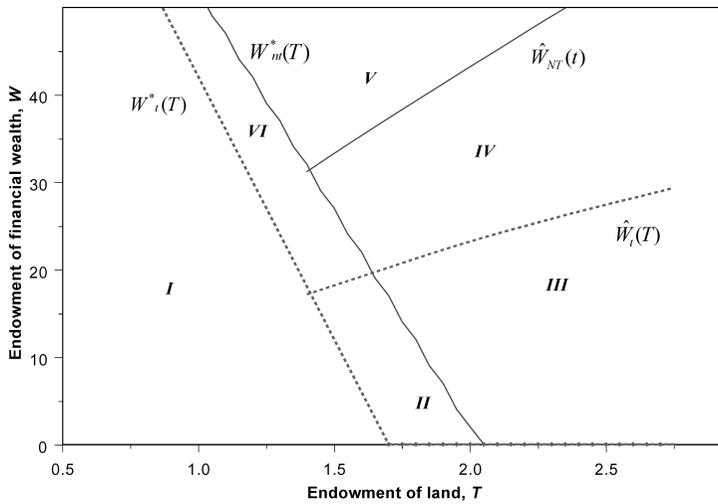
Figure 3. Titling, credit rationing, and activity choice

they have sufficient collateralizable wealth to qualify for a loan contract), but they are unwilling to bear the risk of newly available contracts in the absence of insurance markets given the heavy collateral requirements that result from the asymmetric information and moral hazard. Finally, the agents in area IV of the wealth space shift from being price-rationed commercial farmers pre-titling to risk-rationed subsistence farmers following land titling. This somewhat surprising shift results from the fact that the increased marketability of their land dilutes incentives for the provision of high effort, leading the financial system to offer only more heavily collateralized, and less favorable, loan contracts.

These results are of course ultimately artifacts of the particular numerical specification used to analyze the model. The real-world effects of land titling would depend on the true parameter values, as well as on the distribution of agents across the different zones of the endowment space. Nonetheless, this theoretical perspective suggests how such empirical analysis needs to be structured in order to fully comprehend the impact of land titling efforts.[24]

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[24] Recently collected data from an agricultural region in Peru indeed shows that the land titling was accompanied by a shift in the credit rationing regime boundaries consistent with figure 3. Guirkinger and Boucher (2006) report that between 1997 and 2003, individual titles were provided to 40% of the sample farmers. Quantity rationing in this area fell from 50% to 15% of all farmers. At the same time, risk rationing went up by 50%, rising from 14% to 21% of all farm households. While the net effect was a reduction in nonprice rationing, these figures illustrate that titling in the absence of insurance markets may be insufficient to eliminate the costs of asymmetric information in credit markets. The discussion

Conclusion

The theoretical model developed in this paper has shown that by shrinking the available menu of loan contracts, the asymmetric information can result in two sorts of wealth-biased, nonprice rationing in credit markets. The first is conventional quantity rationing in which a subset of low-wealth agents find that no contract is made available to them because they lack the minimum collateral necessary to secure a loan. The second is what this paper has labeled risk rationing. Risk-rationed agents are able to borrow, but only under relatively high-collateral, moral hazard-proof contracts that expose them to an unacceptable risk of collateral loss. Absent insurance markets that permit them to independently insure against this risk, the risk-rationed will turn down the available loan contract and retreat to a safe reservation activity that offers them higher expected utility, but lower expected returns.

Like quantity-rationed agents, the risk-rationed are a class for whom decentralized credit markets do not perform well. Both risk and quantity rationing are also socially expensive as otherwise bankable projects (in which the expected returns exceed the opportunity cost of capital) are not undertaken in a world constrained by moral hazard and missing insurance markets. Risk rationing is likely to be particularly relevant in the agriculture of

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here of these simple descriptive results is of course no substitute for a more thorough econometric analysis. Future work will more carefully analyze these data.

developing countries where insurance markets are scarce and risk averse agents may seek credit contracts both to overcome liquidity constraints and to obtain insurance against production or price shocks. Data from several Latin American farm surveys reveal exactly this pattern as some 15% to 20% of the agricultural producers are risk rationed and allocate their resources to low-returning activities in a way that mimics the behavior of quantity-rationed producers.

While the incidence of conventional quantity rationing is straightforward (the poor cannot qualify for loan contracts), the incidence of risk rationing is less straightforward. One contribution of this paper has been to show that its incidence depends on the type of wealth. In particular, this paper shows that Newman's (1995) counterintuitive finding that the poor and not the rich will be the entrepreneurs is true only for financial wealth. The opposite is likely to be the case for the agents who enjoy large endowments of productive wealth or land. Data from the Latin American farm surveys are consistent with this expectation that risk rationing will be biased against small farmers.

Finally, this paper's model, with its more nuanced understanding of the demand and supply sides of the credit markets, permits exploration of the impact of land titling programs. While titling land indeed reduces quantity rationing by enhancing the collateral value of a farmer's wealth, it does not necessarily increase the farmer's willingness to put her wealth at risk. The model thus predicts that land titling would not only reduce quantity rationing, but would also increase risk rationing. The model thus helps interpret the recent empirical results that find limited impacts of land titling programs on investment and credit market participation in Latin America (Carter and Olinto (2003); Fields and Torero (2004); and Galeana (2005)).

While the empirical illustrations used in this paper are meant to be more provocative than definitive, together with the theoretical argument, they do underwrite two strong practical suggestions. The first is that the empirical analysis of rural financial markets needs to consider the possibility of risk rationing. Failure to account for risk-rationed agents, who have bankable projects but are discouraged from implementing them because of the riskiness of the available loan contracts, may lead to a misrepresentation of the health of the rural financial system. This bias is especially likely to be the case if the risk-rationed are simply ignored and mixed in with the price-rationed, making the behavior of this group appear to more closely match the productivity and the behavior of the quantity-rationed.

The paper's second practical implication concerns the design of policies aimed at improving the functioning of the rural credit markets and the functioning of the agricultural economy. While the current wave of policies oriented toward providing farmers with legally secure land titles is warranted on several grounds, the analysis here warns that titling may simply shift some producers from the quantity-rationed to the risk-rationed box. Resolution of this problem, and realization of the full productive potential of agriculture (especially small farmer agriculture), will require more than the provision of land titles. Locally based credit institutions that suffer less from asymmetric information and can thus offer credit contracts with less collateral risk offer one possible resolution. While microcredit institutions and informal local lenders may fit this bill (see Boucher and Guirkinger(forthcoming) for the latter), their ability to finance agriculture may be limited by the existence of covariant risks. In this case, comprehensive reform of agricultural credit markets will require the innovation of instruments to directly reduce risk. Current efforts to promote moral hazard proof weather insurance (e.g., see Hess et al. (2002) and Skees et al. (2001)) may be one way to resolve this problem and underwrite an agricultural economy in which markets work for both large-and-small-scale producers.

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Appendix Numerical Analysis

Utility

(A.1)

$$u(C_j, e)$$
$$= \begin{cases} \left(\dfrac{1}{1-\gamma}\right)(C_j + c_0)^{(1-\gamma)} - D, & \text{if } e = H \\ \left(\dfrac{1}{1-\gamma}\right)(C_j + c_0)^{(1-\gamma)}, & \text{otherwise} \end{cases}$$

where $\gamma = 1.1$, $D = 1.1$, and $c_0 = 10$

Entrepreneurial Activity

Gross entrepreneurial incomes:	$x_g = 100$; $x_b = 0$.
Success probabilities:	$\phi^H = 80\%$; $\phi^L = 20\%$.
Capital investment requirement:	$k = 25$.
Interest rate:	$r = 20\%$.
Expected net entrepreneurial income under high effort:	$\bar{x}^H - rk = 62$;

Safe Wage/Rental Activity

Subsistence returns per unit land	$\omega = 25$.
Land price (titled)	$p_T = 10$.