

## EQUILIBRIUM CREDIT RATIONING OF SMALL FARM AGRICULTURE\*

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It is often argued that externally imposed contractual restrictions lead to inequitable credit rationing. This paper argues that *unrestricted*, laissez-faire markets may also inequitably ration credit. A formal model, which grants borrowers autonomy in credit application and use, demonstrates that adverse incentive and selection effects may cause banks to endogenously impose interest rate restrictions and ration small farms out of the credit market. Consequently, liberalization of financial markets may be insufficient to guarantee small farms access to credit.

### 1. Introduction

Recent years have seen the growth of a large literature which is critical of interest rate restrictions on agricultural loans in LDCs [see the Adams and Graham (1981) review]. Foremost in this literature is the proposition that governmentally imposed interest rate restrictions cause banks to ration credit in a way that excludes small farms from formal credit markets. Gonzalez-Vega (1977) dubs this 'the iron law of interest rate restrictions'. The present paper uses a theoretical model to argue that unrestricted, laissez-faire credit allocation is likely to be similarly unequal because of statistical discrimination against small firms, and because adverse incentive and selection effects may lead banks to ration small farms out of the credit market. The analysis thus tries to account for the pattern of unequal credit access which has been observed empirically [e.g., Barraclough (1982)] and incorporated as a stylized fact into models of agrarian structure and performance [e.g., Feder (1985) and Eswaran and Kotwal (1986)]. On a policy level, the analysis suggests that the informational problems which ultimately underlie credit rationing must be addressed if formal credit is to be extended to the small farm sector.

The model developed in this paper draws on Stiglitz and Weiss (1981) and Tybout (1984). It has three key assumptions – a contractual, an informational, and an environmental one:

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- (1) Contractually it assumes that loans are always undercollateralized in the sense that the net value of collateral to the lender is less than principal plus interest.
- (2) Informationally it assumes that a lender cannot distinguish between individuals within a class of borrowers, and that the lender cannot monitor individual behavior.
- (3) Environmentally it assumes that small farm production is riskier than large farm production because of the less diversified resource base of small farms.

While it is argued that all three assumptions are quite defensible in the context of LDC agriculture, they do circumscribe the generality of the results.

Section 2 of the paper characterizes the production and information environment of the model. Section 3 models credit allocation by a bank which faces distinguishable groups of borrowers whose behavior is assumed to be unaffected by loan contract terms. Under these conditions it is shown that contractual restrictions may indeed lead profit maximizing banks to exclude small farms from the credit market. However, even in the absence of restrictions, allocation of credit to small farms is distorted by a form of statistical discrimination. Section 4 expands the model to permit borrowers to change their behavior in response to contract terms. Borrowers endogenously self-select and change their choice of technique and credit use as contract terms change. Because the average characteristics of a borrowing group can worsen as credit terms change, banks may impose their own interest rate restrictions, causing laissez-faire credit allocation to follow an 'iron law' of credit rationing similar to that generated by governmentally imposed interest rate restrictions.<sup>1</sup>

## **2. Production and information in LDC agriculture**

This section offers a stylized representation of the production and information environment of LDC agriculture. Later sections model the allocation of annual production credit by a formal lender (the 'bank') within this environment.

The bank is assumed to face observationally distinguishable groups of borrowers. It knows the average characteristics of each group, but it cannot

<sup>1</sup>Like most social science propositions, there is nothing immutable nor metallic about 'laws' of credit rationing. In addition to the assumptions stated in the text, rationing results depend on the assumption that profit maximization guides credit allocation. Clearly there is no necessity to this assumption. Post-revolution Nicaragua, for example, tried to bend profit maximizing rationing principles by diverting credit to the small farm, food producing sector. Such a diversion could be socially efficient if the distortions of profit maximizing credit allocation discussed in this paper are serious.

distinguish between members of a group, nor can it monitor individual behavior. The bank is thus vulnerable to shifts in the behavior and composition of a group. The bank offers loans of a fixed amount per hectare. This assumption does not stray far from actual LDC agricultural bank practice. The seed-fertilizer package approach to the green revolution has led to standardized per-hectare lending. Recent research [e.g., Horton (1984)] shows that farmers often do not completely adopt recommended packages, and in section 4 farmers are given autonomous choice of technique. For simplicity's sake, the loan package is assumed to be 1 dollar per hectare.

Per-hectare agricultural production is specified as

$$Q_{ij} = \theta_{ij} g_i(K).$$

$Q_{ij}$  is per-hectare production revenues for the  $j$ th farm in the  $i$ th group. These revenues measure the farm's repayment capacity and thus are net of non-financed post-harvest expenditures (e.g., labor payments or subsistence obligations). The function  $g_i$  which differs across farm groups, has a positive first and a negative second derivative.  $K$  is the price aggregated value of purchased inputs, which is less than or equal to the \$1 loan amount. The stochastic term  $\theta_{ij}$  reflects the impact of uncontrollable natural events and inputs on production. It is assumed that  $\theta$  ranges over the closed interval  $[0, m]$ , where the maximum value  $m$  can be viewed as optimal production conditions. Each farmer knows the specific distribution for his  $\theta_{ij}$ , while the lender knows only average distributions for borrower groups. Probability distributions between individuals are assumed to differ by mean preserving spreads (defined below). Let  $f_i(\theta)$  be the average probability density function (pdf) for the  $i$ th group. The cumulative density function,  $F_i(\theta)$ , is defined as

$$F_i(x) = \int_0^x f_i d\theta \quad \text{where} \quad F_i(m) = 1.$$

Much of the LDC agricultural credit literature focuses on the allocation of credit between 'large' and 'small' farms. While imprecise, and meaning different things in different places, this classification does point to the structural dualism common in LDC agriculture. The analysis here observes this classification and assumes that lenders can costlessly segregate borrowers into large and small farm groups. Let the subscript 1 indicate small farms, and subscript 2 large farms. Lenders correctly perceive two differences assumed to exist in the average characteristics of large versus small farms. First, the pdf of the risk parameter  $\theta$  of small farms differs from the pdf of large farms by a mean preserving spread,

$$f_1(\theta) = f_2(\theta) + s(\theta), \tag{1a}$$

where  $s$  is defined so that

$$\int_0^m s \, d\theta = \int_0^m \theta s \, d\theta = 0, \quad (1b)$$

and

$$\int_0^y (F_1 - F_2) \, d\theta \geq 0 \quad (1c)$$

for  $y < m$ .<sup>2</sup> Second, average per-hectare revenues of small farms are less than those of large farms,

$$g_1(K) \leq g_2(K) \quad \forall K.$$

The greater variation in small farm revenue implied by the mean preserving spread (1a) reflects the less diversified resource base on small farms. Micro-environmental events can easily affect the entire production of a small farm plot, whereas diversity across fields is likely to smooth out fluctuations in per-hectare production on large farms, which can be conceptualized as diversified holdings of multiple small plots. For example, following the subdivision of a 200 hectare rice farm in the Dominican Republic, the *intranannual* coefficient of variation of net income across the resulting 66 three hectare farms was 63% [Carter (1987)]. While it would be incorrect to attribute all this variation to environmental events, a figure of this magnitude across seemingly homogeneous farms is consistent with the assumption of relative revenue instability on and among small farms.<sup>3</sup>

The assumption that  $g_2(K)$  is not less than  $g_1(K)$  can be justified in several ways. First it may reflect some scale economy in the production process – perhaps large farms can obtain better quality and more timely inputs. Second, it may reflect the greater experience and skill of large farms in using modern techniques. It might be objected that this assumption contradicts the

<sup>2</sup>Rothschild and Stiglitz (1970) demonstrates the equivalence between these integral conditions and more conventional definitions of risk.

<sup>3</sup>Some of the reported variation undoubtedly reflects diversity in farming skill and strategy. Commentators dating back to Lenin and Chayanov have noted the strong diversity of small farm performance. Unlike large farms, which can be expected to respond to market prices and follow the dictates of conventional profit maximization, small farms may optimize household utility. That the latter maximand may lead small firms to stray from profit maximizing behavior has long been recognized [Singh, Squire and Strauss (1986) give an elegant rendition]. Of particular relevance here is the implication that in *equilibrium* one would expect variation in small farm productivity, while large farms should appear identical (assuming constant returns to scale). Such variation could result from the static allocational differences usually discussed, and also from less skilled small producers (who should exit farming by commercial criteria) continuing to produce because of weak alternative opportunities for their household resources. From the point of view of the lender, such diversity in small farm strategy would further augment the variability in small farm revenue recorded by condition (1a).

commonly observed inverse farm size–productivity relationship. However, Carter (1984), for example, estimates that the inverse relationship results from allocational behavior of small farmers (e.g., labor intensive multiple cropping) and not from higher small farm productivity for a given technique. Repayment capacity, which the  $g_i$  functions measure, could thus fulfill the hypothesized inequality even in the presence of an inverse relationship. In any event, the results presented below unambiguously carry through as long as the reverse strict inequality ( $g_1 > g_2$ ) does not hold.

### 3. Credit allocation when group characteristics are fixed

This section examines credit allocation under the assumption that the composition and average characteristics of each loan applicant group are fixed to the lender and are invariant to contract terms. The analysis proceeds under the further assumption that individuals who receive loans purchase and apply the recommended \$1 seed–fertilizer package. Section 4 relaxes these assumptions, and endogenizes group characteristics to reflect borrower self-selection and autonomy in credit use.

#### 3.1. Lender behavior and iso-expected profit contracts

The bank offers loan contracts for the fixed \$1 amount per hectare in order to maximize expected profits. There are two variable contract terms: the interest rate,  $i$ , and per-hectare collateral requirements,  $c$ . Loan contracts are completely described by two variable parameters,  $c$  and  $r$ , where  $r = (1 + i)$ .

Lender profits per-hectare financed, or equivalently per-dollar loaned, are

$$\pi(r, c) = \min(Q + c, r) = \begin{cases} Q + c & \text{if } \theta < (r - c)/g(1), \\ r & \text{if } \theta > (r - c)/g(1). \end{cases}$$

Note that  $r$  is the lender's return when the \$1 loan is completely repaid. This specification, which follows Stiglitz and Weiss (1981), contains two implicit assumptions. First, it rules out voluntary default. The loan is always repaid if production is high enough to permit it. This assumption of no voluntary default is partially relaxed in section 4. There the individual can, through choice of technique, divert credit to non-production uses, but will still repay the loan if production permits. Also implicit in this specification of lender profits is the assumption that the value of collateral to the lender,  $c$ , is less than  $r$ , the principal and interest owed on the loan. This assumption is crucial to the way the model works, and it underlies the adverse self-selection discussed later. Within the context of loans to small farms, this assumption is probably not inaccurate given their limited assets and insecure tenure, and the

costs which would be associated with seizing collateral assets. Fig. 1 graphs lender profits as a function of  $\theta$ . Note that at the kink point  $t$ ,  $\theta = (r - c)/g$ .

Given the greater riskiness and lower productivity of small farms specified in section 2, it can be shown that for given contract terms  $\bar{r}$  and  $\bar{c}$  expected bank profits are higher on loans to large farms than on loans to small farms,<sup>4</sup>

$$E\pi(\bar{c}, \bar{r} | g_2, f_2) - E\pi(\bar{c}, \bar{r} | g_1, f_1) \geq 0. \quad (2)$$

This proposition can be most easily demonstrated by separately considering the impacts of productivity and risk differences on lender profits.

First, it is intuitively obvious and easy to demonstrate that expected lender profits are greater on loans to higher productivity farms when risk is held

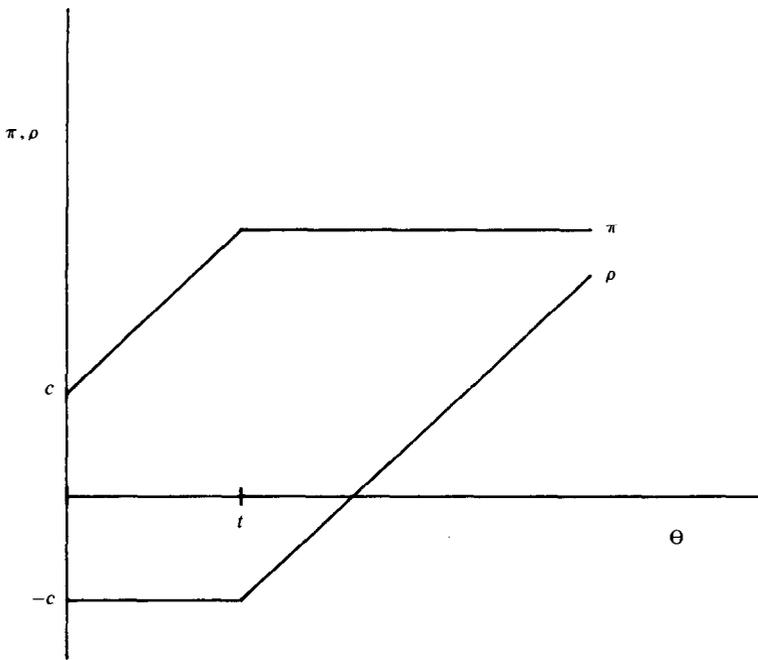


Fig. 1. Lender profit and borrower returns functions.

<sup>4</sup>The analysis here excludes borrower and lender transaction costs. These costs would be relatively high per dollar loaned to small farmers. Inclusion of lender transaction costs would serve only to widen the expected profit gap between large and small farm loans. [Tybout (1984) models differential transactions costs.] Inclusion of borrower transaction costs could cause small farmers to self-select out of the credit market at lower rates of interest [see Adams and Nehman (1979) and Binswanger and Sillers (1983)]. In this case the impact of statistical discrimination discussed in section 3.2 would be even larger, with perhaps all small farmer credit demand drying up as the interest rate is pushed up to offset the unfavorable production, risk and transaction cost characteristics of small farmers.

constant across farms. In other words, suppressing the notation indicating the fixed contractual terms,

$$E\pi( | g_2, \bar{f} ) - E\pi( | g_1, \bar{f} ) \geq 0, \tag{3}$$

where as before  $g_2 \geq g_1$ .

Expected lender profits are also greater on lower risk farms when productivity is assumed to be constant across farms,

$$E\pi( | \bar{g}, f_2 ) - E\pi( | \bar{g}, f_1 ) \geq 0, \tag{4}$$

where as before  $f_1 = f_2 + s$  and  $s$  is a mean preserving spread. This latter proposition can be demonstrated by substituting in the expression for expected lender profits given fixed contract terms  $\bar{c}$  and  $\bar{r}$ ,

$$\left[ \int_0^t (\bar{c} + \theta \bar{g}) f_2 d\theta + \int_t^m \bar{r} f_2 d\theta \right] - \left[ \int_0^t (\bar{c} + \theta \bar{g}) f_1 d\theta + \int_t^m \bar{r} f_1 d\theta \right].$$

Rearranging terms and integrating by parts gives

$$(\bar{r} - \bar{c}) \{ F_1(t) - F_2(t) \} - \bar{g} \left\{ (\theta(F_1 - F_2))'_0 - \int_0^t (F_1 - F_2) d\theta \right\}.$$

Noting that  $t = (r - c)/g$  this expression reduces to

$$\bar{g} \int_0^t (F_1 - F_2) d\theta,$$

which is non-negative by condition (1). More generally, if  $\xi$  indexes pdf's made more risky through the consecutive addition of mean preserving spreads, then  $\partial E\pi/\partial \xi \leq 0$  (where the index  $\xi$  increases with risk).

Intuitively, this result can be explained as follows. Expected lender profits diminish with mean preserving risk because the increased probability of low production (and lender returns below  $r$ ) which occurs as risk increases, is not offset by extraordinary lender profits when production is high. Even under exceptionally fortuitous circumstances, the lender only receives the return  $r$ . Therefore increased risk always diminishes bank profits as the concavity of the lender profit function in fig. 1 implies.

The initial proposition of the differential probability of loans to large and small farms can now be seen by rewriting (2) as

$$[E\pi( | g_2, f_2 ) - E\pi( | g_2, f_1 )] + [E\pi( | g_2, f_1 ) - E\pi( | g_1, f_1 )].$$

By (3) and (4), both expressions in square brackets are positive, so that expected profits are in fact higher on large farms if contract terms are identical.

However, if there are no contractual restrictions, lenders can always realize the same profits on loans to small farms as on loans to large farms by offering different loan terms to the different groups. To see this, consider the following model of lender behavior.

Let  $\bar{E}\pi$  be the opportunity cost of loanable funds to the bank.<sup>5</sup> The profit maximizing bank will offer loans to members of group  $i$  if there exist group specific contract terms such that

$$E\pi(r_i, c_i | g_i, f_i) \geq \bar{E}\pi. \quad (5)$$

Such contract terms always exist as can be seen by examining the total differential of the iso-expected profit condition (5),

$$d\bar{E}\pi = \frac{\partial E\pi}{\partial \xi} d\xi + \frac{\partial E\pi}{\partial g} dg + \frac{\partial E\pi}{\partial r} dr + \frac{\partial E\pi}{\partial c} dc = 0,$$

where

$$\frac{\partial E\pi}{\partial g} > 0, \quad \frac{\partial E\pi}{\partial \xi} \leq 0, \quad \frac{\partial E\pi}{\partial r} = 1 - F(t) > 0 \quad \text{and} \quad \frac{\partial E\pi}{\partial c} = F(t) > 0.^6$$

Higher risk and/or lower farm productivity can always be offset by a higher interest rate or collateral requirement to maintain expected profits at  $\bar{E}\pi$  as  $\partial r/\partial \xi, \partial c/\partial \xi > 0$  and  $\partial r/\partial g, \partial c/\partial g < 0$ . Also it can be seen that the negative impact of lower collateral on expected profits can be offset by an increased interest rate, and vice versa, as  $\partial r/\partial c < 0$ .

In this world of exogenously fixed borrower behavior, it is always possible to devise a contract so that loans to any group will fulfill the iso-expected profit condition (5). Consequently, the bank will be willing in equilibrium to lend to members of any borrowing group, including small farms, as long as it is able to freely write group specific credit contracts.

### 3.2. *Unrestricted equilibrium credit allocation and statistical discrimination*

Given the lender behavior just outlined, there will be no quantity rationing in credit market equilibrium in the absence of contractual restrictions. That

<sup>5</sup>This paper will not discuss bank competitiveness and the determination of  $\bar{E}\pi$ . For discussion on these topics, see Tybout (1984) and Virmani (1982).

<sup>6</sup>Expected bank profits can be written as

$$E\pi = \int_0^1 (c + \theta g) f d\theta + r(1 - F(t)).$$

Differentiation of this expression yields the terms reported in the body of the paper.

is, every borrower willing to pay the contractual terms necessary to yield the bank an expected profit of  $E\bar{\pi}$  will be able to obtain credit. Of course these terms will be different for different classes of borrowers, and in equilibrium, small farms will be offered less favorable contracts than large farms.<sup>7</sup>

While it is not characterized by quantity or non-price rationing, this credit market equilibrium is distinctive in one important way. Farms with equal productivity and risk characteristics are offered different loan contracts if they are members of different farm size groups. Banks 'statistically discriminate' against small farmers when they rely on farm size as an (imperfect) indicator of individual farm characteristics. Because farms are imputed the average characteristics of their group, relatively productive and low risk small farms are offered discriminatory contracts which discourage credit use, and, other things equal, distort equilibrium credit allocation away from small farms. Correction of this distortion, which is based on informational problems, would require credit institutions which can efficiently collect better information than can the formal banking system under discussion.

### 3.3. *Contractual restrictions and credit market equilibrium*

Two types of contractual restrictions may impinge on the credit market equilibrium just discussed. First, it is unlikely that collateral can be used as a freely variable contract term in LDC agricultural credit markets. What matters to the lender is the sale value of collateral net of transaction costs. Small farms, held perhaps with uncertain legal title, may offer limited net collateral value. Such a situation would impose a collateral ceiling on small farm credit contracts, and restrict feasible loan terms to the low collateral, high interest rate segment of the expected profit surface.

By itself, the assumption of a collateral ceiling on small farm loans does not substantially change the mechanics of credit market equilibrium as described above. There would always exist a relatively high interest rate so that loans to small farms fulfill the iso-expected profit condition (5). However, if interest rate restrictions are exogenously imposed, the conventional result on inequitable non-price credit rationing applies a fortiori. With the interest rate restricted, and high collateral not an option, there may be no contract which can be offered to small farms to yield the requisite expected profit level. If the interest rate ceiling is binding in equilibrium, then banks would simply refuse to make loans to small farms, and would shift their lending to better collateralized and, on average, safer and more

<sup>7</sup>While the analysis here relates high interest rates on loans to small farms to risk characteristics [thus agreeing with studies such as Bottomley (1975)], it does not judge the contentious issue of whether interest rates are usurious or exploitative. A credit or other contract can be Pareto optimal and still be phenomenologically exploitative if one party lacks any other viable alternative. On this relation between exploitation and alternatives, see Romer (1982). MacPherson (1973) makes a similar point with less devotion to the mathematical muse.

productive large farms.<sup>8</sup> Even if the same collateral ceiling applied to large farms, lenders would still prefer large farm to small farm loans and would ration credit accordingly. The rest of this paper assumes that collateral limits equally constrain both large and small farm contracts, and the analysis will be carried out only in terms of interest rate variations.<sup>9</sup>

The operation of Gonzalez-Vega's (1977) 'iron law of interest rate restrictions' is now plainly visible, as is the laissez-faire policy prescription drawn from it. In this model of fixed borrower behavior, interest rate deregulation would eliminate discriminatory credit rationing and lead to a more equitable and efficient (although still second best) equilibrium. Section 4, however, challenges the behavioral assumption of that model, and with it the notion of unrestricted market equilibrium free of credit rationing.

#### **4. Credit allocation with borrower autonomy and endogenous group characteristics**

Contrary to the assumptions in section 3, borrowers in this section are permitted to autonomously and systematically choose whether or not to apply for credit, and how to allocate credit they receive between competing uses. This section will show that contract terms affect borrower behavior in two ways, and thereby affect average group characteristics faced by the bank. First, such changes have an 'incentive effect': Borrowers' choice of technique and allocation of credit between production and consumption uses responds to changes in contract terms. Second, changing contract terms induce 'adverse selection': Borrowers self-select out of the credit market in a way that worsens average borrower characteristics (from the lender's point of view) as contractual terms are raised. Because lenders are aware of these effects, unrestricted market equilibrium can exhibit *self-imposed* interest rate restrictions and the same unequal non-price rationing which characterized the exogenously restricted equilibrium discussed in section 3.3.

##### *4.1. Adverse borrower self-selection and incentive effects*

This section models incentive and self-selection effects using the assumption that borrowers are risk neutral. The results which emerge are of the same general character as the risk averse case considered below, and they are more transparent.

<sup>8</sup>The discussion in the text ignores general equilibrium feedback effects on  $\bar{E}\pi$ . To the extent that interest rate restrictions force down  $\bar{E}\pi$ , it becomes more likely that small farmers will receive some credit. But again the basic rationing priority of first lending to large farmers would remain.

<sup>9</sup>Ruling out high collateral credit contracts is of no analytical significance in this section, nor in section 4 where adverse incentive and selection effects are studied. Wette (1983) shows that in the Stiglitz-Weiss model collateral changes have identical effects as interest rate changes as long as  $c$  remains less than  $r$ .

Borrower behavior is here modelled as a two step sequence. First, for given loan contract terms the borrower decides how to optimally allocate credit between production and consumption uses. Second, the borrower decides whether or not to apply for credit by comparing the expected utility which results from optimal credit use with the expected utility obtainable without credit. The first stage decision embodies incentive effects, while the second shows borrower self-selection.

Returns to the borrower from a loan,  $\rho$ , are defined as follows:

$$\rho = \max(Q - r, -c) = \begin{cases} -c & \text{if } \theta \leq t, \\ Q - r & \text{if } \theta \geq t, \end{cases} \quad (6)$$

where again  $Q = \theta g(K)$  and  $t = (r - c)/g(K)$ . Every individual is assumed to know the distribution of  $\theta$  specific to his individual farm. Full loan repayment will be made if production is high enough, ruling out voluntary default of the sort examined by Allen (1983) and Jaffee and Russell (1976). Fig. 1 graphs  $\rho$  as a function of  $\theta$ .

Risk neutral borrowers are assumed to choose  $K$ , the amount of the \$1 loan invested into production, in order to maximize expected income. The borrower's income is the sum of income in period zero, when the loan is made, and in period one, when the harvest occurs.<sup>10</sup> Period zero income is composed of prior savings,  $y_0$ , plus the amount of credit diversion,  $1 - K$ . Period 1 income is the borrower's return from production,  $\rho$ . Formally, the borrower who faces the given loan contract terms offered to his group chooses  $K$  in order to

$$\max_K E\{y_0 + (1 - K) + \rho\}, \quad (7)$$

subject to

$$\text{eq. (6),}$$

$$K \leq 1.$$

The maximization problem yields the following first order condition:

$$\int_t^m g' \theta f d\theta \geq 1, \quad (8)$$

<sup>10</sup>Inclusion of a term to discount future harvest earnings is appropriate, but it would clutter the notation. Its analytical significance would be to increase the likelihood of credit diversion.

where  $K = 1$  if the strong inequality holds. Alternatively, (8) can be written as

$$\{1 - F(t)\} E(\theta g' | \theta > t) \geq 1. \tag{8'}$$

Denote the solution to this problem as  $K^*(r)$ . As (8') clearly shows,  $K^*(r)$  is selected by comparing the expected marginal return to investing borrowed funds in production with their certain opportunity cost as current income. No analytically useful expression can be given for conditions under which the solution to (7) is an interior maximum and diversion of credit to current consumption occurs (i.e.,  $K^* < 1$ ). Nonetheless, for given contract conditions, as  $K$  approaches 1, expected borrower income is almost certainly concave in  $K$ , and may be decreasing.<sup>11</sup>

We are now in a position to see the incentive effect of a higher interest rate on borrower behavior. As  $r$  increases, the kink point  $t = (r - c)/g$  shifts out and increases the level of  $\theta$  and production needed for the borrower's return to exceed  $-c$ . Expected returns to investment subsequently decline, and as the LHS of condition (8) decreases, incentives for credit diversion increase.<sup>12</sup> Actual credit diversion will increase if the solution to (7) is, or becomes, an interior one. Other things equal, increased credit diversion will decrease  $g(K)$  and expected lender profits. The impact of this incentive effect on credit market equilibrium is examined in more detail below. Note, however, that lenders can diminish incentive effects by restricting loan size so that marginal returns to invested funds ( $g'$ ) remain high. The tendency of agricultural banks to lend only a percentage of the cost of the optimal input package can be interpreted in this light.

In addition to their autonomy in credit use, borrowers, or potential borrowers, autonomously select whether or not to apply for credit by comparing the expected income attainable with and without credit. Denote

<sup>11</sup>Differentiation of the first order condition (8) with respect to  $K$  yields

$$\left[ \underset{(-)}{g''} \left( \underset{(+)}{\int_t^m \theta f d\theta} \right) \right] + \underset{(+)}{[g'(t^2 f(t)g'/g)]}.$$

The sign of this expression is ambiguous in general. But, as  $K$  increases (and  $t$  decreases)  $g'$  decreases, and eventually so does  $f(t)$  if  $f$  is normal looking. Also,  $\int_t^m \theta f d\theta$  increases as  $t$  decreases. Expected borrower income thus has a concave portion with respect to  $K$ , and may have a turning point.

<sup>12</sup>Incentives for direct voluntary default (i.e., the borrower refuses to pay back the loan even if  $Q$  is high enough to permit full repayment) also increase as  $r$  increases. Inclusion of a class of 'dishonest borrowers' who voluntarily default would strengthen both the adverse incentive and selection effects of this model. Direct voluntary default can be controlled if crop sales go through official marketing channels, with the sale proceeds passing through the bank and only then to the borrower. The Dominican Republic's Agrarian Bank has successfully used this device to achieve 90%-plus short term repayment rates on loans to large collective farms. Clearly, however, enforcement of marketing rules would be more difficult for small farmers, and voluntary default becomes more of a reality. Jaffee and Russell (1976) and Allen (1983) model voluntary default.

the optimum value function which solves the borrower's maximization problem (7) as  $V^*(r)$ . In choosing whether to apply for a loan, borrowers compare  $V^*$  with their alternative opportunity, denoted  $\bar{V}$ . As the interest rate rises,  $V^*$  declines and potential borrowers self-select out of the market when their  $V^* < \bar{V}$ . Self-selected borrowers may in general still divert credit to consumption uses.<sup>13</sup>

Borrower self-selection is an adverse selection in the present model because the characteristics of the borrowers who remain in the market become less favorable for lenders as the interest rate raises. For any given  $r$ , maximized expected income is always greater for a borrower with a riskier distribution of  $\theta$  than for an otherwise identical safer borrower. Assuming that  $\bar{V}$  is the same for all individuals, as  $r$  rises and  $V^*$  declines, less risky borrowers will always self-select out of the credit market first, leaving a less desirable pool of loan applicants.

To demonstrate this proposition, let the subscript 1 indicate the riskier borrower, and 2 the safer borrower such that  $f_1 = f_2 + s$ , where  $s$  is a mean preserving spread. Adverse selection will occur if

$$V_1^*(r) - V_2^*(r) \geq 0. \quad (9)$$

Condition (9) can be rewritten as

$$\begin{aligned} & [V_1^*(r) - E(y_0 + (1 - K) + \rho_1 \mid K = K_2^*(r))] \\ & + [E(y_0 + (1 - K) + \rho_1 \mid K = K_2^*(r)) - V_2^*(r)] \geq 0. \end{aligned} \quad (9')$$

The first term in square brackets is non-negative by the definition of  $V^*$  as an optimal value function. The second term in square brackets can be signed

<sup>13</sup>Borrower self-selection raises the issue of whether incentive effects really matter: Would any individual apply for a loan when the best he or she can do is consume part of the loan? Formally, this question can be stated as whether

$$V^*(r) - \bar{V} \geq 0 \quad (i)$$

when  $K^*(r) < 1$ . In the model of section 4.1, no individual would ever *at the margin* borrow an additional dollar which costs, say, an additional \$1.10. However, the individual is not permitted to make marginal adjustment in the green revolution loan package. Expanding the LHS of (i) to examine this dichotomous choice gives

$$[1 - K^*] + (1 - F(t))[E(\theta \mid \theta > t)(g(K^*) - g(0)) - r] - F(t)[c + E(\theta \mid \theta < t)g(0)], \quad (ii)$$

where  $g(0)$  is traditional production with zero purchased inputs. The first term in square brackets is the gross gain from any immediate consumption of credit, the second term is the expected net gain from credit under relatively good conditions ( $\theta > t$ ), and the third term shows the loss of collateral and foregone traditional production under bad conditions ( $\theta < t$ ). The first two terms should certainly be non-negative at  $K^* = 1$ , while the last term is negative. At an interior solution with  $K^* < 1$ , (8') holds as an equality and (ii) can be written as

$$[1 - K^*] + [(g(K^*) - g(0))/g'] - [r(1 - F(t))] - F(t)[c + g(0)E(\theta \mid \theta < t)]. \quad (ii')$$

Expression (ii') shows that when returns to  $K, g'$ , diminish quickly relative to the total gain from the new technology, individuals with  $K^* < 1$  are still likely to demand credit.

by examining the difference in expected income between the riskier and the safer borrower at some arbitrary  $\hat{K}$ .

This difference in expected income between borrowers, given  $K = \hat{K}$ , is

$$E[y_0 + (1 - \hat{K}) + \rho_1] - E[y_0 + (1 + \hat{K}) + \rho_2],$$

which can be rewritten as

$$\left\{ -cF_1(t) - r[1 - F_1(t)] + g \int_t^m \theta f_1 d\theta \right\} \\ - \left\{ -cF_2(t) - r[1 - F_2(t)] + g \int_t^m \theta f_2 d\theta \right\}.$$

After integration by parts, this expression reduces to

$$g \int_0^t [F_1 - F_2] d\theta \geq 0, \quad (10)$$

which is non-negative by condition (1c) above. Now letting  $\hat{K} = K_2^*(r)$ , condition (10) implies that the second term in square brackets in (9') is non-negative. Therefore the LHS of (9) is always non-negative, and adverse selection occurs as the interest rate rises.

Fig. 2 illustrates the adverse effects of borrower self-selection as the interest rate increases. Assuming that all borrowers have the same  $\bar{V}$ , then at interest rate  $r_1$ , only borrowers with risk greater than  $\xi_1$  will apply for credit. As the interest rate rises to  $r_2$ , shifting down  $V^*$ , only borrowers with risk greater than  $\xi_2$  will apply for credit. The higher interest rate thus increases the riskiness of the average loan applicant – a shift in characteristics which reduces expected lender profits, as shown in section 3.1. The impact of adverse selection and incentive effects on credit market equilibrium is examined in section 4.3 below.

#### 4.2. *Adverse selection and incentive effects under risk aversion*

The degree to which risk aversion influences small farm decision making is a current topic of research.<sup>14</sup> This subsection shows that even if borrowers are assumed to be risk averse, lenders still potentially face adverse incentive

<sup>14</sup>The importance of small farmer risk aversion has been and remains a topic of extensive study, particularly in the area technology adaptation. Binswanger and Sillers (1983) discuss the relative importance of risk aversion and credit constraints in explaining the non-adoption of new techniques by small farmers. They downplay the risk factor per se, and emphasize small farmer credit constraints which they explain in terms of factors similar to those being modelled here.

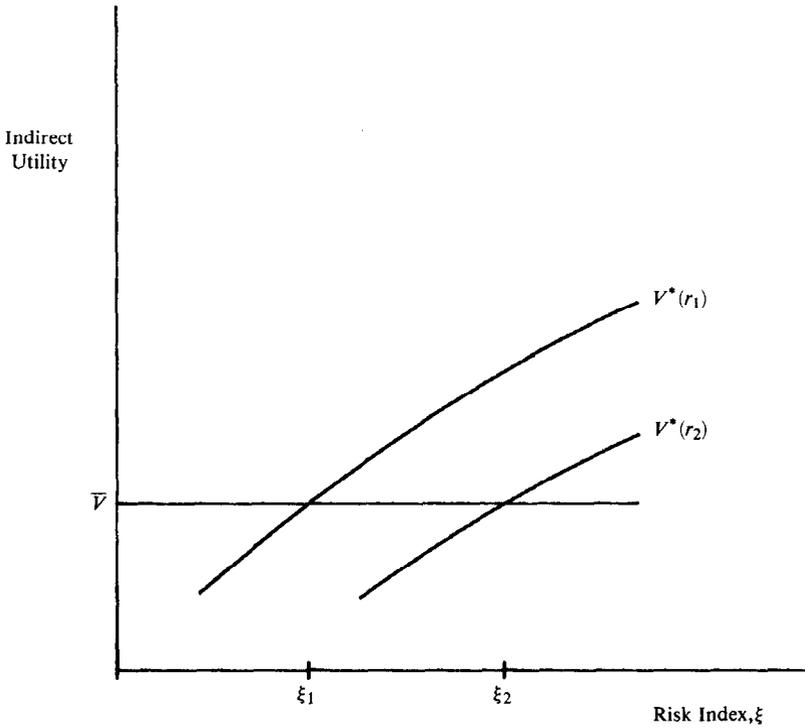


Fig. 2. Adverse selection.

and selection effects. To capture the effects of risk aversion, the borrower's objective function is reformulated as

$$U^0(y_0 + 1 - K) + U^1(\rho),$$

where  $U^0, U^1 > 0$  and  $U^{0''}, U^{1''} \leq 0$ . Note that borrowers' utility is no longer a strictly convex function of  $\theta$ .

After substituting this new objective function into the borrower's problem (7), the first order condition governing the optimal choice of  $K$  becomes

$$g'(1 - F(t)) E(\theta U^{1'} | \theta > t) \geq U^{0'}. \tag{11}$$

As in the risk neutral case, incentives for credit diversion increase with the interest rate because the first order condition is decreasing in  $r$ . There are several factors which make a credit diverting interior maximum more likely. First, assuming that  $U^{1'''} = 0$ , (11) can be rewritten as

$$g' \geq U^{0'} / [\bar{U}^1 (1 - F(t)) (\bar{\theta} - R\sigma_{\theta}^2 / \bar{\theta})], \tag{11'}$$

where  $\bar{\theta} = E(\theta | \theta > t)$ ,  $\bar{U}'$  is marginal utility at  $\bar{\theta}$ ,  $\sigma_{\theta}^2 = V(\theta | \theta > t)$ , and  $R$  is relative risk aversion at  $\bar{\theta}$ .<sup>15</sup> Condition (11') shows that credit diversion becomes more likely as risk and risk aversion increase because both of these factors diminish the expected utility of investing credit into risky production. Also, the smaller is  $y_0$ , the more likely is credit diversion. The individual at low living standards (and high  $U^0$ ) has strong incentives to increase current consumption at the expense of future investment returns. Together these factors make it more likely that the incentive effects of a higher interest rate will adversely affect lender profits by increasing credit diversion.

In addition to these problematic incentive effects, the bank may still face an adverse selection problem when borrowers are risk averse. Because the risk averse borrower's objective function is not convex, expected utility no longer necessarily increases with risk. However, riskier distributions will always yield greater expected utility once the interest rate increases past a critical level, and adverse selection will occur.<sup>16</sup> In addition, as risk aversion decreases, the probability of adverse selection increases for all values of  $r$ .

A high interest rate thus creates incentives for credit diversion and can induce adverse self-selection by risk averse borrowers, exactly as in the risk neutral case. A bank could find that average riskiness rises, and average productivity falls, for any borrowing group as loan contract terms are raised. Because banks take this borrower behavior into account, their credit offer curve and the nature of credit market equilibrium will be different from that discussed in section 3.

<sup>15</sup>Condition (11') can be obtained from (11) by noting that  $E(\theta U^1) = \text{cov}(U^1, \theta) + E(U^1)E(\theta)$ , where all terms are valued for the conditional distribution  $f(\theta | \theta > t) = f/1 - F(t)$ . The assumption that  $U''' = 0$  makes  $U''$  a linear function of  $\theta$ , with constant slope  $U''$ . Noting that relative risk aversion  $R = U''\theta g(K)/U^1$ , (11') follows immediately.

<sup>16</sup>For any given  $K$  and  $r$ , the difference in expected utility between the riskier and the less risky borrower,  $(EU)_2 - (EU)_1$ , can be rewritten as

$$(F_1 - F_2)U^1(-c) + \int_t^m U^1(\theta g - r)(F_1 - F_2) d\theta. \tag{iii}$$

If this expression is positive in the relevant range, then adverse selection will occur. After integrating by parts and noting that  $t = (r - c)/g$ , (iii) reduces to

$$-g \int_t^m U^1[F_1 - F_2] d\theta. \tag{iii'}$$

From integral condition 2 of Rothschild and Stiglitz (1970, p. 230), there exists a  $z$  such that

$$F_1(x) - F_2(x) \begin{cases} \geq 0 & \forall x < z, \\ \leq 0 & \forall x > z. \end{cases}$$

If  $r$  is high enough so that  $t$  exceeds this critical  $z$ , then expression (iii') would always be non-negative (as  $U^1$  is a positive function of  $\theta$ ) and adverse selection would unambiguously occur. If  $t$  is below this critical level, negative values of (iii') are possible. However, the less sharply marginal utility diminishes (i.e., the smaller is  $U''$  in absolute value and the lower risk aversion), the more likely it becomes that (iii') is positive even when  $t < z$ .

#### 4.3. Credit rationing under adverse incentive and selection effects

The analysis has shown that borrower autonomy in credit use and application can cause average borrower characteristics to worsen (from the point of view of the bank) as the interest rate increases. Expected bank profitability on loans to borrowers in some group  $i$  must now be rewritten to reflect the endogeneity of group characteristics,

$$E\pi[r, c \mid g_i(K^*(r)), f_i(r)].$$

Expected profits no longer strictly increase in the interest rate because

$$\frac{\partial E\pi}{\partial r} = \frac{\partial E\pi}{\partial r} \Big|_{\bar{j}, \bar{g}} + \frac{\partial E\pi}{\partial g} g' \frac{\partial K^*}{\partial r} + \frac{\partial E\pi}{\partial \xi} \frac{\partial \xi}{\partial r}, \quad (12)$$

the latter two terms of which are, or can become negative as  $r$  increases. The positive first term is strictly decreasing in  $r$ . As noted earlier, a similar analysis could be done with collateral requirements, although it was argued that the limited assets of small farms makes analysis of increasing collateral requirements irrelevant. Finally, had the model allowed direct voluntary default (incentives for which increase as the interest rate rises), yet another negative term would have been added to eq. (12).<sup>17</sup>

Lenders in this model thus face a situation similar to that in the Stiglitz–Weiss model. After some critical interest rate  $r_i^*$ , expected profits per loan to borrowers in group  $i$  begin to decrease in  $r$ . The impact of this functional relationship on credit market equilibrium can be briefly explained.

First, imagine that all potential borrowers are from a single group – i.e., treat all borrowers as indistinguishable. If there is excess supply of loans at the critical interest rate  $r^*$ , then adverse incentive and selection effects are irrelevant, and the market will clear ‘normally’ with no quantity rationing. However, if there is excess demand for agricultural loans at  $r^*$ , then the bank will do better if it arbitrarily rations credit to applicants at  $r^*$  than if it raises the interest rate to eliminate the excess demand. At the excess demand interest rate  $r^*$ , the bank can still make the same volume of loans that it could at a higher interest rate. Because the average characteristics of borrowers are superior at the lower rate, average profits per loan made will be higher at  $r^*$  even though borrowers are arbitrarily selected to receive loans. Banks, in other words, would find it profit maximizing to impose their own interest rate restrictions.

<sup>17</sup>Countervailing indirect controls could be used to raise the cost of default and thereby lessen adverse incentive effects. These devices include interlinkage of credit transactions with transactions in other markets [e.g., see Braverman and Stiglitz (1982)], and future access to the credit market [see Allen (1983) and Stiglitz and Weiss (1983)].

Borrowers are of course not all observationally indistinguishable to the bank. The analysis here has divided borrowers into stereotypical small farms (group 1) and large farms (group 2). When the bank can distinguish between large and small farms, endogenous interest rate restrictions imposed by banks have the same qualitative effect on credit allocation as do the externally imposed restrictions discussed earlier. Section 3 demonstrated that for given contract terms, expected profits on loans to large farms exceed those on loans to small farms. Even if incentive and adverse selection effect were identical on small and large farms (so that  $r_1^* = r_2^*$ ), then this differential expected profitability alone could cause small farmers to be rationed out of the credit market. Put most simply, at the endogenous interest rate ceiling of  $r^*$ , it would always be more profitable to lend to large farms as fig. 3 shows. Only after the interest rate to large farms had been lowered to  $\hat{r}$ , and all large farmers desiring loans at  $\hat{r}$  had been given credit, would it be possible for any small firm to receive credit. Whether credit would ever be extended to small farmers depends on the supply of loanable funds and the opportunity cost of funds,  $E\bar{\pi}$ .

In fact, the situation is likely to be even less favorable for small farms than fig. 3 shows. Because period zero income and consumption is likely to be

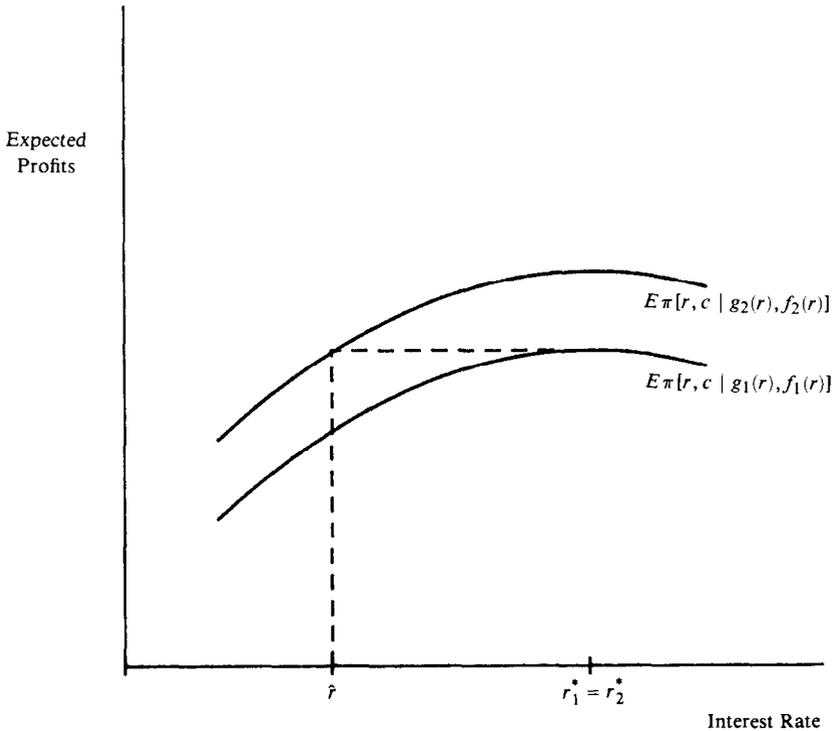


Fig. 3. Endogenous interest rate restrictions and equilibrium credit rationing.

relatively low on small farms, incentives for credit diversion are likely to be relatively high, as (11') shows. Greater risk aversion and output variability on small farms would further heighten relative small farm adverse incentive effects.

Adverse selection problems are also likely to be more severe on small farm loans. Adverse selection is rooted in information costs which create borrower anonymity. The model here assumed that the bank cannot distinguish between potential borrowers in either farm size group. While this is a good assumption for small farms, it is less applicable to large farms. Banks may well have information on specific characteristics of large farms (e.g., the bank may know the specific risk distributions,  $f_{2j}$ , for each large farm). In effect, each large farm would be its own group. Specific contracts could be tailored for individual large farms, and adverse selection problems would disappear for large farm loans.

More severe incentive and selection effects on loans to small farms would imply that per-loan expected profits begin to diminish at a lower interest rate on small farm loans ( $r_1^* < r_2^*$ ). Fig. 4 illustrates this situation. At best, in an adverse incentive and selection constrained equilibrium, small farms will now only be rationed credit after all large farms desiring credit at interest rate  $\hat{r}'$

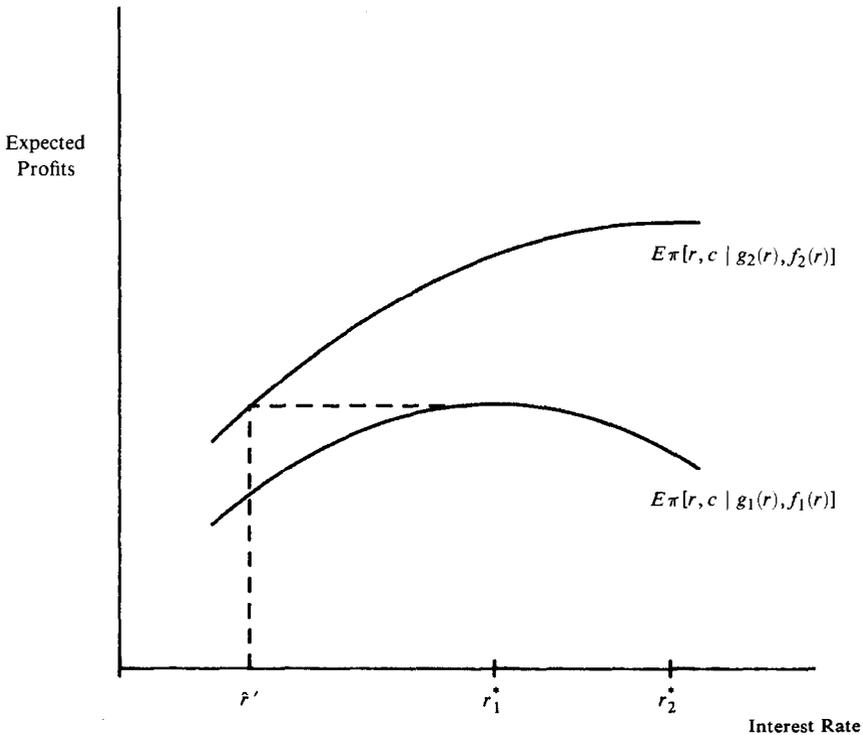


Fig. 4. Credit rationing when incentive and selection effects are more severe on small farms.

receive loans. For a given opportunity cost and supply of loanable funds, it becomes more likely that small farms will be completely rationed out of formal credit markets.

## **5. Conclusion**

The theoretical analysis in this paper has shown that small farms may be rationed out of unrestricted, *laissez-faire* credit markets. Adverse incentive and selection effects, combined with farm size statistical discrimination, conspire against access to formal credit for small farms. The observed tendency of large farms to soak up formal credit is explained as the systematic outcome of profit maximizing behavior by competitive lenders. The key factors in this microeconomic story of credit rationing are variability in production which makes small farm loans risky and unprofitable, and informational imperfections which leave banks vulnerable to the adverse changes in borrower behavior which would be induced by high, risk-compensating interest rates.

Government market interventions designed to enhance small farm credit access have been criticized as counterproductive. The model of credit market equilibrium offered here suggests that alternative, *laissez-faire* credit policies are likely to be similarly impotent. Under either policy regime, informational imperfections loom large in explaining the small farm credit problem. The ability of local money lenders to profitably lend to the small farm sector is rooted in their better information and control devices (the latter could include market interlinkage as well as strong arm tactics, both of which raise the cost of default to the borrower). It is also their comparative advantages in these items that provides the margin of monopoly profits, and distortion, which informal lenders can extract [see Virmani (1982)]. Successful extension of formal credit to small farms would thus seem to require institutions capable of economically resolving the information problems that the small farm sector presents to profit maximizing banks. Without such institutions, one could predict market pressure to concentrate farm ownership to an informationally optimal size.

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