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## Risk, Insurance and Default in a Rural Credit Market: An Empirical Investigation in Northern Nigeria

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CENTER DISCUSSION PAPER NO. 636

RISK, INSURANCE AND DEFAULT

IN A RURAL CREDIT MARKET:

AN EMPIRICAL INVESTIGATION IN NORTHERN NIGERIA

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RISK, INSURANCE AND DEFAULT IN A RURAL CREDIT MARKET  
AN EMPIRICAL INVESTIGATION IN NORTHERN NIGERIA

Abstract

This paper examines the role played by credit transactions in permitting households to cope with risk in an environment characterized by incomplete markets and imperfect information. Within small communities in northern Nigeria credit transactions play a direct role in pooling risk between households through the use of contracts which make owed repayments depend on the realization of random shocks by both borrowers and lenders. The aim of the paper is to consider the institutional and informational context which permits state-contingent loan contracts to be made and enforced. The paper presents a model of a bilateral credit relationship which can accommodate a wide range of informational environments and which explicitly incorporates the contractual enforcement mechanisms available in these villages. The terms of the loan contract are negotiated with each household taking into account the fact that, depending on the realized state of nature, the other may default on its obligations. The structure of an econometric model is derived from the Nash bargaining solution. The results support the hypothesis that loan repayments include state-contingent payments that serve to pool risk between the borrower and the lender. The research is based on a year long survey in Zaria, Nigeria conducted by the author.

Key Words: Rural Credit, Risk

Risk is a central fact of life in rural areas of less developed countries. There is a vast, mainly theoretical literature that explores its consequences for individual behavior and the evolution of institutions.<sup>1</sup> In the absence of complete insurance markets, households utilize a variety of economic strategies in order to mitigate the consequences of this risk. This paper uses a unique data set to analyze in some detail one institution that plays an important role in allowing households to cope with risk.

Credit transactions take on a special role when insurance markets are incomplete by allowing households to smooth their consumption streams in the face of random income fluctuations. This observation, of course, is the basis of much of the literature on the intertemporal allocation of consumption (e.g., Zeldes [1989]). Eswaran and Kotwal (1989) provide an extension of this theoretical work to joint production and consumption decisions in agriculture in LDCs. Recently, empirical studies of credit markets LDCs have begun to take explicit account of intertemporal consumption-smoothing in the face of income shocks as a motivation for credit transactions (Rosenzweig [1990], Morduch [1990]). In northern Nigeria, the credit market seems to play a more direct role in households' risk management. In earlier work based on a survey in northern Nigeria (Udry [1990, 1991a]), I argue that the repayment owed on a loan depends upon random production and consumption shocks received by both the borrower and the lender, permitting these households to insure each other directly against idiosyncratic risk. State-contingent loan contracting permits more efficient risk pooling between borrowers and lenders, and allows credit transactions in this Islamic region to conform to the prohibition of fixed interest lending by Shari'a law.

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<sup>1</sup>See Bardhan (1989) and Bell (1988) for references.

My goal in this paper is to consider these loan transactions in their institutional context, that is, to examine the personalized interaction between borrower and lender in the setting of a village economy. The result is a structural econometric model of the determinants of net borrowing or lending, the repayment owed by the borrower (including, *inter alia* any state-contingent adjustment of this quantity), and the decision by the borrower as to whether to default on his obligations.<sup>2</sup> I am able to establish exclusion restrictions which permit the decision to default on a loan and the determination of the state-contingent amount owed on a loan to be identified separately. Furthermore, I am able to consider the actual contractual mechanisms through which the repayments owed on a loan are made state-contingent.

I am able to shed light on these details by excluding from consideration the general equilibrium properties of state-contingent loan contracting, which are the focus of Udry (1991a). There are only three actors in this paper. Two are households which may transact credit. One of these two is called "the household" or "the sample household"; the other is "the transaction partner," or "the partner." The final actor has no independent motivation and would in other contexts be called the court system. Here it is the community or family authority concerned with monitoring and enforcing contracts.

In section A I provide some background information concerning credit transactions in northern Nigeria and describe the physical and information environment faced by the household and its transaction partner. I describe the contractual form of the loan transactions and the community-based

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<sup>2</sup>There have been relatively few attempts to estimate structural models of informal credit transactions in developing countries. See Iqbal (1981), Kochar (1991), and Bell, Srinivasan and Udry (1991).

mechanisms which serve to enforce the contracts in section B. These observations serve as the basis for the model of a bilateral credit relationship with state-contingent repayments which is introduced in the same section.

Enforcement of these credit contracts is not perfect; 10 percent of all loans are defaulted by the borrower.<sup>3</sup> Section C, therefore, is devoted to the decision by the borrower as to whether to default on his repayment obligations. In section D I derive the indirect expected utility of the household and its transaction partner as a function of the contractual terms of the loan. In section E, I describe the equilibrium loan size and repayment using the natural symmetrical Nash bargaining solution. In order to account for the one-fifth of sample households which do not participate on either side of the credit market, the possibility of transactions costs is introduced in this section. This study is based on a survey of 196 households in four northern Nigerian villages. I provide a brief description of the study area and survey methodology in section F, along with a discussion of the variables used in the analysis. In section G, I develop an econometric specification based on the bargaining solution to the bilateral model. Estimation results are presented in section H. The most important finding is that state-contingent payments are embedded in the loan repayments, and that these payments serve to pool risk between the borrower and the lender.

#### A. Risk and Information Flow within the Village.

The four villages are small (an average of 366 resident households) but not isolated. Three quarters of the households produce vegetables and non-food cash crops for the market, over half of the labor used on farms is hired,

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<sup>3</sup>The definition of a defaulted loan is described in section F.

and virtually all land is treated with modern chemical fertilizer. All of the sample households name farming as their primary occupation.

Loans in these villages are quite informal. They are made without witnesses or written records. Although the borrower and lender negotiate over the size of the loan, explicit interest rates or repayment dates are almost never set. The loans are made between individuals who are well-known to each other and who share a great deal of information about each others' farming activities and household events; neither formal sector lending institutions nor specialized private moneylenders participate in the credit market. 97 percent of loans (weighted by value) are between neighbors or between relatives. For 82 percent of loans, survey participants were able to provide an accounting of activities on the farms of those from whom they borrowed, or to whom they lent (Udry [1990, p. 259]). Common institutional adaptations to information asymmetries are not found in this credit market. There is no evidence of contractual interlinkages involving loans, and only 3 percent of loans (by value) are backed by collateral (Udry [1990, section III]).<sup>4</sup>

The free flow of information within these rural communities facilitates the practice of implicitly embedding insurance contracts within loan transactions. The survey data show that realized rates of return are lower and repayment periods are longer for debtor households which have received adverse shocks (table 1). This observation is consistent with standard credit contracts because debtors who receive adverse shocks are more likely to default. There is also evidence, however, that repayments respond to the

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<sup>4</sup>On the role of collateral and contractual interlinkages in credit transactions subject to moral hazard or adverse selection, see Chan and Thakor (1987), Bell (1988), Stiglitz and Weiss (1986), and Rogerson (1985). See Udry (1991b, chapter 2) for more a complete set of references.

circumstances of the lending household (table 1). This finding is not consistent with conventional models of loan contracting, nor with credit contracts in the form of equity investments by the lender in the borrower's activities.<sup>5</sup> Rather, these loans appear to be true risk pooling arrangements between the two households.

The existence of these state-contingent contracts raises the possibility that the allocation of resources might approximate that which would be achieved with complete competitive markets. A number of studies have recently explored this possibility in other contexts (Altonji and Hayashi [1991]; Cochrane [1989]; Lim [1990]; Mace [1989]; Townsend [1991]), but in Udry (1991a) I test and reject the hypothesis that a Pareto Efficient allocation is achieved in these villages through these loan transactions.

Given that Pareto Efficiency is not achieved through these loan transactions, their institutional structure and the information environment in which they occur become germane. While it appears that information moves between borrowers and lenders in these villages more freely than is permitted in much of the theoretical literature, the ten percent default rate on loans implies that the possibility of some degree of information asymmetry must be investigated. When the promised transfer of future resources is not certain, the character of a loan is influenced by the risks faced by the parties involved, by their knowledge of each other and of their activities, and by the monitoring and enforcement mechanisms associated with the loan transaction.

In this section, I make assumptions concerning the economic and institutional environment within which the loan transactions occur. Consider

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<sup>5</sup>Equity investments are a common mechanism for avoiding the prohibition by Shari'a law on fixed interest charges. See Iqbal and Abbas (1987).



a village in which two agents ("the household" and "the partner") interact. The model permits two sources of random variation in income; one source is publicly observed by the entire community (and will be referred to as the observable shock), the other is private knowledge to the recipient (and will be referred to as the unobservable shock). There are two periods, with  $S$  observable "states of nature" in the second period indexed by  $s$ , each with objective and commonly known probability of occurrence  $\pi^s$ . Both agents and the village community at large observe the realization of the state in the second period. There is only one good, of which the household receives an income  $Y_0$  in the opening period, while the partner receives  $\tilde{Y}_0$ . In the next period they receive random observable incomes of  $Y^s$  and  $\tilde{Y}^s$ , which vary across the states of nature. This variation in income across the  $S$  states of nature is referred to as the observable shock. In addition to the observable income shock, the household and its partner respectively are subject to additional unobservable income shocks  $\epsilon$  and  $\eta$ , distributed continuously with densities  $h^s(\epsilon)$  and  $p^s(\eta)$ , so that their total incomes are  $Y^s + \epsilon$  and  $\tilde{Y}^s + \eta$ , respectively. Given the state of nature,  $\epsilon$  and  $\eta$  are distributed independently. However, the densities are permitted to vary across states, so  $\epsilon$  and  $\eta$  may include unobserved village level shocks. The supports of  $h^s(\epsilon)$  and  $p^s(\eta)$  are such that  $Y^s + \epsilon > 0$  and  $\tilde{Y}^s + \eta > 0$  for all  $\epsilon$  and  $\eta$  such that  $h^s(\epsilon) > 0$  and  $p^s(\eta) > 0$ . The realization of  $\epsilon$  is observed only by the household, and only the partner observes the realization of  $\eta$ .

The model therefore permits two sources of variability in a household's income which differ according to their visibility to the rest of the community. A wide range of informational environments, from the complete information of Udry (1991) to drastic information asymmetry, can be

accommodated within the model. If information concerning farming activities and outcomes flows freely through the village, so that all income shocks are observable, then the variances of  $g^s(\epsilon)$  and  $f^s(\eta)$  are zero. On the other hand, if information concerning all income shocks is private, then  $Y^s=Y$  and  $\tilde{Y}^s=\tilde{Y}$  for all  $s$ .

#### B. A Bilateral Credit Relationship with State-Contingent Payments.

The household and its partner may make loan contracts with each other. The loans are advanced in the initial period and repaid in the final period. The contracts are state-contingent in the sense that the repayments owed by the borrower may vary with the realization of the state of nature in the final period. The environment outlined above provides two motivations for state-contingent credit transactions by risk averse agents. The first is to even out expected consumption across the two periods. If  $Y^0$  is below  $E(Y^s+\epsilon)$ , for instance, the household may wish to borrow to increase initial period consumption. Second, both agents may wish to engage in a credit transaction in order to reduce the variance of second period consumption through access to any state-contingent payments that flow toward an agent who has received an adverse realization of a second period income shock.

There are two institutional considerations that are of particular importance to the econometric investigation which follows. The first is the precise manner in which the loan contracts are made state-contingent. The second is the mechanism which is used to enforce repayment of loan obligations. I will root the discussion of both of these issues in an analysis of the role of the community, taking as a central fact the finding that virtually all loans are transacted between residents of the same village, or between relatives.

A standard method of modeling contract enforcement is to consider the transaction as one instance of a repeated interaction.<sup>6</sup> A default may then be prevented by threatening the potential defaulter with exclusion from future transactions. Such a self-enforcing contract would flow naturally from a repetition of the bilateral relationship modeled here. This repeated game approach to modeling contract enforcement, however, is inappropriate in this setting. The credit transactions in these villages are not repeated. 82 percent of loans occur between households which have never before engaged in a loan transaction with each other. These contracts do not need to be self-enforcing because direct penalties can be imposed on defaulters. Both borrower and lender are members of the same community, therefore penalties for default can be imposed by an authority of the community. These penalties are not explicitly codified as law, but they operate in much the same way. The particular enforcement mechanisms are discussed in detail in Udry (1990); for the purposes of this discussion it is sufficient to summarize some of the main points. First, enforcement is carried out by village authorities or senior members of the families involved in a dispute. The enforcing authority has access to the free flow of information within the village regarding farming activities and outcomes (that is, the authority also knows the realization of the observable shocks). In order to reach a judgement as to whether a default has occurred, therefore, he must know the (unwritten) contractual terms of the loan including the state-contingent adjustments in owed repayments. Second, an important component of the penalties that are imposed by these authorities is a direct utility cost to the defaulter (in the form of admonishment or

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<sup>6</sup>Recent applications of the theory of self-enforcing insurance can be found in Thomas and Worrall (1988), Coate and Ravallion (1989), and Kletzer and Wright (1991).

public embarrassment). The penalties available to the authority are graduated, with more severe penalties imposed for more serious offenses.

The mechanism available to enforce contracts limits the domain of outcomes over which repayments may be made contingent. Owed repayments cannot be made contingent upon the realization of the unobservable shocks  $\epsilon$  or  $\eta$ , as no incentive compatible mechanism exists which could induce a household to reveal its true unobservable shock.<sup>7</sup> Therefore, I introduce state-contingent contracting into the model by allowing owed repayments to vary across the  $S$  observable states of nature.

The model accommodates two alternative interpretations of the manner in which owed repayments are made contingent upon the realization of observable shocks to the incomes of the borrower and lender. First, the two households might negotiate over state-contingent adjustments in owed repayments. The household and its partner would then be negotiating over  $S+1$  contractual terms: the net amount lent by the household to the partner (which may be negative) and the  $S$  owed repayments, which vary according to the observable shocks received by the two households. Alternatively, in accordance with the observation that the loans are made with very little negotiation, there are exogenous community standards that dictate appropriate payments contingent upon the realization of particular states.<sup>8</sup> If the latter assumption is correct, the task faced by the enforcement authority is eased. He knows both the realized state of nature and the required adjustment in owed repayments;

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<sup>7</sup>It will be seen in section C that the possibility of default (and the associated penalties) introduces an incentive compatible mechanism for adjusting actual (as opposed to owed) repayments to realizations of the unobservable shocks.

<sup>8</sup>These standards must change over time (with, for example, technology) but an exploration of this process is left for future work.

in order to make a judgement as to whether a default has occurred, he needs to learn only the size of the loan and the agreed-upon base repayment. In this interpretation, the state-contingent adjustments to owed repayments are exogenous to the contracting parties; the decision to adhere to the community norms that dictate these adjustments, however, is endogenous through the default decision. A test between these alternative hypotheses is presented in section H.

If the terms of the contract, the costs of default, and both households' utility functions are common knowledge, then the cause of a default must lie in an income shock that raises the utility cost of repayment beyond that expected by the lender. The unobservable shocks  $\epsilon$  and  $\eta$ , on which no contingent payments are based, provide the variation in income that could lead some households to default on their obligations.

The time sequence of events is as follows: the household and its potential transaction partner have completed harvesting and have received incomes  $Y_0$  and  $\tilde{Y}_0$  from last season's production. Based on these incomes they negotiate over a loan, to be repaid after the following harvest. They have the freedom to bargain over the direction and size of the loan and over the amount to be repaid. They also may bargain over state-contingent adjustments in owed repayments. Alternatively, they share as common knowledge the community standards that require adjustments to the amount owed depending on the realized (observed) state of nature  $s$  in the final period. Both parties realize that there are two sources of variance in next period incomes. There are observable income shocks across the  $S$  states of nature for which some adjustment in owed repayments may be made. The second source of income

variation is the unobservable shock ( $\epsilon$  and  $\eta$ ) for which no additional adjustment in owed repayments is made.

A deal is made and the loan is transacted. At harvest, both discover the realized observable shocks to each of their incomes (represented by the state of nature) and their individual unobservable shock  $\epsilon$  or  $\eta$ . The repayment that is owed is calculated based upon the agreed upon terms (or on the community dictated adjustments) according to the realized observable shocks to income. The party who owes the other, taking into account its total income including the unobservable shock  $\eta$  or  $\epsilon$ , now decides whether to default. Community authorities then impose penalties on any defaulter.

The notation shall be as follows. Let  $L$  be the amount lent by the household to its partner (if negative, the household is borrowing). The amount owed is determined by the agreed base repayment  $R$  and by the negotiated or community-determined adjustment in the amount owed as a result of the observable shocks to both households' incomes. Denote this adjustment if it exists as  $R^s$ , the payment contingent upon the realization of the observable shocks defined by  $s$ . This payment is embedded in the loan contract and is made simultaneously with the repayment of the loan. This state-contingent payment may be positive or negative. The main hypothesis to be tested in the empirical work of this paper is that the state-contingent payment is positive when the realized observable state  $s$  is in some sense (to be defined below) adverse to the household, and negative when the realized state is adverse to the partner. Thus  $OWED^s = R + R^s$  is the amount owed by the partner to the household if state  $s$  occurs in the final period. The definition of the levels of  $R$  and  $R^s$  is arbitrary (any two levels of  $R$  can be made equivalent by adding a constant to all  $R^s$ ). If the households negotiate over the state-contingent

adjustments  $R^s$ , then without loss of generality set  $R^1=0$ . Thus  $R+R^1=R$  is the amount owed if state 1 is realized. Alternatively, if  $R^s$  is determined outside the model by community norms, this ties down  $R$ . If  $OWED^s$  is negative, then the household owes a payment to the partner.

The budget constraints faced by the household and its transaction partner can now be defined. Consumption by the household (partner) in period zero is  $c_0 = Y_0 - L$  ( $\tilde{c}_0 = \tilde{Y}_0 + L$ ). Let  $c_{s,\epsilon,\eta}$  ( $\tilde{c}_{s,\epsilon,\eta}$ ) denote consumption by the household (partner) in state  $s$  of the final period when unobservable shocks  $\epsilon$  and  $\eta$  are received. In the final period, the budget constraints are:

$$\text{Household: } c_{s,\epsilon,\eta} = Y^s + \epsilon + OWED^s$$

$$\text{Partner: } \tilde{c}_{s,\epsilon,\eta} = \tilde{Y}^s + \eta - OWED^s$$

when there is no default, or if the debtor defaults:

$$\text{Household: } c_{s,\epsilon,\eta} = Y^s + \epsilon$$

$$\text{Partner: } \tilde{c}_{s,\epsilon,\eta} = \tilde{Y}^s + \eta$$

Both parties receive utility from consumption in the two periods. I will model the cost of defaulting as a direct reduction in utility in the final period  $C(DEF^{s,\epsilon,\eta})$  where  $DEF^{s,\epsilon,\eta} = |OWED^s|$  if the debtor defaults, and zero otherwise. The form of this function is discussed in section C. The separable Van Neuman-Morgenstern utility of the household is

$$1. \quad EU = U(c_0) + \beta \sum_s \pi^s \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} [U(c_{s,\epsilon,\eta}) - C(DEF^{s,\epsilon,\eta})] h^s(\epsilon) p^s(\eta) \delta\epsilon\delta\eta.$$

where  $U$  is increasing and strictly concave. Similarly, for the household's partner:

$$2. \quad EV = V(\tilde{c}_0) + \beta \sum_s \pi^s \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} [V(\tilde{c}_{s,\epsilon,\eta}) - C(\tilde{DEF}^{s,\epsilon,\eta})] h^s(\epsilon) p^s(\eta) \delta\epsilon\delta\eta.$$

$U()$  and  $V()$  are both increasing, strictly concave, bounded from above, and twice continuously differentiable. Also assume that as  $x \rightarrow 0^+$ ,  $U(x) \rightarrow -\infty$ . The dependence of  $DEF^{s,\epsilon,\eta}$  and  $\tilde{DEF}^{s,\epsilon,\eta}$  on the realized state of nature and on  $\epsilon$  and  $\eta$  must now be described.<sup>9</sup>

### C. The Default Decision.

Approximately ten percent of all loans are defaulted, therefore the possibility of default is an important element on the model. It will be seen that the possibility of default and the associated enforcement technology provides an incentive compatible mechanism which permits some adjustment in repayments in response to the realization of unobservable shocks to income. In this section I will explore the decision of the partner to default. I focus on the partner's decision because the partner may choose to default when  $OWED^s > 0$ . The exposition will be clarified somewhat by working with positive quantities. There is a utility cost to default  $C(\tilde{DEF})$ , which depends upon the amount defaulted. Assume that  $C(0) = 0$ , that for  $\tilde{DEF} > 0$   $C(\tilde{DEF})$  is continuous and continuously twice differentiable with  $C'(\cdot) > 0$ ,  $C''(\cdot) < 0$ , that  $C(\cdot)$  is bounded from above, and that as  $x \rightarrow 0^+$ ,  $C(x) \rightarrow k$ ,  $k > 0$ . There is a fixed cost to even a small default, and the cost of defaulting rises at a decreasing rate with the size of the default. The default decision is made after the realization of the observable state of nature  $s$  and the unobservable income shocks ( $\eta$  and  $\epsilon$ ).

The decision to default is characterized in the appendix. The fixed cost associated with defaulting implies that in any observable state  $s$ , given

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<sup>9</sup>The assumption that the utility cost of default is additively separable is made for simplicity. The analysis of the decision to default is not affected if the cost of default is modeled more generally as  $U(c_{s,\epsilon,\eta}, DEF^{s,\epsilon,\eta})$ . Full details are available from the author.



an unobservable total income  $Y_s + \eta$ , the partner will default if and only if the amount owed  $OWED^s$  is larger than a certain critical size. I show that when the partner owes some obligation, it will choose to default if and only if it receives a "bad" enough unobservable shock to its income. In any state  $s$ , for any level of repayments  $OWED^s$ , define  $\eta^s(OWED^s)$  as the value of the unobservable shock  $\eta$  such that the partner will choose not to default for all  $\eta > \eta^s(OWED^s)$  and will default for all  $\eta \leq \eta^s(OWED^s)$ . If there is a bad enough unobservable shock to the borrower's income he will repay nothing, thus partially smoothing the unobservable shock to his income. The default penalty ensures that the borrower makes his owed repayment if the unobservable shock to his income is not too severe.

$\eta^s(OWED^s)$  is a continuous and continuously differentiable increasing function of  $OWED^s$ . It is also, therefore, a differentiable function for all values of  $R$  and  $R^s$ . For all values of  $R$ ,  $R^s$  and observable states of nature  $s$  such that the partner owes no repayment there is no possibility that the partner will default. In this instance,  $\eta^s(OWED^s)$  is defined so that  $p(\eta^s(L, R)) = P(\eta^s(L, R)) = 0$  so the probability of the partner defaulting is correctly evaluated at zero ( $P(\eta)$  is the distribution function corresponding to  $p(\eta)$ ). Similarly,  $\epsilon^s(OWED^s)$  (a  $C^2$  decreasing function of  $OWED^s$ ) can be defined.  $\epsilon^s(OWED^s)$  is the critical value of  $\epsilon$ , below which the household will choose some level of default and above which the household will not default. Neither party will chose to default unless it receives a bad unobservable shock to its income. As the repayment owed by a party increases, less of a bad unobservable shock is required to induce it to default.  $\epsilon^s(OWED^s)$  and  $\eta^s(OWED^s)$  are abbreviated to  $\epsilon^s$  and  $\eta^s$  below.

D. Household Preferences over Contract Terms.

The indirect expected utility of the household is then

$$3. \quad EU = U(y_0 - L) + \beta \sum_s \pi^s \left[ \int_{\epsilon^s}^{\infty} U(Y^s + R + R^s + \epsilon) \times (1 - P^s(\eta^s)) h^s(\epsilon) d\epsilon \right. \\ \left. + \int_{\epsilon^s}^{\infty} \int_{-\infty}^{\eta^s} U(Y^s + \epsilon) h^s(\epsilon) p^s(\eta) d\eta d\epsilon + \int_{-\infty}^{\epsilon^s} [U(Y^s + \epsilon) - C(|OWED^s|)] h^s(\epsilon) d\epsilon \right]$$

The first integration is over those values of the unobservable shock  $\epsilon$  for which the household does not choose to default in state  $s$ . The integrand is the utility in the case of no default multiplied by the probability that the partner does not default in state  $s$ .

The second integration is over those values of  $\epsilon$  for which the household does not choose to default and those values of  $\eta$  for which the partner does choose to default. If this term is not zero (that is, if  $\eta^s$  is large enough that  $P^s(\eta^s) > 0$ ) then the integration is over the entire support of  $\epsilon$  because it is impossible for both the household and its partner to have a positive probability of defaulting in the same state. That is, if  $OWED^s < 0$ , then the partner will never default ( $P^s(\eta^s) = 0$ ) and this term will be zero. If  $OWED^s > 0$  then the household will never default,  $H^s(\epsilon^s) = 0$  and the integration is over the entire support of  $\epsilon$ . The integrand is the utility in the case of the partner defaulting.

The final integration is over the values of  $\epsilon$  for which the household wants to default. Therefore, the utility cost of a default is included in this integrand. It should be noted that the expected utility function depends on the partner with whom the household is transacting.

The indirect indifference map in  $(L,R)$ -space associated with this utility function is drawn below (Fig. 1). The  $S$  state-contingent payments  $R^s$  are held fixed in figure 1. Recall that if the two households negotiate over the state-contingent payments the normalization  $R^1=0$  is adopted.<sup>10</sup> Of course a similar map can be drawn for the partner. The critical feature of the diagram is the indifference curve  $I^0$ , corresponding to the level of utility that the household would achieve in autarky. Note that this indifference curve passes below the origin, reflecting the insurance benefit of access to the state-contingent payments  $R^s$ . It should also be noted that like all of the other indifference curves,  $I^0$  is not continuous; it has a hole at  $(0,R^0)$  and includes the origin itself. The distance  $L^0-0$  is the amount the household would be willing to pay in the first period for access to the state-contingent payments  $R^s$  in the second period (the "insurance premium"). The distance  $0-R^0$ , of course, is the amount the household would be willing to pay in the second period for access to  $R^s$ . It is easy to show that in the vicinity of  $(L^0,0)$  (with the probability of default equal to zero), the indifference curve  $I^0$  is upward-sloping and strictly convex. For large enough positive values of  $R$ , default by the partner becomes virtually certain and  $I^0$  asymptotes to the vertical line through  $(L^0,0)$ .

#### E. Equilibrium.

A variety of equilibrium concepts might be employed. For instance, the lender might choose optimally the contractual terms subject to keeping the borrower at or above a reservation utility. This approach, however, implies too much asymmetry between the borrower and lender, for this is a market in

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<sup>10</sup>In this case, a map similar to figure 1 can be drawn in any  $(L,R^s)$ -space for  $2 \leq s \leq S$ .

which households frequently switch between borrowing and lending over time. Instead, I adopt the symmetric Nash bargaining solution, with threat points being no transaction, as the natural equilibrium concept. The choice between these alternative approaches to equilibrium has little effect on the structure of the econometric model to follow. The choice does have implications, however, for certain coefficients, and in section H this will serve as the basis of an informal test between the alternative equilibria.

I allow for the possibility that there may be transaction costs to engaging in this loan contract. Transaction costs could emerge, for instance, if some effort is required to observe the state  $s$  (and therefore to know the contingent payments that are owed). Assume that this cost is a lump sum utility cost; this is equivalent to adding a constant to the utility at each party's threat point.

Let  $EU(L, R)$  be the expected utility to the household from a deal involving a loan of  $L$  to the partner, with agreed upon repayments  $R$  by the partner to the household, where  $R$  is a scalar if we interpret the state-contingent payments as set by community norms. In this case,  $R=R$  in equation 3. If we adopt the alternative interpretation that the households negotiate the state-contingent payments, then  $R$  is an  $S$ -dimensional vector.  $R^1=0$  is our arbitrary normalization. In this case, the households negotiate over a base repayment  $R$  (which is owed regardless of the realization of the state) and over  $R^s$  for  $2 \leq s \leq S$ . Let  $EV(L, R)$  be the expected utility to the partner of the same deal. The symmetric Nash bargaining solution can be characterized by finding

$$4. \text{ Arg Max}_{L,R} \Gamma = \left[ EU(L,R) - U(Y_0) - \beta \sum_S \pi^S \int_{-\infty}^{\infty} U(Y^S + \epsilon) g^S(\epsilon) d\epsilon - T \right] \\ \times \left[ EV(L,R) - V(\tilde{Y}_0) - \beta \sum_S \pi^S \int_{-\infty}^{\infty} V(\tilde{Y}^S + \eta) f^S(\eta) d\eta - T \right],$$

where  $T$  is the transaction cost. The equilibrium is pictured in figure 2. The household's indifference curves are solid; those of the partner are dashed. The core is the set of tangencies between the two indifference maps for which the expected utilities achieved by each party (inclusive of transaction costs) are greater than the expected utility they achieve at the threat point. The bargaining solution is in the core at, say, point 1.

Some comparative statics have been calculated given that the second order conditions are met at equilibrium. *Ceteris paribus*, an increase in first period income increases lending (reduces borrowing). Increased first period income improves the terms at which a household transacts the loan;  $\delta R / \delta Y_0 > 0$ . The signs of the derivatives can be understood with reference to figure 3. Here the household is again the lender. An increase in  $Y^0$  will shift its entire indifference map down and to the right (it is better off at any  $(L,R)$ ) and the slope of the new  $I^0$  is smaller at the x-axis (the household is willing to lend more at a parametric  $R$ ). Equilibrium will shift from point 1 to point 2, with a larger loan and higher repayment.

#### F. Data.

I undertook a survey of 200 households in 4 villages near the city of Zaria from February 1988 to February 1989. The survey consisted of monthly interviews with each of the household heads and (separately) his wives. The questionnaires were designed to yield a complete picture of each household's asset and debt position; an account of its credit, labor, product, asset, and asset-rental transactions over the previous month; and a range of demographic

and background data. For details on the study area and survey methodology, see Udry (1990, 1991b). Table 2 lists the variables used in this study.

*Net Lending, Repayments, and Defaults* - The dependent variables are calculated from data on all loans taken or extended by a sample household for a single main cropping period.<sup>11</sup> The loans included in this analysis are those initially extended during the period from the harvest before the survey began until the middle of the main cropping season during the survey year (September). By September, early crops have been harvested and some loan repayments begin. Net lending by household  $i$  ( $L_i$ ) is the nominal value of loans extended minus loans taken during this period, while net repayments  $REP_i$  is the net nominal value of repayments received by the household on those loans until the end of the survey in February. Repayments, therefore, are measured as actual *ex post* transfers, not as *ex ante* contractual agreements. There is no correction for price level changes over this period. The rare transaction made in kind is valued at the market price of the item at the time of the transaction. It should be noted that this bilateral model allows for only a single transaction partner for each of the sample households. Each of the sample households, however, has an average of two and one half transaction partners in the credit market. I will assume that the loan "partners" of each of the sample households acts as a consortium, the members of which are fixed exogenously. The "partners" negotiate as one against the sample household.

This study also requires an indicator of which loans have been defaulted. The fact that no repayments have been made on a loan is not a sufficient indicator that the loan has been defaulted.  $R + R^s$  may equal zero

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<sup>11</sup>In this semi-arid environment there is only one rain-fed crop per year, with planting beginning in May.

in states of nature in which the borrower receives an adverse observable shock. Therefore, a loan is considered to be in default only if no repayments have been made and there is another indication that the borrower has not met his obligations. This supplementary indicator is based on the response to a question concerning the willingness of a lender to make loans in the future to the borrower. If the respondent was the lender, the respondent was asked about his or her willingness to make a loan in the future to this borrower. If the answer was no and the respondent expected to receive no future payments on the loan from the borrowing household, then the loan was judged to be in default and DEFAULT was set equal to one. If the respondent was the borrower, the respondent was asked about the lender's willingness to make a loan to respondent in the future. If the response was negative and the respondent expected to make no further payments on the loan, the loan was judged in default and DEFAULT was set equal to one.

This is not an entirely satisfactory indicator that a default has occurred. Most importantly, it includes no information concerning the triggering of any enforcement mechanisms, for instance an appeal by the lender to the borrower's senior relatives or to village authorities concerning repayment of the loan. Unfortunately, I collected no such information during the survey. As long as at least temporary exclusion from future access to credit from the lender is a component of the penalty for default, then the present indicator captures all defaulted loans. However, as there may be other reasons for excluding a particular borrower from future access to credit, this indicator may overstate the prevalence of default. On the other hand, this indicator of default errs on the conservative side in its treatment of the timing of repayments. No loan is considered in default as long as the

respondent expects that further payments will be made. This is equivalent to assuming that the period of loans is open; as long as they are eventually repaid, no default has occurred. If there are misclassification errors concerning which households have defaulted, then the likelihood function is incorrect and the estimates will be inconsistent.<sup>12</sup>

This measure indicates that overall, 10.3 percent of loans are defaulted. Respondents who were lenders reported that 8.0 percent of the loans that they extended were defaulted. Respondents who were borrowers admitted that they defaulted on 14.4 percent of the loans that they had taken. This rather surprising difference in responses (in which borrowers admit to more defaults than lenders claim) is not statistically significant at the 5 percent level.

*Observable Shocks to Income* - The observable state of nature  $s$  is defined by the realization of observable shocks to the incomes of the household and its transaction partner. I have two indicators of the realized observable shock to a sample household's income. They are based on self-reported unexpected adverse events on the sample household's uplands and lowlands farms. The indices are weighted averages of these negative events (examples: flooding, lodging, animal invasions) on each plot and the weights are the relative sizes of each plot. The indices are broken down by upland and lowland plots because the two types of land are characterized by different farming systems. Upland plots are entirely rainfed and are farmed once a year

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<sup>12</sup>See Lee and Porter (1984) for a discussion of the effect of misclassification in an exogenous switching regression model. Freeman (1984) discusses the impact of similar misclassification in binary choice models. Stapleton and Young (1984) provide a cautionary note concerning measurement error affecting the dependent variable in a Tobit model (but not causing misclassification as censored or uncensored).



during the rainy season. On the lowland (*fadama*) plots there is dry season irrigated farming.  $Y_h$  is the vector of these two indicators of the observable shock to a sample household's income.  $Y_p$  is the measure of the observable shock to the income of the transaction partner. This variable is the proportion of the total value of loans of the sample household which was transacted with partners who received an adverse shock between the time the loan was made and when it was repaid. All three of these indices are identical to those used in table 1.

The use of these indices depends upon the assumption that the events used in their construction are observable to the village community (including the household, its partner, and family and village authorities) and are exogenous to the behavior of the agents. The first assumption is strongly supported by the evidence presented Udry (1990) that information concerning farming activities and outcomes flows freely within the village. The second assumption is more problematic, for while some events which enter the index are plausibly exogenous (e.g. animal invasions), others are not. The probability of lodging or flooding, for example, can be influenced by farming practices. However, if farming activities themselves are observable to the community, the moral hazard otherwise arising from the endogeneity of these events can be controlled.

*Unobservable Shocks to Income* - The household's decision to default is affected by the realization of  $\epsilon$  - the unobservable shock to household income for which there is no state-contingent adjustment in owed repayments. For these agricultural households, the most important element of  $\epsilon$  is the accumulation of the myriad of tiny variations in the quality and timing of inputs that causes significant variation in yields from year to year. Seed

quality and the day-to-day timing of rainfall are examples of variables with significant random components that are important, at least according to these farmers, in the determination of yield. In order to measure the cumulative effect of variations in these inputs I use the value of per hectare yield on the household's upland and lowlands farms. These two variables compose the vector  $Z$ . Sample households could not provide information concerning the yields of non-sample households, so no measure of the unobservable shock to the partner household's income can be constructed.

The use of this measure of  $\epsilon$  depends upon the assumption that no contingent payments are made based on its components. This assumption will be justified if the components of  $Z$  are in fact unobservable to the village community. This is not a necessary condition, however. It is sufficient that no community standard ( $R^s$ ) calls for a contingent payment on the realization of an element of  $Z$ . The use of  $Z$  in this specification also depends on the assumption that its realization is econometrically exogenous to the credit market activities of the household. This assumption is more problematic; I will return to it during the discussion of the results.

$Z$  may also be subject to important measurement error, as different farmers are likely to have systematically different methods for estimating their output. A better measure could be based on a 'difference of differences' variable which would use the difference between this year's yield (relative to the village average) and last year's yield (relative to last year's village average). However, this is as much a measure of last year's 'unobservable' shock as it is of this year's, and thus would have to be included in the loan size and owed repayment equations as well as in the

default equation, and thus could not provide an instrument to identify the default decision.

*Village effects ( $X_v$ )* - Village dummy variables capture village-specific effects. There are differences in infrastructure, soil quality, and market access across the four villages which will affect the net supply of credit. The different villages will have been subject to different random production shocks in the previous cropping year and this will also affect the net supply of credit. These same factors will influence the negotiation over repayment. The village dummy variables act as predictors of income, and therefore must be included in the default equations for both the sample households and their partners. Also, the village dummy variables are likely to influence the default decision because of differences in the social environments of the different villages which affect the availability of information and enforcement mechanisms needed to support these credit transactions.

*Household Characteristics ( $X_h$ )* - The wealth variable (WEALTH) is equal to the value of holdings of grain, trading stocks, livestock, and household goods (durable consumer goods such as radios, housewares, and farming implements) at the start of the survey. As discussed in section E, an increase in wealth is expected to increase the net supply of credit (or reduce the net demand for credit). In addition to increasing net lending, increased wealth also increases a household's disagreement payoff. Net repayments to the household, therefore, should increase with increased wealth. If the sample household owes a repayment, an increase in its wealth should reduce the likelihood that it will default (by increasing second period income).

The SKILLS variable is a dummy variable indicating the presence of at least one household member with a special skill. Such skills include

carpentry, traditional medicine, tailoring, or being a religious teacher. This variable should act as a fixed asset, increasing the demand for working capital in order to use the skill, and thus decreasing the net lending of the household and worsening the terms at which loan transactions are made. Net repayments to the household should decrease in the presence of a skilled household member. SKILLS is included in the default equation for borrowers because of its effect on income. Higher skills should be correlated with higher income and therefore a lower likelihood of default. This correlation and its effect on default will tend to improve the terms at which the household borrows and makes the final effect of skills on owed repayments and net lending indeterminate when the household is a borrower.

Land ownership is broken down into upland plots (UPLAND) and lowland plots (LOWLAND) because the different types of land require different levels of inputs. Lowlands require much more intensive inputs than do uplands (because the soil is heavier, and because farming can continue year-round). Land ownership should affect net lending, the owed repayment, and the default decision in much the same way as SKILLS. That is, increased land holdings should reduce net lending, worsen the terms at which loan transactions are made, and reduce the incidence of default.

The age of the household head (AGE) should influence net lending and repayments in the same way as other fixed assets.<sup>13</sup> Older household heads should have lower net lending and the terms at which the household transacts loans should become worse. These results, however, were derived assuming that the probability of default was negligible. If older household heads are more

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<sup>13</sup>Rosenzweig and Wolpin (1985) propose plot-specific farming experience as one important route through which age could have an important affect.

able to utilize village mechanisms to enforce loans they have made, or are more subject to the discipline of village authorities when they borrow, then the affect of age on repayments becomes indeterminate.

#### G. Model Specification.

In this section I develop an econometric specification of loan transactions based on the model of the preceding sections. Each of the sample households is assumed to be engaged in a bilateral credit relationship. The empirical work below is characterized in terms of net lending by the sample household and net repayments to the sample household.

The first order conditions of equation 4 implicitly define net lending as a function of characteristics of the household and its partner:

$L=L(X_{hh},X_{partner})$ . The comparative statics of this equilibrium are complicated, but as noted above, the derivatives of the reduced form do not switch signs depending on net borrowing/lending status as long as the Nash solution is symmetric. Similarly, there is a reduced form for base repayments  $R=R(X_{hh},X_{partner})$ .

As noted above, the terms at which credit is transacted are implicit; the owed repayment is not observed. It must therefore be estimated from observed repayments. If we adopt the interpretation that any state-contingent adjustments in owed repayments are exogenously determined by community norms, then the amount owed in state  $s$  is  $OWED^s=R(X_{hh},X_{partner}) + R^s$ .  $OWED^s$  is observed in those instances in which there is no default.  $R^s$  is not observed, but is a function only of the observed state  $s$  which is realized in the final period. Alternatively, if the state-contingent payments are negotiated by the two parties, then  $R^s=R^s(X_{hh},X_{partner})$ . In either case the contractual repayment  $R$  is independent of observable shocks, but depends upon a range of household

characteristics, while the state-contingent payment  $R^s$  depends on the realization of observable shocks.  $R^s$  and  $R$  therefore are identified though exclusion restrictions. It is possible to test between our two hypotheses concerning the determination of the state-contingent payments. Evidence that household characteristics help predict these payments supports the notion that they are negotiated rather than determined by community norms.

As described in section C, the default decision of the household (if it owes a repayment) depends on its realized final period income, the amount it owes, and the utility cost of defaulting. One component of the income of the household is the unobservable income shock  $\epsilon$  that it receives. The contractual repayment  $R$  is independent of this unobservable income shock in the final period because it is set before the realization of  $\epsilon$ . Owed repayments are contingent upon the realization of the observable state of nature only, so  $R^s$  is also independent of  $\epsilon$ . The measure of this shock ( $Z$ ) will therefore serve to identify the default decision of the household. An analogous measure of the unobservable income shock received by the partner would serve to identify its default decision. No such measure is available, however, so the amount defaulted by the partner is identified only through the non-linearity of the optimal default schedule.

The reduced forms for both  $L(.)$  and  $R(.)$  include characteristics of both the household and its partner. During the fieldwork, attempts were made to collect information concerning the transaction partners, but they met with only minor success. Sample households in general refused to reveal the identity of their partners and would provide only limited information concerning them. The estimation that follows therefore is affected by omitted variables bias.

The system to be estimated is set forth below. Individual household subscripts are omitted. Equations (5a) and (5b) define net lending ( $L$  is positive when a loan is made from a sample household to its partner). The friction represented by  $k_L$  is required by the possibility of transaction costs (introduced in eq. 4). An asterisk indicates that a variable is latent.

$$5a. \quad L^* = X_v \alpha_0 + X_h \alpha_1 + \nu_1$$

$$b. \quad L = \begin{cases} 0 & \text{if } 0 < L^* < k_L \\ L^* & \text{if } L^* < 0 \quad (\text{borrowing}) \\ L^* - k_L & \text{if } L^* > k_L \quad (\text{lending}) \end{cases}$$

Equation 6 defines the net repayments owed to sample households ( $OWED^*$  is positive for a repayment to a sample household from its partner).

$$6. \quad OWED^* = \begin{cases} X_v \beta_0 + X_h \beta_1 + Y_h \beta_2 + Y_p \beta_3 + \nu_2 & \text{if } L \neq 0 \\ 0 & \text{if } L = 0. \end{cases}$$

Recall that  $Y_h$  and  $Y_p$  consist of the indicators of the observable shocks to the incomes of the household and the partner. Together, they define the observable state on nature  $s$ , which in turn determines the state-contingent payment  $R^s$ .  $Y_h$  and  $Y_p$  identify any state-contingent payments contained within the loan repayments. Indicators of observable shocks received by both the household and its partner are included in the estimation of the repayment equation because the state-contingent payments may depend on the shocks received by both parties. The central hypothesis tested below is that the state-contingent payments serve to pool risk between the household and its partner by flowing toward the party which has received a particularly adverse observable shock.

Equations 7a and 7b describe a sample household's default decision.

7. if the household is a borrower:

$$a. \quad D^* = X_v \gamma_0 + X_h \gamma_1 + Y_h \gamma_2 + Z \gamma_3 + \gamma_4 \text{OWED}^* + \nu_3$$

$$b. \quad \begin{cases} \text{REP} = 0 \text{ and } D = 1 & \text{if } D^* > 0 \\ \text{REP} = \text{OWED}^* \text{ and } D = 0 & \text{if } D^* \leq 0. \end{cases}$$

The default decision depends upon the household's income and the amount owed, given the cost of a default. Village dummy variables  $X_v$  are included to capture the effect of village residence on both income and the (community determined) cost of a default. Household specific variables  $X_h$  are included as predictors of income. For the same reason the indices of observable ( $Y_h$ ) and unobservable ( $Z$ ) shocks to the household's income are included.

Equations 8a and 8b describe a partner's default decision.

8. if the sample household is a lender:

$$a. \quad D^* = X_v \lambda_0 + Y_p \lambda_1 + \lambda_2 \text{OWED}^* + \nu_4$$

$$b. \quad \begin{cases} \text{REP} = 0 \text{ and } D = 1 & \text{if } D^* > 0 \\ \text{REP} = \text{OWED}^* \text{ and } D = 0 & \text{if } D^* \leq 0. \end{cases}$$

Village dummy variables are again included because of their effect on both the partner household's income and the cost of a default. Equations 7 and 8 should be identical, but no household characteristics of the partner are available. The only available household level indicator of the partner's income is  $Y_p$ , the index of observable adverse shocks affecting the partner household. I have no measure of farm yields for non-sample households, so no measure of the unobservable income shock received by the partner household can be constructed.

The random variables  $\nu_1$ ,  $\nu_2$ ,  $\nu_3$  and  $\nu_4$  are assumed to be jointly normally distributed with zero mean and covariance matrix  $\Sigma$ . The parameters of the default decisions (eqs. 7-8) are identified only up to scale, so the variances



of  $v_3$  and  $v_4$  are set to unity. The contribution of each observation to the likelihood function can be found in the appendix.

As noted above,  $L^*$ ,  $OWED^*$ , and  $D^*$  are latent variables, while  $L$ ,  $I$ ,  $REP$ , and  $D$  are observed. The covariance between  $v_3$  and  $v_4$  cannot be identified at all, as it has no effect on observed outcomes. The Rosett-type friction of equation 5 is identified through its non-linearity; no variables are available to identify the friction independently of the determinants of loan size. Equation 7 is identified by the vector  $Z$ , which affects the amount defaulted but not the repayment owed. Equation 8 is identified only through its non-linear structure, as I have no measure of the yields achieved on the partners' plots.

The assumption that the idiosyncratic shocks (both  $Y$  and  $Z$ ) are serially uncorrelated is critical. However, as long as the deviation of the household level shock from the village shock is not serially correlated, the estimates are consistent. Net lending  $L^*$  is affected by last year's idiosyncratic shocks ( $Y_{t-1}$  and  $Z_{t-1}$ ). This dependence is captured in the random variable  $v_1$ . If the idiosyncratic shocks are serially correlated, then  $v_1$  is correlated with  $Y_h$ ,  $Y_p$  and  $Z$  and the estimates are inconsistent. Serial correlation in shocks that affect the entire village are not problematic, as they are reflected in the coefficients of the village dummy variables.

#### H. Estimation Results.

I present FIML estimates of the base specification in table 3, and some variations on this base model in tables 4-5. Each variation is a

generalization of the base model, so that nested tests of the significance of each generalization can be made.<sup>14</sup>

*State-contingent payments* - The results presented in section B of table 3 indicate that observable shocks received by sample households after a loan is extended improve the terms at which the loan is repaid. Observable shocks received by a household's partner worsen the terms faced by the sample household. The point estimates imply that a one standard deviation adverse shock to the household's lowland plots is associated with a N61 contingent payment to the household (the average amount lent is N191, or about \$40). A one standard deviation adverse shock received by the household's partner leads to a N29 contingent payment by the household to its partner. The point estimate of the impact of observable shocks on the household's upland plots indicates that the household receives only a N5 contingent payment for a one standard deviation shock, and the coefficient is not significantly different from zero. The results confirm the hypothesis that owed repayments are state-contingent, and that this flexibility allows for direct risk pooling between borrowers and lenders.<sup>15</sup>

The finding that state-contingent payments are made in response to the realization of observable shocks on lowlands plots, but not on upland plots (the data on shocks realized by transaction partners do not differentiate between uplands and lowlands) is not untenable, as lowland and upland land

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<sup>14</sup>The tables are based on specifications which gain efficiency by imposing the restriction that the covariances  $\sigma_{13}$ ,  $\sigma_{14}$ ,  $\sigma_{23}$  and  $\sigma_{24}$  are zero. The likelihood ratio test of the joint restriction that these covariances are zero yields a  $\chi^2(4)$  test statistic of .6, which is insignificantly different from zero. Moreover, no coefficient changes sign in the unrestricted specification, nor is there any statistically significant change in any estimate.

<sup>15</sup>This confirms the central findings of Udry (1990) and Udry (1991).

historically have been treated differently in a number of respects, from land tenure to farming practices.<sup>16</sup> Furthermore, upland plots are dispersed throughout the land surrounding the village, while lowland plots are concentrated on the banks of the few streams near each village. Therefore it is easier to monitor events on transaction partners' lowland plots than on their upland plots.

In order to test the hypothesis that the state-contingent payments are negotiated rather than set by community norms, the model was estimated with interactions between the indicators of observable shocks and various household characteristics. Three different specifications were estimated. First, interactions were allowed between adverse shocks on the different types of land and the area owned of each type of land. The likelihood ratio test of the restriction that the interaction coefficients are zero yields a  $\chi^2(4)$  test statistic of 3.4, which is not significantly different from zero at the 5 percent level. There is no evidence, therefore, that the payment which is contingent upon receipt of a particular adverse observable shock varies according to the size of the plot affected by the shock. Second, I added interactions between the village dummy variables and the indicators of adverse observable shocks. The likelihood ratio test of the restriction that these interaction coefficients are zero yields a  $\chi^2(6)$  test statistic of 7.0, which is not significantly different from zero. The size of the state-contingent payments does not seem to vary across the four villages. Finally, I permitted interactions between all the household characteristics ( $X_h$ ) and the indicators of observable shocks. The  $\chi^2(10)$  likelihood ratio test statistic of the restriction that these interactions are zero is 10.4, which again is not

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<sup>16</sup>See Norman (1972), Hill (1977) and Ega (1984).

significantly different from zero. There is no evidence, therefore, that the state-contingent payments depend on the characteristics of the household. This series of tests provides no support for the hypothesis that households negotiate over the state-contingent payments which are embedded in these loan transactions. Rather, there seem to be community standards that prescribe appropriate payments contingent on the realization of particular observable shocks.<sup>17</sup>

Table 4 reports the results of a specification which permits the coefficients of the indices of observable adverse events to vary according to the sample household's net borrower/net lender status. The results in section B show that when adverse shocks are received by sample households who are net borrowers, they pay back less. Similarly, when the sample household is the lender, an adverse shock received by its transaction partner is associated with lower repayments to the household. These results could be consistent with conventional models of loan contracting, as the lower repayments might simply reflect a higher incidence of default on the part of borrowers who receive adverse shocks. Here, however, the results control for the default status of the borrower. Owed repayments, therefore, depend on the realization of adverse shocks by the borrower. This finding is consistent with a notion of a loan as an equity investment in the borrower's enterprise, an appropriate form of lending under Shari'a law.

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<sup>17</sup>Community norms which dictate risk sharing between households are an oft-cited element of the 'moral economy' or 'subsistence ethic' which has been hypothesized to provide a measure of security in peasant communities in risky environments (Scott [1976]; Watts [1983]). The present model may be interpreted as an effort to place an analysis of rural credit based on household optimizing behavior within the context of a village moral economy.

Even more striking, however, are the results in section B of table 4 which indicate that when adverse shocks are received by lenders, they are paid back more. When the sample household is the lender, adverse shocks on its lowland plots are associated with higher repayments to the household. Similarly, when the sample household is the borrower, adverse shocks affecting its transaction partner are associated with higher repayments by the sample household. In fact, there is no statistically significant difference between the responses of repayments to adverse shocks received by net lenders and net borrowers. A likelihood ratio test of the restriction that the coefficients of the indices of adverse shocks are the same for net lenders and net borrowers yields a  $\chi^2(3)$  test statistic of 0.4, which is not significantly different from zero at the 10 percent level. This provides no evidence, therefore, against the hypothesis of symmetric Nash equilibrium; borrowers and lenders appear to be treated symmetrically.

*Household characteristics* - Turn now to the other results from the base specification. The net lending equation reported in section A of table 3 confirms the hypothesis of transaction costs in lending. The friction coefficient is significantly different from zero. As expected, households with higher levels of wealth holdings at the start of the sample year have higher net lending. The effect of wealth on repayments, however, is insignificant.

Ownership of upland and lowland land affect net lending in opposite directions. Households with larger holdings of upland plots tend to lend more, while households with larger holdings of lowlands borrow more (though this latter coefficient is only marginally significant). This may reflect the higher working capital requirements of lowlands plots.

Households containing at least one family member with a special skill borrow, on average, N63 more than other households. This result is in accordance with the expectation that extra working capital would be required to employ these skills. Similarly, households with older household heads have significantly less net lending than those headed by younger men. In another specification (not reported), I included measures of the household head's formal education (both western and Islamic). Neither measure had any significant effect on the household's behavior in the credit market and a test of the joint significance of the education variables yields a  $\chi^2(4)$  test statistic of only 2.4. These findings are in accordance with the hypothesis advanced by Rosenzweig and Wolpin (1989) that farming experience rather than formal education is an important determinant of farming ability in risky but stationary environments.

The estimates of the default equation for the household and its partner are presented in section C of table 3. As expected, after controlling for observable adverse events, households which received lower yields are more likely to default. Also in accordance with theoretical expectations, households which owed higher repayments were more likely to default. In order to explore the consequences of omitted variables in the partner's default equation, section C of table 5 presents estimates from a specification which permitted the effects of owed repayments on the default decision to vary between sample households and their partners. There is no significant difference between the two coefficients.

A household's wealth has no significant effect on the default decision. Households with larger land holdings are significantly more likely to default, contrary to theoretical expectation. An observable shock on its land reduces

the probability of default by the household. This is a puzzling result because the theoretical model implies that a reduction in income should increase the probability of default. It is possible that after an adjustment in owed repayments has been made in response to receipt of a shock, the cost of defaulting increases. It is interesting, however, that observable shocks affecting the household's partner increase the probability of default by the partner, though the coefficient is only marginally significant.

The village dummy variables play an important role in each equation. They capture a variety of different collinear effects including village level shocks, infrastructure, and the socially-determined costs of default.

#### I. Conclusions.

One of the primary motivations for borrowing in agricultural societies is to stabilize consumption in the face of fluctuating incomes. Households borrow more when they suffer an adverse shock and they lend more when they are favored with a positive shock. Credit transactions in rural northern Nigeria play a more direct role in pooling risk between households. Repayments owed on a loan depend upon the realization of random production and consumption shocks by both borrower and lender. The restriction of loan transactions to agents within a small social space allows the free flow of information between borrower and lender that is necessary to support state-contingent contracting and provides access to community-based mechanisms to monitor and enforce the contracts. The results of this paper confirm that state-contingent payments which flow to the recipients of adverse shocks are embedded within loan repayments.

The estimation carried out in this paper is based on a bilateral model of loan contracting. This model admits a wide range of assumptions concerning

the flow of information within the village. It also permits an investigation of the decision by a household to default on its repayment obligations. Most importantly, this approach captures at least a portion of the rich social and institutional context within which the loans are transacted.

Nevertheless, the weaknesses of this approach must be acknowledged. Some are technical, and have been detailed in the body of the paper. These include the drought of information concerning the transaction partners of sample households; the difficulty of determining whether or not a default has occurred; and the assumptions that are required to identify the default decisions of the transaction partners of the sample households. Other weaknesses are necessary consequences of the approach taken. By focusing attention on the loan transaction itself, the properties of the general equilibrium are lost. More generally, the two primary actors in the model interact within the rules set by the small community in which they reside, but they make no contribution to any changes which occur in that community. I have treated the community as autonomous, setting norms of behavior and providing neutral monitoring and enforcing authority. This has enabled me to analyze the behavior of optimizing agents within the context of their community, but provides no mechanism for exploring the community itself. This work, therefore, invites extensions which move away from this partial equilibrium method. Most simply, the Nash bargaining game could be generalized to allow for community-wide rather than bilateral equilibrium. More ambitious research would focus on changes in the community norms and monitoring and enforcement mechanisms which set the context for these state-contingent loan transactions.



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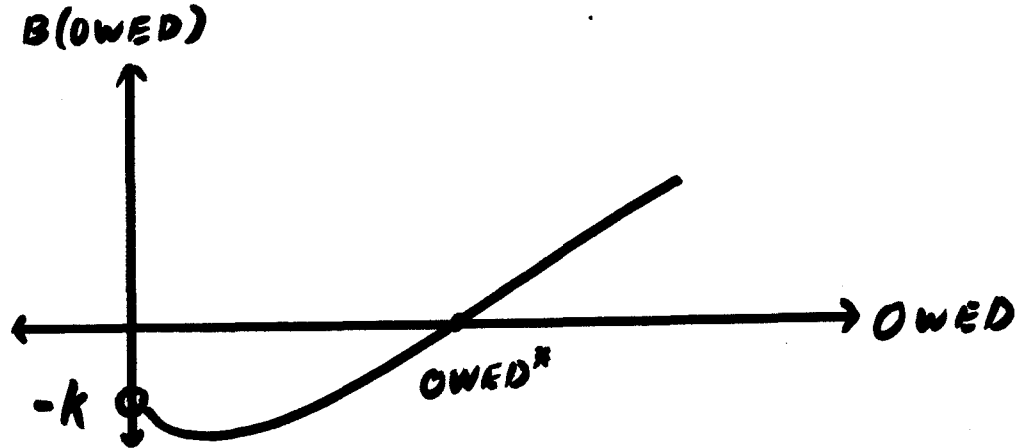
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## APPENDIX: THE DEFAULT DECISION

Consider a given state of nature  $s$ . Let  $z = \tilde{Y}^s + \eta$  and  $OWED = R + R^s$ . The partner will default if the benefit from defaulting  $U(z) - C(OWED) - U(z - OWED) > 0$ . Recall that  $U(\cdot)$  is continuous and that the limit as  $x \rightarrow 0^+$  of  $C(x) = k > 0$ . Therefore, the limit as  $OWED \rightarrow 0^+$  of  $U(z) - C(OWED) - U(z - OWED) = -k < 0$ . For a small enough amount owed, the partner will not default. Because the limit as  $x \rightarrow 0^+$  of  $U(x) \rightarrow -\infty$  and  $C(x)$  is bounded from above the limit as  $OWED \rightarrow z^-$  of  $U(z) - C(OWED) - (z - OWED) \rightarrow \infty$ .  $U(\cdot)$  and  $C(\cdot)$  are continuous, so there exists some  $OWED^*$  such that  $U(z) - C(OWED^*) - U(z - OWED^*) = 0$ . Because  $B(OWED) \equiv U(z) - C(OWED) - U(z - OWED)$  is strictly convex and the limit as  $OWED \rightarrow 0^+ < 0$ ,  $OWED^*$  is unique (see figure A1).



Now consider a given level of  $OWED = R + R^s > 0$ . Define  $\tilde{B}(z) \equiv U(z) - C(OWED) - u(z - OWED)$ . The limit as  $z \rightarrow OWED^+$  of  $\tilde{B}(z) \rightarrow \infty$ . Because  $U(\cdot)$  is increasing, concave and bounded from above, the limit as  $z \rightarrow \infty$  of  $\tilde{B}(z) = C(OWED) < 0$ . Therefore, there is some  $z^c$  such that  $\tilde{B}(z^c) = 0$ .  $\partial \tilde{B} / \partial z < 0$ , so  $z^c$  is unique.  $z^c(OWED)$  is a continuous and continuously differentiable function implicitly defined by  $\tilde{B}(z^c(OWED)) = 0$ . From the implicit function formula,

$$\frac{\delta z^c}{\delta OWED} = - \frac{U'(z^c - OWED) - C'(OWED)}{U'(z^c) - U'(z^c - OWED)} > 0$$

because the denominator is negative and the numerator is positive when  $\bar{B}(z)=0$ .  $z^c$  is implicitly defined as a differentiable function of OWED for all OWED > 0, with  $z^{c'}(\text{OWED}) > 0$ . Define  $\eta^c(\text{OWED}) = z^c(\text{OWED}) - Y$ . Note that as OWED  $\rightarrow 0^+$ ,  $z^c(\text{OWED}) \rightarrow 0$  and  $\eta^c(\text{OWED}) \rightarrow -Y$ .

The critical value of random income  $\eta^c(\text{OWED})$  is now defined. Note however that  $\eta^c$  is not defined for OWED < 0, for in such situations the partner never defaults. In order to avoid technical difficulties in describing the equilibrium in section E, it is useful to define an arbitrary continuation of the function  $\eta^c(\text{OWED})$  for values of OWED less than zero which is continuous and differentiable for all values of OWED. I have dropped all state superscripts to avoid notational clutter during this discussion. But the critical value of random income obviously varies across states of nature. Therefore, for each state  $s$ , define  $\eta^s(\text{OWED}^s)$  as equal to the function  $\eta^c(\text{OWED})$  as discussed above for this state for all OWED<sup>s</sup> > 0, and equal to any arbitrary differentiable continuation of this function for OWED<sup>s</sup> ≤ 0.

## APPENDIX: THE LIKELIHOOD FUNCTION

There are five observationally distinct cases, depending upon the borrowing/lending and default status of each household. I have dropped the  $i$  subscripts; each equation refers to an individual observation. The contribution of each observation to the likelihood function is as follows:

Case 1:  $L < 0$ , the household is a net borrower:

$$A1. \quad \nu_1 = L - X\alpha$$

Subcase (a):  $D = 0$ :

$$A2. \quad \text{and } \nu_2 = \text{REP} - X\beta_0 - Y\beta_1$$

$$A3. \quad \text{and } \epsilon_1 = \nu_3 + \gamma_4 \nu_2 < -[X_v \gamma_0 + X_h \gamma_1 + Y_h \gamma_2 + Z \gamma_3 + \gamma_4 (X\beta_0 + Y\beta_1)].$$

Subcase (b):  $D = 1$ ,  $\text{REP} = 0$ :

$$A4. \quad \text{and } \epsilon_1 \geq -[X\gamma_0 + X\gamma_1 + Y_h \gamma_2 + Z\gamma_3 + \gamma_4 (X\beta_0 + Y\beta_1)].$$

If  $\nu_2$  and  $\nu_3$  have mean zero, variances  $\sigma_2^2$  and  $\sigma_3^2$  and covariance  $\sigma_{23}$ , then  $\sigma_\epsilon^2 = \sigma_3^2 + (\gamma_4)^2 \cdot \sigma_2^2 + 2\sigma_{23} \cdot \gamma_4$ ,  $\sigma_{1\epsilon} = \gamma_4 \sigma_{12} + \sigma_{13}$ , and  $\sigma_{2\epsilon} = \gamma_4 \sigma_{22} + \sigma_{23}$ .

Case 2:  $L > 0$ , the household is a net lender:

$$A5. \quad \nu_1 = L + k_L - X\alpha$$

Subcase (a):  $D = 0$ :

$$A6. \quad \text{and } \nu_2 = \text{REP} - X\beta_0 - Y\beta_1$$

$$A7. \quad \text{and } \epsilon_2 = \nu_4 + \lambda \nu_2 < -[X_v \lambda_0 + Y_p \lambda_1 + \lambda_2 (X\beta_0 + Y\beta_1)]$$

Subcase (b):  $D = 1$ ,  $\text{REP} = 0$ :

$$A8. \quad \text{and } \epsilon_2 \geq -[X_v \lambda_0 + Y_p \lambda_1 + \lambda_2 (X\beta_0 + Y\beta_1)]$$

The covariance matrix of  $\epsilon_2$  and  $\eta_2$  is defined similarly to that of  $\epsilon_1$  and  $\eta_1$ .

Case 3:  $L = 0$ , the household neither borrows nor lends):

$$A9. \quad k_L - X\alpha < \nu_1 < -X\alpha.$$

# TABLES AND FIGURES

Table 1: Realized Terms vs. Borrower and Lender Shocks Received

| Adverse shock<br>received by:      | <u>Sample means</u>       |                          |                             |
|------------------------------------|---------------------------|--------------------------|-----------------------------|
|                                    | monthly rate of<br>return | simple rate of<br>return | repayment<br>period in days |
| <hr/>                              |                           |                          |                             |
| (A) Borrower                       |                           |                          |                             |
| -no shock                          | 0.5%                      | 20.4%                    | 67                          |
| -shock                             | -4.0%                     | -0.6%                    | 72                          |
| Impact of shock<br>on mean:<br>(t) | lower<br>(1.58)           | lower<br>(2.20)          | longer<br>(1.03)            |
| <hr/>                              |                           |                          |                             |
| (B) Lender                         |                           |                          |                             |
| -no shock                          | -7.5%                     | -5.0%                    | 89                          |
| -shock                             | 2.6%                      | 11.8%                    | 80                          |
| Impact of shock<br>on mean:<br>(t) | higher<br>(4.56)          | higher<br>(3.06)         | shorter<br>(1.89)           |
| <hr/>                              |                           |                          |                             |

The impact of the shocks is judged by a two-sided t-test of equal means ( $\mu_{\text{no shock}} - \mu_{\text{shock}}$ ). The absolute value of the t-statistic is in parentheses.

The measure of 'adverse shock' is:

1. A respondent (borrower or lender) is judged to have received an adverse shock if he reported an unexpected adverse event on any of the fields he farms during the term of the loan. Common events were flooding, wind damage, or infestation by insects.

2. The other party (borrower or lender) is judged to have received an adverse shock if the respondent reported an unexpected, serious event that occurred in the other household during the term of the loan. Common events were farming events as in (1), and medical problems, rain damage to houses, and other 'household emergencies.'

Table 2: Variables Used

|   | <u>Mean</u> | <u>Std.</u> |
|---|-------------|-------------|
| <b>A. Dependent Variables</b>   |             |             |
| NET LENDING : net amount lent (x N100)*   | 1.91        | 24.16       |
| REPAYMENT : net amount repaid (xN100)<br>(to sample household by others)  | 2.50        | 26.75       |
| DEFAULT : indicator of default on loan  | 0.16        | 0.37        |
| <b>B. Household Characteristics (<math>X_h</math>)</b>  |             |             |
| WEALTH : value of livestock, household articles,<br>grain and trading stocks evaluated at the<br>start of the survey (x1000). | 2.25        | 45.12       |
| AGE : age in years of household head.   | 40.64       | 12.23       |
| HERELONG : dummy variable. 1 if family of household<br>head has been in village 2 or more<br>generations.                     | 0.68        | 0.47        |
| SKILLS : dummy variable. 1 if at least one member<br>of household has special skills.   | 0.60        | 0.24        |
| UPLAND : gona (upland) land owned in hectares.  | 3.24        | 4.69        |
| LOWLAND : fadama (lowland) land owned in hectares.  | 0.44        | 1.04        |
| <b>C. Indicators of Observable Shocks to Household Income (<math>Y_h</math>)</b>  |             |             |
| UPROBLEM : index of self-reported problems<br>on upland farms.  | 0.22        | 0.35        |
| LPROBLEM : index of self-reported problems<br>on lowland farms.   | 0.27        | 0.26        |
| <b>D. Indicator of Observable Shocks to Partner Income (<math>Y_p</math>)</b>   |             |             |
| PARTPROB : proportion of loans with partners who<br>received adverse shocks   | 0.20        | 0.30        |
| <b>E. Indicators of Unobservable Shocks to Household Income (<math>Z</math>)</b>  |             |             |
| UYIELD : log of per-hectare yield on upland farms   | -0.49       | 1.20        |
| LYIELD : log of per-hectare yield on lowland farms  | -0.54       | 0.83        |

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\*The Nigerian currency is the Naira. The exchange rate ranged from \$1 = N4 in February 1988 to \$1 = N7 in February 1989.



Table 3: Bilateral Model FIML Estimates

## A. Net Lending Equation (positive -lending from the household to the partner):

| Variable         | Parameter | T-Ratio |
|------------------|-----------|---------|
| CONSTANT         | 5.885     | 26.32   |
| VILLAGE1         | -2.304    | -10.44  |
| VILLAGE2         | -3.029    | -13.77  |
| VILLAGE3         | -1.373    | -6.22   |
| WEALTH           | 0.138     | 2.10    |
| AGE              | -0.070    | -3.76   |
| SKILLS           | -0.629    | -3.14   |
| UPLAND           | 0.405     | 3.67    |
| LOWLAND          | -0.372    | -1.86   |
| FRICTION CUTOFF: |           |         |
|                  | 4.499     | 21.39   |
| $\sigma$         | 7.944     | 41.75   |

## B. Net Repayment Equation (positive-repayments from partner to the household):

| Variable | Parameter | T-Ratio |
|----------|-----------|---------|
| CONSTANT | 1.982     | 8.91    |
| VILLAGE1 | 0.790     | 3.62    |
| VILLAGE2 | -1.808    | -8.33   |
| VILLAGE3 | -1.150    | -5.26   |
| WEALTH   | 0.083     | 1.24    |
| AGE      | -0.026    | -1.57   |
| SKILLS   | -1.095    | -5.77   |
| UPLAND   | 0.257     | 2.81    |
| LOWLAND  | -0.248    | -1.33   |

## INDEX OF SELF-REPORTED SHOCKS:

|              |        |       |
|--------------|--------|-------|
| ON UPLANDS   | 0.220  | 1.00  |
| ON LOWLANDS  | 2.263  | 10.17 |
| LOAN PARTNER | -1.427 | -6.45 |
| $\sigma$     | 6.217  | 35.21 |
| rho12        | 0.759  | 19.13 |

Table 3: Bilateral Model FIML Estimates (Continued)

## C. Default Equation:

| Variable              | Parameter | T-Ratio |
|-----------------------|-----------|---------|
| CONSTANT              |           |         |
| - sample households   | 0.745     | 3.33    |
| - transaction partner | -4.488    | 2.03    |
| VILLAGE1              | -1.123    | -5.13   |
| VILLAGE2              | -0.025    | -0.11   |
| VILLAGE3              | -1.014    | -4.50   |
| WEALTH                | 0.018     | 0.24    |
| GONA                  | 0.776     | 8.20    |
| FADAMA                | 0.770     | 3.41    |

## INDEX OF SELF-REPORTED SHOCKS:

|              |        |       |
|--------------|--------|-------|
| ON UPLANDS   | -4.787 | -2.14 |
| ON LOWLANDS  | -8.011 | -3.59 |
| LOAN PARTNER | 2.124  | 0.94  |

## FARM YIELD:

|             |        |       |
|-------------|--------|-------|
| ON UPLANDS  | -3.153 | -1.40 |
| ON LOWLANDS | -8.778 | -3.95 |
| AMOUNT OWED | 5.782  | 28.12 |

-LN(Likelihood) = 1209.0

Table 4: Testing the Responsiveness of Contract Terms to Shocks:  
Sample Households vs. Partner Households

A. Net Lending Equation (positive -lending from the household to the partner):

| Variable         | Parameter | T-Ratio |
|------------------|-----------|---------|
| CONSTANT         | 5.884     | 26.31   |
| VILLAGE1         | -2.304    | -10.44  |
| VILLAGE2         | -3.030    | -13.77  |
| VILLAGE3         | -1.375    | -6.23   |
| WEALTH           | 0.138     | 2.10    |
| AGE              | -0.070    | -3.76   |
| SKILLS           | -0.630    | -3.14   |
| UPLAND           | 0.405     | 3.67    |
| LOWLAND          | -0.373    | -1.86   |
| FRICTION CUTOFF: |           |         |
|                  | 4.492     | 21.36   |
| $\sigma$         | 7.942     | 41.74   |

B. Net Repayment Equation (positive-repayments from partner to the household):

| Variable | Parameter | T-Ratio |
|----------|-----------|---------|
| CONSTANT | 2.005     | 9.01    |
| VILLAGE1 | 0.765     | 3.51    |
| VILLAGE2 | -1.831    | -8.43   |
| VILLAGE3 | -1.173    | -5.36   |
| WEALTH   | 0.083     | 1.24    |
| AGE      | -0.026    | -1.59   |
| SKILLS   | -1.097    | -5.78   |
| UPLAND   | 0.259     | 2.83    |
| LOWLAND  | -0.251    | -1.34   |

INDEX OF SELF-REPORTED SHOCKS:

|              | Borrowing Households |       | Lending Households |       |
|--------------|----------------------|-------|--------------------|-------|
| ON UPLANDS   | 0.221                | 1.00  | 0.071              | 0.31  |
| ON LOWLANDS  | 2.273                | 10.21 | 2.000              | 8.83  |
| LOAN PARTNER | -1.408               | -6.37 | -1.112             | -4.91 |
| $\sigma$     |                      | 7.947 |                    | 41.75 |
| rho12        |                      | 0.760 |                    | 19.14 |

Table 4: Sample Households vs. Partner Households (Continued)

## C. Default Equation:

| Variable              | Parameter | T-Ratio |
|-----------------------|-----------|---------|
| CONSTANT              |           |         |
| - sample households   | -2.209    | -9.86   |
| - transaction partner | -8.030    | -3.69   |
| VILLAGE1              | -0.083    | -0.37   |
| VILLAGE2              | -0.025    | -0.11   |
| VILLAGE3              | -1.451    | -6.43   |
| WEALTH                | 0.388     | 4.39    |
| GONA                  | 1.291     | 12.12   |
| FADAMA                | 0.873     | 3.86    |

## INDEX OF SELF-REPORTED SHOCKS:

|              |         |       |
|--------------|---------|-------|
| ON UPLANDS   | -5.900  | -2.63 |
| ON LOWLANDS  | -13.060 | -5.83 |
| LOAN PARTNER | 8.335   | 3.69  |

## FARM YIELD:

|             |         |       |
|-------------|---------|-------|
| ON UPLANDS  | -10.536 | -4.66 |
| ON LOWLANDS | -14.358 | -6.42 |
| AMOUNT OWED | 8.611   | 40.67 |

$$-\text{LN}(\text{Likelihood}) = 1208.9$$

Table 5: Generalized Default Equation

## A. Net Lending Equation (positive -lending from the household to the partner):

| Variable         | Parameter | T-Ratio |
|------------------|-----------|---------|
| CONSTANT         | 5.884     | 26.31   |
| VILLAGE1         | -2.303    | -10.43  |
| VILLAGE2         | -3.029    | -13.76  |
| VILLAGE3         | -1.373    | -6.22   |
| WEALTH           | 0.138     | 2.10    |
| AGE              | -0.070    | -3.76   |
| SKILLS           | -0.629    | -3.14   |
| UPLAND           | 0.405     | 3.67    |
| LOWLAND          | -0.372    | -1.86   |
| FRICTION CUTOFF: |           |         |
|                  | 4.499     | 21.38   |
| $\sigma$         | 7.944     | 41.74   |

## B. Net Repayment Equation (positive-repayments from partner to the household):

| Variable | Parameter | T-Ratio |
|----------|-----------|---------|
| CONSTANT | 1.988     | 8.93    |
| VILLAGE1 | 0.784     | 3.59    |
| VILLAGE2 | -1.812    | -8.35   |
| VILLAGE3 | -1.156    | -5.28   |
| WEALTH   | 0.083     | 1.24    |
| AGE      | -0.026    | -1.58   |
| SKILLS   | -1.095    | -5.76   |
| UPLAND   | 0.257     | 2.81    |
| LOWLAND  | -0.249    | -1.33   |

## INDEX OF SELF-REPORTED SHOCKS:

|              |        |       |
|--------------|--------|-------|
| ON UPLANDS   | 0.225  | 1.02  |
| ON LOWLANDS  | 2.268  | 10.19 |
| LOAN PARTNER | -1.430 | -6.46 |
| $\sigma$     | 6.217  | 35.21 |
| rho12        | 0.757  | 19.12 |

Table 5: Generalized Default Equation (Continued)

## C. Default Equation:

| Variable              | Parameter | T-Ratio |
|-----------------------|-----------|---------|
| CONSTANT              |           |         |
| - sample households   | 0.484     | 2.23    |
| - transaction partner | -4.320    | -1.97   |
| VILLAGE1              | -1.506    | -6.74   |
| VILLAGE2              | -0.247    | -1.09   |
| VILLAGE3              | -1.298    | -5.73   |
| WEALTH                | 0.021     | 0.94    |
| GONA                  | 0.745     | 3.35    |
| FADAMA                | 0.122     | 0.53    |

## INDEX OF SELF-REPORTED SHOCKS:

|              |        |       |
|--------------|--------|-------|
| ON UPLANDS   | -4.932 | -2.23 |
| ON LOWLANDS  | -8.252 | -3.71 |
| LOAN PARTNER | 1.789  | 0.79  |

## FARM YIELD:

|             |        |       |
|-------------|--------|-------|
| ON UPLANDS  | -3.040 | -1.35 |
| ON LOWLANDS | -8.929 | -4.02 |

## AMOUNT OWED

|                      |       |       |
|----------------------|-------|-------|
| - Sample Households  | 5.761 | 27.82 |
| - Partner Households | 5.962 | 26.71 |

$$-\text{LN}(\text{Likelihood}) = 1208.9$$

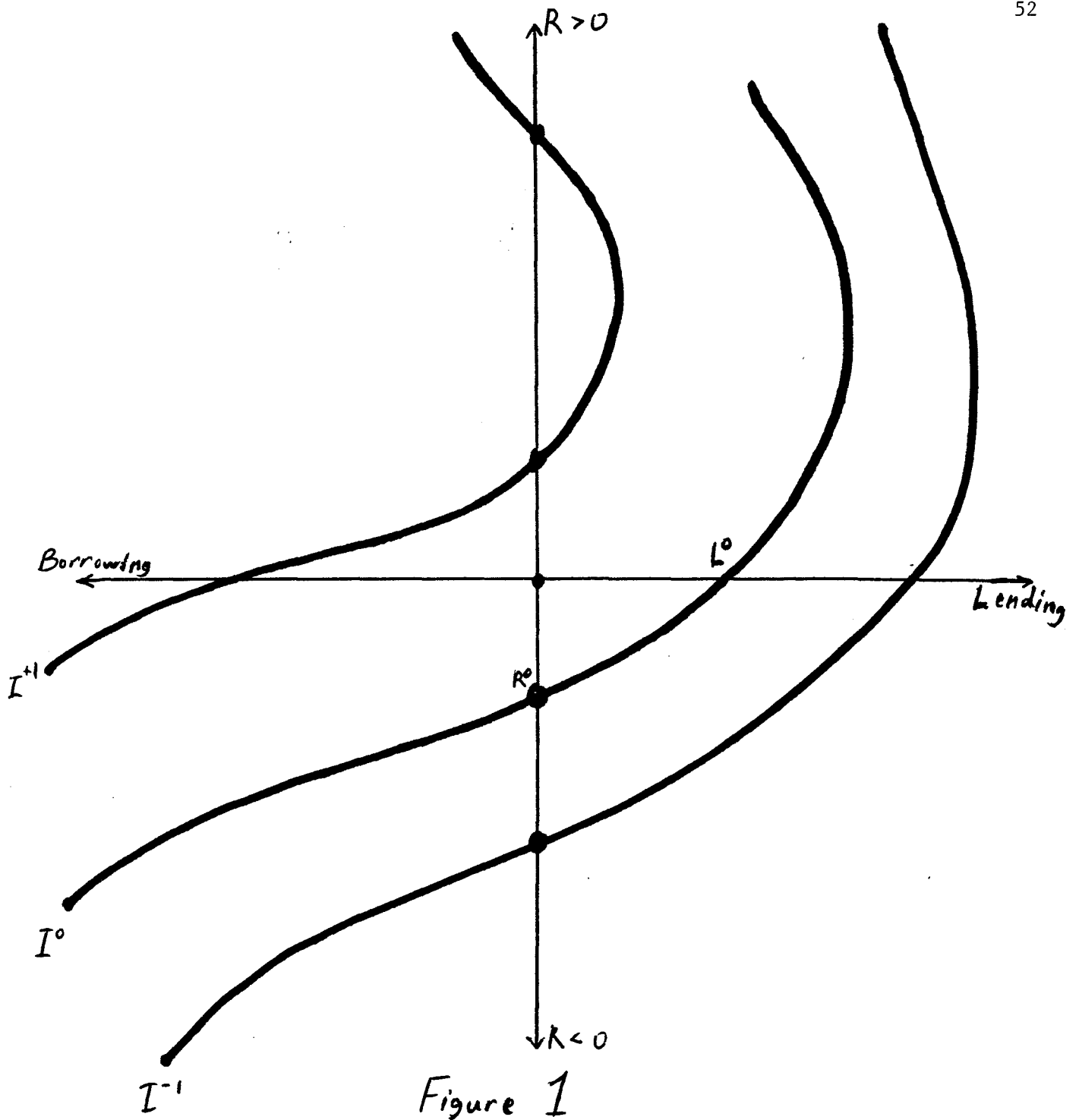


Figure 1

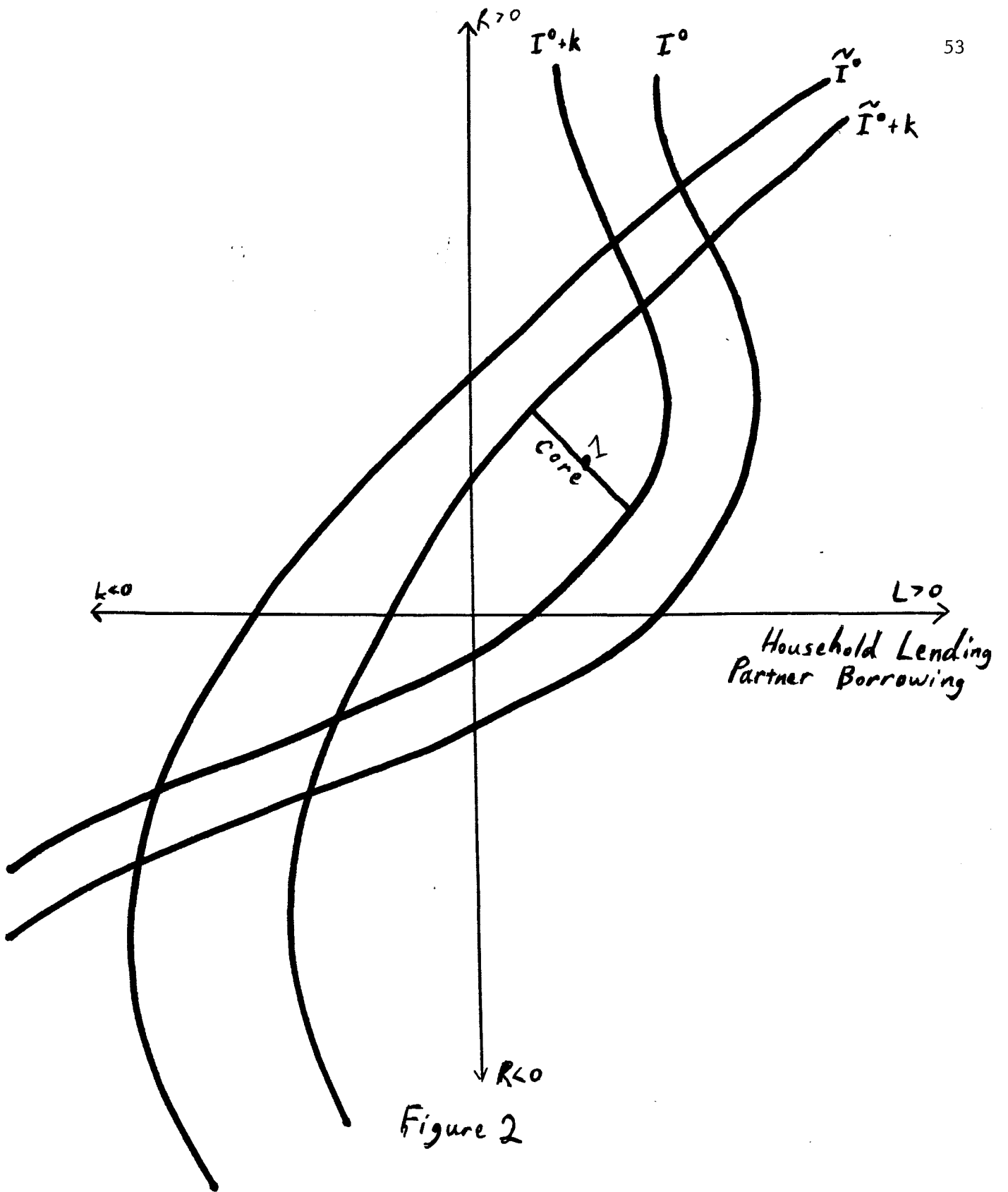


Figure 2



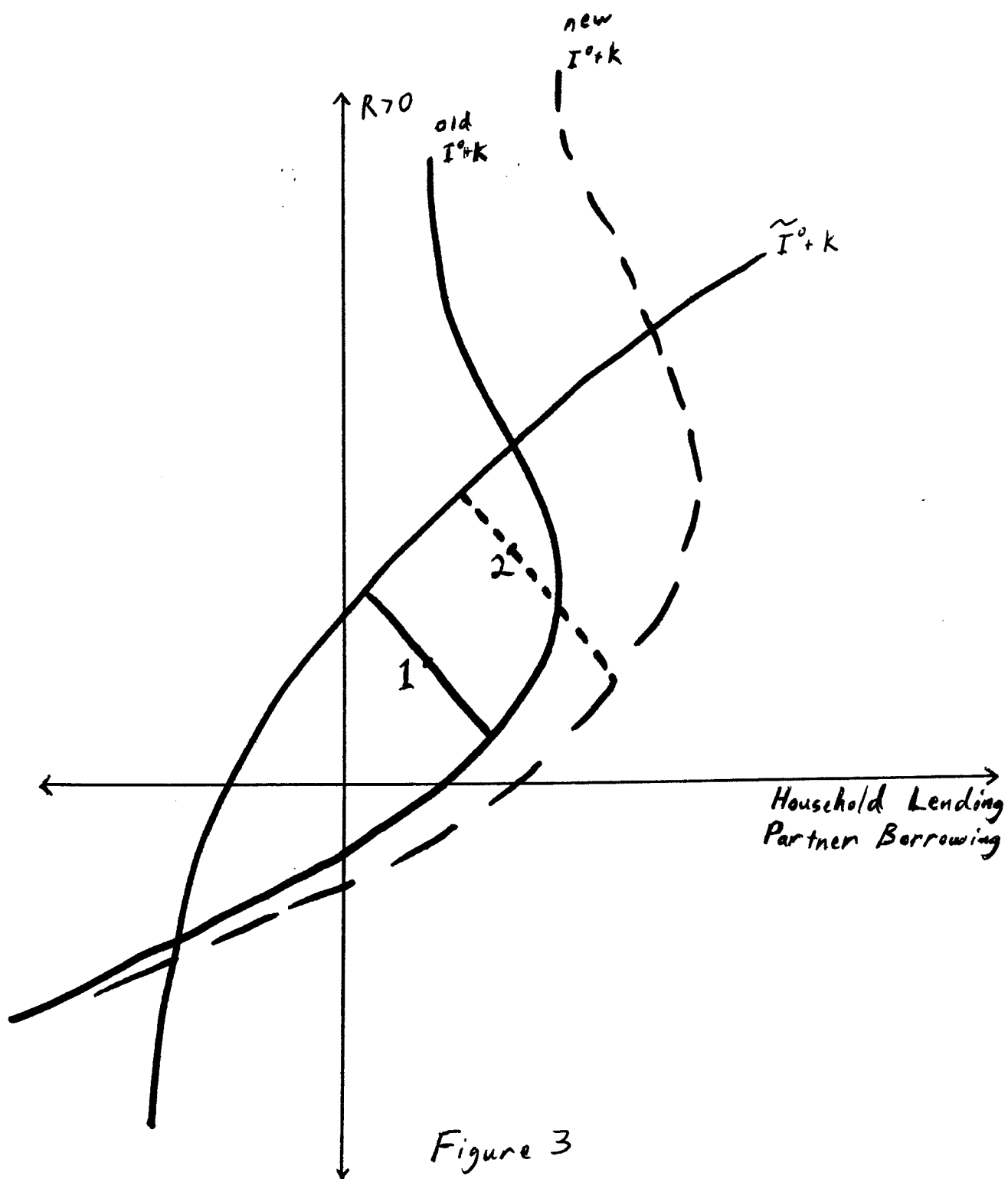


Figure 3