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

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Credit contracts play a direct role in pooling risk between households in northern Nigeria. Repayments owed by borrowers depend on realizations of random shocks by both borrowers and lenders. The paper develops two models of state-contingent loans. The first is a competitive equilibrium in perfectly enforceable contracts. The second permits imperfect information and equilibrium default. Estimates of both models indicate that quantitatively important state-contingent payments are embedded in these loan transactions, but that a fully efficient risk-pooling equilibrium is not achieved. The research is based on a year-long survey in Zaria, Nigeria conducted by the author.

1. INTRODUCTION

Risk is a central fact of life in the rural areas of less-developed countries. There is a large literature that explores its consequences for individual behaviour and the evolution of institutions.[1] Much of this literature focuses on *ex ante* mechanisms which risk-averse households might use to reduce the variance of their incomes. It has been argued that rural households engage in costly diversification (Rosenzweig and Binswanger (1993)), that they participate in a variety of institutions (such as sharecropping and bonded labour) which sacrifice allocative efficiency in order to reduce income fluctuations (several examples are provided in the collection edited by Bardhan (1989)), and that they sometimes do not adopt profitable but risky technologies (Rosenzweig and Shaban (1993)). An alternative to these costly measures, of course, is the possibility that households can smooth their consumption given an income stream. If households have access to *ex post* mechanisms which permit them to stabilize their consumption in the face of income fluctuations, then the need to resort to costly means of minimizing the variance of their incomes is reduced. This paper uses a unique data set to analyse in some detail one institution that plays an important role in allowing households to mitigate the consequences of income risk.

Credit transactions take on a special role when insurance markets are incomplete by allowing households to smooth income shocks over time.[2] The usual assumption in the literature on rural credit in poor countries is that simple competitive models are irrelevant to the study of these markets. Moral hazard and adverse selection are considered to be

1. See Bardhan (1989) and Alderman and Paxson (1992) for references.

2. 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 in 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)).

especially prevalent in credit transactions, therefore, credit markets are commonly thought to incorporate organizational features that serve to mitigate the problems caused by these information asymmetries. A number of papers have explored the implications of imperfect information for contractual forms in credit markets in low-income rural settings.[3]

In contrast to the assumptions of this literature, I argue in earlier work (Udry (1990)) that information asymmetries between borrowers and lenders in northern Nigeria are relatively unimportant. Data collected during a survey of four northern Nigerian villages show that neither formal sector lending institutions nor specialized private moneylenders participate in the rural credit market.[4] 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. There is widespread participation on both sides of the credit market in these villages; over the course of the year-long survey 75% of households made loans and 65% of households borrowed (50% participated as both lenders and borrowers). The transactions occurred between people who know each other well; 97% of the loans (weighted by value) were between neighbours or between relatives. For 82% 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. 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% of loans (by value) are backed by collateral. There is no direct evidence, therefore, that information asymmetries are an important aspect of loan transactions in northern Nigeria. This does not imply that the pattern of information availability is unimportant for the structure of the credit market. Information flows freely between borrowers and lenders within a small geographic or social space. The fact that almost no loans are observed to cross the boundaries of this space may be an indication of the informational advantages held by village co-residents or family members.

The free flow of information between borrowers and lenders allows credit contracts to play a direct role in insuring against risk. 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 I). 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 circumstances of the *lending* household (Table I). 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.[5] Rather, these loans appear to be true risk-pooling arrangements between the two households.

The cross-tabulations of Table I are suggestive, but one can construct alternative explanations for the patterns they reveal. For example, the figures in panel B could result from a conventional credit market equilibrium in which wealthier households are repaid at particularly high interest rates, and also hold particularly risky land. In order to test formally the hypothesis that these credit transactions include state-contingent payments, therefore, it is essential to develop a multivariate generalization of Table I which can hold constant such factors as wealth. The most parsimonious theoretical structure on which I can build a multivariate extension of these results is a simple model of a competitive equilibrium in a market for state-contingent loans. We have seen that there is little direct

3. See Bell (1988) and Besley (1993) for comprehensive bibliographies.

4. The survey data is available from the author.

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

TABLE I

Realized terms vs. borrower and lender shocks received

Adverse shock received by	Sample means		
	Monthly interest rates[a]	Simple interest rates[b]	Repayment period in days
(A) Borrower			
—no shock	0·5%	20·4%	67
—adverse shock	−4·0%	−0·6%	72
Impact of shock			
—on mean:	lower	lower	longer
—(*t*)	(1·58)	(2·20)	(1·03)
(B) Lender			
—no shock	−7·5%	−5·0%	89
—adverse shock	2·6%	11·8%	80
Impact of shock			
—on mean:	higher	higher	shorter
—(*t*)	(4·56)	(3·06)	(1·89)

Notes. The impact of the shocks is judged by a two-sided *t*-test for equal means ($\mu_{\text{noshock}} - \mu_{\text{shock}}$). The absolute value of the *t*-statistic is in parentheses.
The definition 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'.
[a] This is a standard monthly compound interest rate.
[b] This is the simple ratio of the amount repaid minus the amount borrowed to the amount borrowed.

evidence of any important deviation from the complete information assumption of the standard competitive framework. This simple framework, therefore, serves as the benchmark for the analysis of these loan transactions. This competitive general equilibrium model is developed in Section 2. An econometric model based on the general equilibrium results is presented in Section 3. Section 4 provides a brief description of the data. In Section 5, I present estimates which confirm the quantitative importance (as well as statistical significance) of state-contingent payments that flow toward households which receive unexpected adverse shocks.[6]

The apparent importance of direct risk pooling through state-contingent loan repayments raises the possibility that the allocation of risk within these villages approximates Pareto efficiency. A number of studies have recently explored this possibility in other contexts.[7] If these loan transactions mimic a complete set of competitive insurance markets,

6. See Kochar (1991), and Bell, Srinivasan and Udry (1991) for recent empirical models of credit transactions in developing countries.

7. Townsend (forthcoming) shows that there is a high degree of co-movement in individual (age-sex adjusted) consumption across households within villages covered by the ICRISAT Indian survey. He presents evidence, however, that a fully Pareto efficient allocation is not achieved in the Indian villages. Lim (1991), using the same data, tests the hypothesis of Pareto efficiency against the alternative that each household separately smooths its income shocks over time. He concludes that the data correspond more closely to full Pareto efficiency than to the permanent income hypothesis. The complete markets hypothesis has also been tested with data from the U.S. Hayashi, Altonji and Kotilkoff (1991), Altug and Miller (1990), Mace (1991), Zeldes (1989) and Cochrane (1991) provide examples of empirical tests of implications of Pareto efficiency. Only Altug and Miller are unable to reject the (stringent) standard that a complete risk pooling, Pareto-efficient allocation of risk is achieved in the U.S.

then it is not necessary to understand the particular contractual arrangements in these credit markets to discern the economic impact of the loans. On the other hand, if Pareto efficiency is not achieved through these loan transactions, then a more detailed investigation of the institutional and informational setting of these transactions becomes imperative. Although the benchmark competitive model does a surprisingly good job of describing the data, I show in Section 5 that this simple model can be rejected.

Given that Pareto efficiency is not achieved through these loan transactions, their institutional structure and the information environment in which they occur become germane. In Section 6, I develop a model of the personalized interaction between borrower and lender in the setting of a village economy. The result (Section 8) is an 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. I 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 consider the actual contractual mechanisms through which the repayments owed on a loan are made state-contingent. Estimation results are presented in Section 9. The results of this bilateral model accord with both the simple cross-tabulations and the findings of the competitive model: state-contingent payments are embedded in the loan repayments, and these payments serve to pool risk between the borrower and the lender.

2. A COMPETITIVE MODEL

The point of departure for this paper is a simple competitive model of the credit market. This model embraces the notion that information flows freely within the community and that loan contracts are state-contingent. It does so at the cost of treating these personalized contracts in a highly abstract manner, in that it views the household as a price-taker on the loan market. The focus of the model is the general equilibrium and efficiency consequences of state-contingent loan contracting, rather than the institutional arrangements which sustain the contracts.

The economic environment of the model is described in Section 2A. The model considers households living together in a village, subject to both village-level and idiosyncratic variation in income. The model allows for arbitrary correlation between the shocks to the income of different households in the village. A wide variety of financial instruments could be devised to pool risks in this village community. I focus on loans which are taken in one period and which have state-contingent repayments due in the next. This one-period-ahead contracting corresponds to the transactions observed during the fieldwork, in which loans are taken just before (or early in) the planting season and repaid after harvest.

If the set of competitively marketed loans with state-contingent repayments is sufficiently rich, the equilibrium is Pareto efficient. This equilibrium is characterized in Section 2B. Household consumption is determined by aggregate village consumption (and by the household's weight in a corresponding Pareto programme). Conditional on aggregate consumption, household consumption is independent of the idiosyncratic shock to household income. The state-contingent loans support the Pareto-efficient allocation in the following way. In each period t, each household engages in precisely that set of loans for which the state-contingent repayments fully insure the household against its idiosyncratic risk in period $t+1$. The loan repayment in period $t+1$ compensates the household for the idiosyncratic shock to its income, leaving the household with enough

resources to consume at the level determined by aggregate village consumption and still engage in the optimal loan transactions required to insure itself against idiosyncratic risk in period $t+2$. State-contingent loan transactions among village residents can support (in principle) a Pareto efficient allocation of risk within the village. This strong hypothesis is tested in Section 5. The econometric analysis of the paper, however, does not require that full risk pooling be achieved through these transactions.

A. *Loan contracts as state contingent securities*

Consider a world with one (non-storable) good (Y) and N households. Let there be $T+1$ periods, indexed by $t \in \{0, 1, \ldots, T\}$.[8] There are S states of nature indexed by s, each with an objective, constant and commonly known probability of occurrence π_s. This probability is stationary and independent of the history of realized states.[9] There is no production; each household receives each period an endowment of the good which depends upon the realized state of nature. Denote these (positive) endowments by $Y_{i,s}$ for $1 \leqq i \leqq N$ and $1 \leqq s \leqq S$. The endowment of each household depends only on the state of nature, not on the period.

Each bilateral loan contract is interpreted as a collection of contingent securities, where each security entitles the owner to one unit of the good in the next period if a particular state is realized. These contracts are perfectly enforced; default is assumed to be impossible. If default were permitted, under general conditions some households would demand an infinitely large loan at any interest rate, with certain default in the next period. The no default assumption can be dropped and the existence of equilibrium maintained only if other special assumptions are made. In Section 6 I drop the assumption of price-taking behaviour, thereby introducing strategic behaviour by borrowers and lenders who negotiate over contractual terms.

If the available securities span the state space, the competitive equilibrium is Pareto efficient. The first task, therefore, is to describe the relevant characteristics of efficient allocations. Let $h_t = \{s_1, s_2, \ldots, s_t\}$ be the history of states realized from period 1 through period t and $\pi(h_t)$ be the probability that h_t is realized. Let $c_{i,s,t}(h_{t-1})$ be the realized consumption of individual i if state s occurs in period t after history h_{t-1}, and $c_{i,s,0}$ be the consumption of household i in the initial period. The separable von Neumann–Morgenstern utility of household i is:

$$U_i = u_i(c_{i,s,0}) + \sum_{t=1}^{T} \beta^t \left[\sum_{h_{t-1} \in H_{t-1}} \pi(h_{t-1}) \left[\sum_{s=1}^{S} \pi_s u_i(c_{i,s,t}(h_{t-1}))\right]\right], \tag{1}$$

where H_{t-1} is the set of all possible histories that may be realized up to period $t-1$. $u_i(\,)$ is assumed to be increasing, strictly concave and C^2 over $\mathbb{R}^+$, and $u_i'(x) \to +\infty$ as $x \to 0^+$.

Certain familiar results follow immediately. In a Pareto-efficient allocation, $c_{i,s,t}(h_{t-1}) = c_{i,s,t}$ for all $h_{t-1} \in H_{t-1}$. There is no growth in the economy, therefore $c_{i,s,t} = c_{i,s}$ for all t. So consumption is independent of history and period. Finally, each household's consumption in any state is a non-decreasing function of the total community resources available in that state. Transient changes in income are fully pooled at the community level, so no risk diversification will occur within the household. My strategy is to use these efficiency results to examine the consequences of fully flexible contingent markets and then

8. The finite lifetime assumption permits the model to accommodate any life-cycle effects in the level of borrowing. As $T \to \infty$, these life-cycle effects become unimportant. This approach, therefore, allows the data to choose between a (relatively) short fixed-horizon model and a Barro-Becker model of altruism across generations.

9. This assumption is made to simplify notation. Some forms of autocorrelation are permitted below.

to introduce restrictions which modify the fully Pareto-efficient, risk-pooling outcome of the initial model.

The next step is to describe the household's problem. The notational convention is that subscripts refer to states realized in the current period, while superscripts refer to states which may occur in the next period. So let $R^{s'}_{i,s,t}(h_{t-1})$ be the number of securities purchased by household i in state s of period t after history h_{t-1} for payment in state s' of period $t+1$. This number may be negative because borrowing is permitted. Let $q^{s'}_{s,t}(h_{t-1})$ be the price of that security on the competitive market. The budget constraints are:

$$c_{i,s,0} = Y_{i,s} - \sum_{s'} q^{s'}_{s,0} \times R^{s'}_{i,s,0}, \forall s, \tag{2}$$

$$c_{i,s,t}(h_{t-1}) = Y_{i,s} + R^{s}_{i,s^*,t-1}(h_{t-2}) - \sum_{s'} q^{s'}_{s,t}(h_{t-1}) \times R^{s'}_{i,s,t}(h_{t-1}),\ t \in \{1, 2, \ldots, T-1\}, \forall s, \tag{3}$$

$$c_{i,s,T}(h_{T-1}) = Y_{i,s} + R^{s}_{i,s^*,T-1}(h_{T-2}), \forall s, \tag{4}$$

where s^* is the state realized in period $t-1$ of history h_{t-1}.

The household maximizes (1) given (2–4), and calculates its demands for contingent securities for all possible histories h_T. The problem as written is equivalent to the sequential programming problem in which the household re-optimizes each period as the state is revealed.

B. *Efficiency of equilibrium and the behaviour of prices*

If the assumption that the contingent securities span the state space is valid, then markets are complete in this model and the competitive equilibrium is Pareto efficient. A necessary condition for efficiency is that household consumption in any state s is independent of history and period. Substituting this into the first-order condition of the problem defined by (1–4) we find:

$$\frac{q^{r'}_{s,t}(h_{t-1})}{q^{r}_{s,t}(h_{t-1})} = \frac{\pi_{r'}}{\pi_r} \cdot \frac{u_i'(c_{i,r'})}{u_i'(c_{i,r})} \forall i, t, 1 \leqq (r, r', s) \leqq S. \tag{5}$$

So the relative prices of the different securities are independent of the current state s and are constant across time. Thus, we can find a scaler τ_s for each current state s and a constant price for each security q^r such that $q^{r}_{s,t}(h_{t-1}) = \tau_s \times q^r$ where $\tau_s > 0$ and $\sum_r q^r = 1$. This normalization is arbitrary, but has the advantage of excluding the possibility of using a security with a zero price as numeraire. Using the first-order conditions for periods 0 and t:

$$\frac{q^{r}_{s^*,t}(h_{t-1})}{q^{r}_{\hat{s},0}} = \frac{u_i'(c_{i,\hat{s},0})}{u_i'(c_{i,s^*,t}(h_{t-1}))} = \frac{u_i'(c_{i,\hat{s}})}{u_i'(c_{i,s^*})} \forall i, t, 1 \leqq (r, \hat{s}, s^*) \leqq S, \tag{6}$$

where $\hat{s}$ is the state realized in period 0, s^* is the state realized in period t, and r is any of the states which may occur in period $t+1$. Therefore, given $c_{i,\hat{s}}$ (which depends only on community consumption in period 0), the scaling factor τ in any state s depends only on $c_{i,s}$, the realized consumption in that state, which in turn depends only on community consumption in that state. If community consumption is high in that state, then τ_s is also high. A higher τ_s implies that current borrowing for repayment in period $t+1$ is less expensive. In return for a promise of a given set of repayments in period $t+1$ ($R^{s'}_{i,s,t}(h_{t-1})$), the borrower in period t receives $\tau_s \sum_{s'} q^{s'} \times R^{s'}_{i,s,t}(h_{t-1})$. A higher τ_s means that more is received in period t for given repayments in period $t+1$—cheaper credit. Thus in a state in which community income and each individual household's consumption is high, credit is cheap. As community income and each household's consumption decline,

credit becomes more expensive, choking off the potential increase in excess demand for credit in this closed market, thus preserving equilibrium.

The model implies that the securities purchased in any period t are independent of the state realized in that or any previous period.[10] The cost of the securities purchased in period t will depend, however, on τ_s, which in turn depends on aggregate community income in period t. Furthermore, over time the households regress toward zero net lending.[11]

The model can easily be modified to include agricultural production on a fixed amount of land. The efficiency results remain and community income is still pooled. Investment in agricultural production is directed to plots on which output is less correlated with overall community income and this diversification is carried out at the community level, not the household level.[12] If there is more than one alternative asset (e.g., different plots of land, or storage), it can again be shown that investment is guided by the goal of reducing the variance of community income, so no diversification occurs at the household level.

Complete risk pooling within the village can be achieved through a competitive market in state-contingent loan transactions. The econometric analysis of the paper, however, should not require this strong result. Moreover, 10% of the households neither lend nor borrow. This fact does not accord well with a theoretical model based on a smoothly operating competitive market. I therefore call upon the *deus ex machina* of transaction costs so that not all idiosyncratic risk is insured and there is a positive probability that a zero loan size is efficient.

Assume that the transaction costs are of the form of Samuelson (1954)—of each unit of the good that is given up by a household, only a fraction k reaches the recipient household. If $p^{s'}_{s,t}(h_{t-1})$ is the price an agent pays to buy a security and $q^{s'}_{s,t}(h_{t-1})$ is the price received by the agent for a sale, competition in the transfer of securities between households ensures that $q^{s'}_{s,t}(h_{t-1}) = k \cdot p^{s'}_{s,t}(h_{t-1})$, reflecting the constant returns to scale transfer technology. No profits are made by agents engaged in transferring securities. As in the model without transaction costs, the contingent securities span the state space. The wedge between the buying and selling prices of the securities induces households to internalize the transaction costs and the competitive equilibrium is (constrained) Pareto efficient, although complete risk pooling is not achieved.

10. Efficiency and (4) imply $c_{i,s'} - Y_{i,s'} = R^{s'}_{i,s^*,T-1}(h_{T-2}) = R^{s'}_{i,T-1}$ regardless of history h_{T-2} or the state s^* realized in $T-1$. Similarly, $c_{i,s} + \tau_s \Sigma_{s'} q^{s'} \times R^{s'}_{i,T-1} - Y_{i,s} = R^{s}_{i,s^*,T-2}(h_{T-3}) = R^{s}_{i,T-2}$. This demonstration of the independence of security transactions from history or the current state can be repeated for $R^{s}_{i,T-3}$, and all earlier periods.

11. If $\Sigma_s (q^s \times R^s_{i,T-1}) > 0$, then $R^s_{i,T-2} > R^s_{i,T-1}$ for each s. Starting from period $T-k$ moving towards period T, we see that in each realized state the household receives smaller net repayments (and lends less). The converse holds if the household is a net borrower. This later finding may be more difficult to verify empirically than it was to show theoretically. As the number of periods T is increased, the period-to-period change in net lending is reduced. Other factors are also changing over time. In particular, if the age of a household head has any effect on his productivity, it may be difficult to separate the effects of progressing age from movement across periods. This point is reinforced by the fact that in actuality the number of periods of loan transactions remaining to a household is uncertain, and the best predictor of that number may be the age of the household head.

12. Let $Y = g(i, s, k)$, where k is the amount of the good Y devoted to production on a fixed amount of land. Since the amount of land is fixed, it is embodied in the function $g(\ )$. There is no labour; corn is simply invested to produce more corn. The budget constraints (2)–(4) must be modified: for period t the household now faces

$$c_{i,s,t}(h_{t-1}) = g(i,s,k_{i,s^*,t-1}) + R^s_{i,s^*,t-1}(h_{t-2}) - \textstyle\sum_{s'} q^{s'}_{s,t}(h_{t-1}) \times R^{s'}_{i,s,t}(h_{t-1}) - k_{i,s,t}(h_{t-1}) \qquad (3')$$

where $k_{i,s,t}$ is investment in state s of period t for production in period $t+1$. Using the F.O.C. for securities purchases and investment ($k_{i,s,t}$), we find $\tau_{s^*} \Sigma_s [q^s \cdot \partial g(i, s, k_{i,s^*,t-1})/\partial k] = 1$ for $1 \leqq t < T$. This can be interpreted as $MVP_k = MC$, and the production decision is separable from consumption. If $g(i, s, k) = \Theta^{is} g_i(k)$ this simplifies to $\tau_{s^*} g'(k_t) \times \Sigma_s q^s \Theta^{is} = 1$, and households which own farms whose output is less correlated with overall output (as indexed by q) invest more. The econometric specification incorporates the potential demand for loans for working capital.

3. AN ECONOMETRIC MODEL

The model of Section 2 established that: (1) households may engage in multiple credit transactions and may participate on both sides of the market (buying and selling securities simultaneously) in order to spread risk throughout the village. The variables of interest, therefore, are the net borrowing of each household over a specified period (B) and the net repayment of those loans (R) (the convention will be that all amounts flowing *to* a sample household are positive); (2) the set of securities purchased by each household is independent of current aggregate or idiosyncratic shocks to income, but the cost of those securities rises with village income. Therefore, net borrowing will depend on this village-level shock, which is captured by village effects (X_v); (3) there may be life-cycle effects on credit market behaviour. Net borrowing and repayments regress toward zero as the number of periods the household has been involved in the market (P) increases. Therefore, the coefficient associated with P should be negative if the household is a net borrower, and positive if the household is a net lender, necessitating the use of a switching regression; (4) transaction costs rationalize a positive probability of zero loan size. The form of transaction costs assumed implies that borrowing is subject to friction as described by Rosett (1959). Once the possibility of non-participation in the market is acknowledged, estimation of the repayment equation must take into account the selection bias thereby induced; (5) household consumption is determined by aggregate village consumption. The net repayments received by a household compensate the household for the idiosyncratic shock to its income, leaving the household with just enough resources to consume at the level determined by aggregate village consumption after purchasing the efficient quantity of securities for the next period. Net repayments, therefore, are a function of the determinants of net borrowing, and also depend on both the aggregate shock to village resources and the idiosyncratic shock to household i's income. Z_h is the measure of the receipt of idiosyncratic shocks by the household while the loan is outstanding; X_v controls for the shock to aggregate village income while the loan is outstanding. In addition, both borrowing and repayments depend on a vector of household characteristics X_h. The model is:

$$B = X_v\alpha_v + X_h\alpha_h + \alpha_B P + \nu_1 \quad \text{if } X_v\alpha_v + X_h\alpha_h + \alpha_B P + \nu_1 > 0 \tag{7a}$$

$$B = X_v\alpha_v + X_h\alpha_h + \alpha_L P + \nu_1 + F \quad \text{if } X_v\alpha_v + X_h\alpha_h + \alpha_L P + \nu_1 + F < 0 \quad (F>0) \tag{7b}$$

$$B = 0 \quad \text{otherwise} \tag{7c}$$

$$R^* = X_v\beta_v + X_h\beta_h + (1-I)\beta_L P + I\beta_B P + Z_h\gamma + \nu_2, \tag{8}$$

where $I=1$ if $B \geqq 0$, $I=0$ if $B<0$.

$$R = \begin{cases} 0 & \text{if } B=0 \\ R^* & \text{if } B<>0. \end{cases} \tag{9}$$

The model may suffer from incoherence because equations 7(a) and (b) can be true simultaneously. This is unlikely to occur because it requires the effect of P on net borrowing to be so different when the household borrows than when it lends that the household switches from demanding loans to supplying loans. To lead to incoherence this switch must be large enough to overcome the friction effect F.[13] A sufficient condition for coherence is

13. X_v includes a constant, so only one friction coefficient (representing the difference between the constant terms when borrowing and lending) is estimated.

$\alpha_B \geqq \alpha_L$ and $F > 0$. No variables are available which can serve to identify the friction coefficient F separately from the net borrowing equation. This coefficient is identified, therefore, through the nonlinearity of the model and distributional assumptions. I assume that v_1 and v_2 are jointly normal. The likelihood function is presented in Appendix A.

4. DATA

This research is based on a survey of 200 households in four villages near the city of Zaria that I undertook 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, labour, product, asset, and asset-rental transactions over the previous month; and a range of demographic and background data.

Rain-fed agriculture predominates in this region, though there is also dry-season irrigated farming on lowlands bordering streams (*fadama*). In this semi-arid environment there is only one rain-fed crop per year, with planting in May. The villages are small (an average of 366 households) but well-integrated into the regional economy. Of the sample households, 73% of the produce vegetables and non-food cash crops for the market and 53% of all labour used on sample household farms is wage labour. 95% of cultivated land is treated with chemical fertilizers. A large variety of non-agricultural occupations exists, but every household in the sample operates a farm. For details on the study area and survey methods, see Udry (1991). Table II lists the variables used in the analysis.

TABLE II

Variables used

	Mean	Standard
Dependent variables:		
Net amount borrowed (B) (×N100)	−1·91	24·16
Net amount repaid (REP) (×N100) (to sample household by others)	2·50	26·75
Household Characteristics (X):		
WEALTH: value of livestock, household articles, grain and trading stocks evaluated at the start of the survey (×N1000)	2·25	45·12
AGE: age in years of household head	40·64	12·23
PRIMARY: number of years of western schooling completed by household head	0·54	1·73
ISLAM: number of Koran sections (*sura*) known by household head	23·69	24·26
HERELONG: dummy variable. 1 if family of household head has been in village 2 or more generations	0·68	0·47
SKILLS: dummy variable. 1 if at least one member 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
PERIOD (P): number of years since the household head first married, or since he moved to this village, whichever is smaller	16·07	10·00
Adverse Shocks:		
Index of self-reported problems (S):		
on uplands	0·22	0·35
on lowlands	0·27	0·26
Difference between yield last year and yield this year:		
on uplands	0·49	1·20
on lowlands	0·54	0·83
Proportion of loans with partners who received adverse shocks	0·20	0·30

The dependent variables are calculated from data on all loans taken or extended by a sample household for a single main cropping period. 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 begun. Net borrowing B is the nominal value of loans taken minus loans extended during this period, while net repayments R is the net nominal value of repayments received by the household on those loans up to the end of the survey in February.[14] There is no correction for price level changes over this period. The rare transaction made in-kind is valued at the current market price.

The indicator of the random shock received by the household after the initial loans have been made (Z_h) is an index of self-reported events on the plots farmed by the household. The index is a weighted average of the number of these negative events (examples: flooding, wind damage, animal invasions) on each plot and the weights are the relative sizes of each plot. The index is broken down by upland and lowland plots, and is the same as that used in the construction of Table I. Its use depends upon the assumption that the events used in its construction are observable to the village community and exogenous to the behaviour of the agents. Further, the deviation of the household's index from the village mean index must be serially uncorrelated. The first assumption is strongly supported by the evidence presented in Udry (1990). 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 wind damage 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. The third assumption corresponds to the stationarity assumption. Village-level shocks can be correlated over time without changing these results, for they influence only the price level τ_s, and will be eliminated through use of the village dummy variables. The equilibrium derived here, however, depends on the deviation of individual shocks from the village mean shock being serially uncorrelated.

The explanatory variables include village dummy variables (X_v), and a vector of household characteristics (X_h). The village dummy variables capture village-specific effects. There are infrastructural differences across the villages that will influence the net demand for credit. There are also likely to be differences in the social environments of the different villages that affect the availability of information and enforcement mechanisms needed to support these credit transactions. Finally, the village dummy variables capture the effect of the village level shocks.

The non-land wealth variable 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. 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. Land ownership is broken down into upland plots and lowland plots because the different types of land require different levels of inputs. Lowlands require much more intensive inputs and have higher yields than do uplands (because the soil is heavier, and because farming can

14. There is little evidence that loan repayments are delayed beyond the start of the agricultural year after the loan was initially extended. Of the 821 loan repayments recorded during the sample period, less than 2% were made on loans taken before the previous year's harvest.

continue year-round). The HERELONG variable is a dummy variable which is one if the family of the household head has been in the village for two or more generations (which includes almost 70% of the sample). Families which have only recently moved into the village may not have as good access to enforcement mechanisms as do other families.

The number of periods the household has been involved in the credit market (P) is approximated by the number of years since the household head first married, or since he moved to his current village, whichever is smaller. This assumes that households enter the credit market as soon as they are formed.

5. ESTIMATION RESULTS

A. *State-contingent payments*

Estimates of the base model are reported in Table III.[15] The results support the hypothesis that repayments vary according to shocks received. Adverse shocks received by the household lead to increases in repayments to the sample household (reductions in repayments to other households), and the estimated coefficients are significantly different from zero at the 5% level. A one standard deviation adverse shock on upland plots increases repayments to the household by N26; a similar shock on lowlands increases repayments by N31. Recall that average net lending is N191.

Table IV reports the results of a specification which permits the coefficients of the indices of adverse events on upland and lowland plots to vary according to the sample household's net borrower/net lender status. This table is the multivariate extension of Table I which motivated this paper. The results show that when adverse shocks are received by sample households which are borrowers, they pay back less. This is consistent with conventional models of loan contracting, as the lower repayments may simply reflect a higher incidence of default on the part of sample households which receive adverse shocks. On the other hand, the estimates also indicate that when adverse shocks are received by sample households which are net *lenders*, they are paid back *more*. This finding cannot be understood in the context of conventional models of the credit market and provides striking evidence that repayments are state-contingent. Owed repayments, therefore, depend upon the realization of random production shocks by both borrower and lender, so these loan transactions permit households (whether borrowing or lending) to insure against at least some portion of output variability. In fact, there is no significant difference between the responses of repayments to adverse shocks received by net lenders and borrowers.[16]

B. *Other results*

1. *Non-land wealth*—as expected, increased non-land wealth increases net lending; the effect of non-land wealth on repayments, however, is insignificant. The model was

15. Diagnostics based on the generalized residuals of the model provide a test of the assumption that the marginal distributions of v_1 and v_2 are homoscedastic normal. I follow the approach of Chesher and Irish (1987) (also used by Blundell, Ham and Meghir (1990)) to develop LM tests for correlations between the generalized residuals of order (2, 0) and a predetermined set of explanatory variables. The tests yield $\chi^2(5)$ statistics of 26·94 (v_1) and 19·26 (v_2). These are relatively large test statistics, and could indicate the presence of heteroscedasticity. However, recent work by Chesher and Spady (1991) indicates that in simple models the χ^2 approximation to the distribution of these statistics is poor in small samples, and that the tests reject far too frequently. Unfortunately, there is no evidence on models of the type used here.

16. A likelihood-ratio test of the restriction that the coefficients of the indices of self-reported adverse shocks are the same for net borrowers and net lenders yields a χ^2 with two degrees of freedom test statistic of 4·58, which is insignificantly different from zero at the 5% level.

TABLE III

Competitive model estimates

Variable	Loan size (net amount borrowed) (×N100)		Repayments (net amount paid in) (×N100)	
	Parameter	*T*-Ratio	Parameter	*T*-Ratio
CONSTANT	−2·947	−2·40	−0·989	−2·02
VILLAGE1	1·490	1·88	−0·287	−0·92
VILLAGE2	2·081	2·94	0·016	0·05
VILLAGE3	0·529	0·72	−0·601	−2·04
WEALTH	−0·058	−1·83	−0·010	−0·54
AGE	0·029	0·96	0·017	1·40
HERELONG	0·227	0·38	0·511	2·14
SKILLS DUMMY	0·456	0·85	−0·317	−1·48
UPLAND	−0·291	−1·73[a]	0·001	0·02[c]
UPLAND SQUARED	0·028	3·00[a]	0·000	0·01[c]
LOWLAND	0·259	0·31[b]	−0·347	−1·10[d]
LOWLAND SQUARED	−0·258	−1·32[b]	0·073	0·99[d]
PERIOD				
LENDING	−0·002	−0·06	−0·009	−0·56
BORROWING	−0·025	−0·64	−0·008	−0·44
FRICTION CUTOFF	1·869	3·38		
INDEX OF SELF-REPORTED SHOCKS				
ON UPLANDS			0·742	2·08
ON LOWLANDS			1·200	3·07
σ	1·829	30·55	1·882	28·27
CORRELATION COEFFICIENT	−0·947	−24·76		

−LN (Likelihood) = 848·86

Notes.

[a] Not jointly significant. The likelihood ratio test of the restriction that both uplands coefficients are zero yields a $\chi^2(2)$ test statistic of 0·18.

[b] Jointly significant at the 5% level. The likelihood ratio test of the restriction that both lowlands coefficients are zero yields a $\chi^2(2)$ test statistic of 6·43.

[c] Not jointly significant.

[d] Not jointly significant. The likelihood ratio test of the restriction that both lowlands coefficients are zero yields a $\chi^2(2)$ test statistic of 1·21.

re-estimated with the non-land wealth variable disaggregated into livestock and trading/grain stock components in order to test the joint hypothesis that different types of wealth have different liquidity properties, and that these differences would lead to an effect of asset composition on borrowing behaviour. The estimated coefficients of the disaggregated components are virtually identical, so it is not possible to reject the hypothesis that they are the same.

2. *Age*—The age of the household head has no significant effect on net borrowing (although the sign is as expected). This result is robust to a variety of different specifications of the AGE variable. Squared terms, dummy variables with different age cut-offs, and linear splines in age were all statistically insignificant. On the other hand, older household heads seem to receive higher net repayments. This could reflect their improved access to information and enforcement mechanisms within the village, and provides a warning that the competitive model misses institutional details that are important to the operation of this market.

3. *Period*—The period coefficients are insignificantly different from zero in all specifications. This is to be expected if T is large, and is consistent with a Barro–Becker model

TABLE IV

Testing the responsiveness of contract terms to shocks: net borrowing households vs. net lending households

Variable	Loan size (net amount borrowed) (×N100)		Repayments (net amount paid in) (×N100)	
	Parameter	*T*-Ratio	Parameter	*T*-Ratio
CONSTANT	−2·947	−2·40	−1·038	−2·12
VILLAGE1	1·490	1·88	−0·209	−0·67
VILLAGE2	2·081	2·94	−0·001	−0·00
VILLAGE3	0·529	0·72	−0·520	−1·78
WEALTH	−0·058	−1·83	−0·008	−0·44
AGE	0·029	0·96	0·021	1·72
HERELONG	0·227	0·38	0·472	1·98
SKILLS DUMMY	0·456	0·85	−0·320	−1·51
UPLAND	−0·291	−1·73[a]	0·008	0·13[c]
UPLAND SQUARED	0·028	3·00[a]	−0·000	−0·04[c]
LOWLAND	0·259	0·31[b]	−0·429	−1·37[d]
LOWLAND SQUARED	−0·258	−1·32[b]	0·090	1·23[d]
PERIOD				
LENDING	−0·002	−0·06	−0·008	−0·48
BORROWING	−0·025	−0·64	−0·020	−1·08
FRICTION CUTOFF	1·869	3·38		
INDEX OF SELF-REPORTED SHOCKS FOR NET BORROWERS				
ON UPLANDS			0·338	0·70
ON LOWLANDS			1·941	3·78
FOR NET LENDERS				
ON UPLANDS			0·969	2·14
ON LOWLANDS			0·350	0·63
σ	1·829	30·55	1·876	28·30
CORRELATION COEFFICIENT	−0·957	−24·97		

−LN(Likelihood) = 846·57

Notes.

[a] Not jointly significant. The likelihood ratio test of the restriction that both uplands coefficients are zero yields a $\chi^2(2)$ test statistic of 0·06.

[b] Jointly significant at the 5% level. The likelihood ratio test of the restriction that both lowlands coefficients are zero yields a $\chi^2(2)$ test statistic of 6·43.

[c] Not jointly significant. The likelihood ratio test of the restriction that both uplands coefficients are zero yields a $\chi^2(2)$ test statistic of 0·04.

[d] Not jointly significant. The likelihood ratio test of the restriction that both lowlands coefficients are zero yields a $\chi^2(2)$ test statistic of 1·89.

of inter-generational altruism.[17]

4. *Households containing at least one member with a special skill* seem to borrow more than other households, though the coefficient is insignificantly different from zero. This may reflect the extra working capital required to employ these skills. On the other hand, no indicator of formal education—whether Islamic *makaranta* or western primary school—had any effect on net borrowing or repayments. A test of the joint significance of the

17. The model was re-estimated with the PERIOD variable excluded and the coefficient of the AGE variable free to vary depending upon net borrowing/lending status. In neither equation were the coefficients of the age variable significantly different depending upon net borrowing/lending status. In both equations, the coefficients of the age variable were similar to those in the specification that included the PERIOD variable. This finding supports the hypothesis that the AGE variable is playing the role described in paragraph 2, and that the time horizon is large enough that households are not making significant yearly adjustments in their net borrowing in anticipation of their final season's transaction.

education variables yields a $\chi^2(4)$ test statistic of 0.82, which is insignificantly different from zero.

5. *A household whose ancestors have been resident* in the village for at least two generations receives significantly higher loan repayments than does a household whose family migrated to the village more recently. As with the AGE variable, this is likely to reflect the better access to information and enforcement mechanisms of better-established households. There is no evidence that newer households respond to this by reducing their net lending.

6. *Land*—The relationship between net borrowing and land ownership is weak and nonlinear. The estimates imply that net borrowing is nearly insensitive to ownership of upland and lowland land for holdings near the sample mean. The coefficients in the net borrowing equation for the ownership of lowlands are jointly significantly different from zero. The (imprecisely estimated) coefficients imply that net borrowing is an increasing concave function of lowland ownership. The turning point beyond which net borrowing begins to decline is 0·5 hectares, just larger than the sample mean. The coefficients in the net borrowing equation for the ownership of uplands are not jointly significantly different from zero. There is no statistically significant relationship between ownership of uplands or lowlands and net repayments.

7. *The village dummy variables* are among the most significant regressors in each of the specifications. They capture a variety of different collinear effects. It is impossible to disentangle, for example, the effect of village level production shocks on loan demand from that of differences in infrastructure across villages.

8. *The correlation coefficient* between v_1 and v_2 is strongly negative. This may reflect omitted variables which are strongly correlated with net borrowing (and which would then be strongly negatively correlated with net repayments to the household).

C. *Testing full risk pooling*

A Pareto-efficient equilibrium with no transactions costs has the property that risks are completely pooled at the community level. Two tests for full risk pooling are developed in this section. The first test emerges from the result that the amount borrowed or lent by a household in any period depends only on aggregate community income in that period. That is, net lending is independent of the state of nature after controlling for community income.[18] To carry out this test of full risk pooling, I include measures of the idiosyncratic shocks received in 1987 (before this year's loans were made) in the net borrowing equation. Under the null hypothesis of complete risk pooling, their coefficients are zero. No index of self-reported events on the household farm is available for the 1987 crop season, so the indicator of random production shocks is based on the deviation of the household's per-hectare yield from the village mean yield in 1987. This indicator is broken down by lowland and upland plots. To control for household fixed effects (in reporting and field quality) the 1987 yield deviation is differenced from the deviation in 1988, so $\text{YDIFF} \equiv (Y_{i,87} - \bar{Y}_{87}) - (Y_{i,88} - \bar{Y}_{88})$. If the idiosyncratic shock to output is uncorrelated over time, then this introduces an errors-in-variables problem of the classic sort (because lending is also unaffected by shocks in 1988). The power of the test is difficult to evaluate and is likely to be low because of the errors-in-variables that arise when the null hypothesis

18. This result remains even if some autocorrelation of random shocks is allowed. If village-wide shocks are correlated over time (e.g. droughts may persist) but idiosyncratic shocks are not, then borrowing and lending are unaffected by the idiosyncratic shock.

is rejected. If the null is false, then the coefficients of the YDIFF variables are biased towards zero. The reported t-ratios of the coefficients of the yield variables and the likelihood-ratio test statistic, however, are correct under the null hypothesis.

The model of equations (7)–(9) is re-estimated by maximum likelihood with the two YDIFF variables added to (7a) and (7b). The upland yield variable has a coefficient (t-statistic) of 0·03 (0·13) in the net borrowing equation; the lowland yield variable has a coefficient of −0·489 (−1·49). The coefficient on lowland yields has the expected sign and approaches conventional levels of significance. Exceptionally good yields on lowland farms seem to decrease borrowing in the succeeding season, contrary to the null hypothesis of full risk pooling. However, the hypothesis of complete risk pooling cannot be rejected, as the coefficients are not jointly significantly different from zero. The likelihood-ratio test of their joint significance yields a $\chi^2(2)$ test statistic of 3·34.

The second test relies on the fact that if full risk pooling is achieved, the shocks received by the transaction partners of a sample household have no effect on loan repayments. That is, after controlling for community income, net repayments are independent of the income of transaction partners. To carry out this test of full risk pooling, I include a measure of the adverse shocks received by the transactions partners of the sample household (Z_p) in the repayment equation. 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. The effect of the average shock received by the village on repayments is captured by the village dummy variable. If the shocks received by transactions partners have an effect on the net repayments received by a sample household, the household has not sufficiently spread its loan transactions around the village, and has subjected itself to theoretically diversifiable risk. In other words, Pareto efficiency implies that the state-contingent net repayments to the sample household (whether borrowing or lending) depend on the random shocks it receives and on total village income, but *not* on the idiosyncratic shocks affecting any other household. Equations (7)–(9) are reestimated with $\alpha_p Z_p$ added to equation (8). The coefficient of the indicator of adverse shocks received by loan transaction partners in the net repayment equation is −0·648 with a t-statistic of −2·10. Adverse shocks received by transactions partners significantly reduce the loan repayments received by sample households. Loan repayments to sample households and, therefore, consumption by sample households vary according to the realization of idiosyncratic shocks by their transaction partners. While these state-contingent loan transactions allow households to insure against some idiosyncratic risk, they do not permit the realization of a fully Pareto efficient pooling of risk within the village. This is evidence that the competitive model ignores institutional details of the loan transactions which have a real effect on the operation of the credit market.

6. A BILATERAL CREDIT RELATIONSHIP WITH STATE-CONTINGENT PAYMENTS

Information moves between borrowers and lenders in these villages more freely than is supposed in much of the theoretical literature, yet a full risk-pooling equilibrium is not achieved. Moreover, enforcement of these credit contracts is not perfect; I present evidence below that 10% of all loans are defaulted. If the probability of default is not negligible, then the competitive equilibrium characterized and estimated in Sections 2 through 5 cannot be sustained. There will be a limit on the quantity of debt a household will be able to incur, and if information is not complete then full risk pooling of idiosyncratic risk will

not be achieved. 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 develop a model of credit transactions in northern Nigeria which explicitly incorporates this institutional context. I am able to shed light on these details by excluding from consideration the general equilibrium properties of state-contingent loan contracting. There are only three actors in this section. Two are households which may transact credit. One of these is called the "household" or "sample household"; the other is the "transaction partner," or "partner." The final actor has no independent motivation and in other contexts would be called the court system. Here it is the community or family authority concerned with monitoring and enforcing contracts.

I describe the contractual form of the loan transactions and the community-based mechanisms which serve to enforce the contracts in Section A. 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. In Section B I discuss the decision by the borrower as to whether to default on his repayment obligations and describe the equilibrium of the model.

A. *Risk and information flow within the village*

Consider a village in which two agents ("the household" and "the partner") interact over two periods. There is one good, of which the household receives an income Y^1 in the opening period, while the partner receives $\tilde{Y}^1$. There are two sources of random variation in second period income. There are S observable "states of nature" in the second period indexed by s, each with objective and commonly known probability of occurrence π_s. In state s, the household and partner receive base incomes of Y_s and $\tilde{Y}_s$. The variation in incomes across the s states is referred to as the *observable shock* and is analogous to the shocks of Section 2. In addition, the household and its partner respectively are subject to additional *unobservable shocks* ε and η, distributed continuously with densities $h_s(\varepsilon)$ and $p_s(\eta)$, so that their total incomes are $Y_s+\varepsilon$ and $\tilde{Y}_s+\eta$, respectively. Given the state of nature, ε and η are distributed independently. However, the densities are permitted to vary across states. I assume that $Y_s+\varepsilon>0$ and $\tilde{Y}_s+\eta>0$ for all ε and η such that $h_s(\varepsilon)>0$ and $p_s(\eta)>0$. The realization of ε is observed only by the household, and only the partner observes the realization of η.

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 can be accommodated within the model. If information on farming activities and outcomes flows freely through the village so that all income shocks are observable, as was assumed in the competitive model, then the variances of ε and η are zero for all s. On the other hand, if information concerning all income shocks is private, then Y_s and $\tilde{Y}_s$ are constant.

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. 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 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.

A standard method of modeling contract enforcement is to consider the transaction as one instance of a repeated interaction.[19] 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. The credit contracts in these villages, however, are not self-enforcing. Both households are members of the same community and penalties for default are imposed by an authority of that community. These penalties are not explicitly codified as law, but they operate in much the same way. The particular enforcement mechanisms are discussed in Udry (1990); for our current purposes 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 knows the realization of the observable shocks. Second, the respondents claim that the most important component of the penalties is a direct utility cost to the defaulter in the form of private or public admonishment. The penalties available to the authority are graduated, with more severe penalties imposed for more serious offenses. Another component of the penalty is the loss of future access to the credit market. This cost is exogenous to the two households (it is imposed by the community) but its presence could introduce some interesting dynamics into the model. Unfortunately, these cannot be explored with these data, because I have only one year of data and no information on past default behaviour.

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 ε or η, as no incentive compatible mechanism exists which could induce a household to reveal its true unobservable shock.[20] Therefore, I introduce state-contingent contracting into the model by allowing owed repayments to vary across the S observable states of nature.

This framework accommodates two alternative models of the manner in which owed repayments are made contingent upon the realization of observable shocks to the incomes of the borrower and lender. *Model A*: 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 partner to the household (B, which may be negative) and the S repayments (R_s) owed by the partner to the household, which depend on the observable shocks received by the two households.[21]

19. Recent applications of the theory of self-enforcing insurance can be found in Thomas and Worrall (1988), Coate and Ravallion (1993), Fafchamps (1992) and Kletzer and Wright (1991).

20. It will be seen in 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.

21. The relationship between this bilateral model and the competitive model developed in Section 2 can be made explicit. If model A is correct and if there are no unobserved shocks ($\sigma_\varepsilon = \sigma_\eta = 0$), then the bilateral model collapses into a special case of the competitive model (with only two households in the village). There will be no defaults and idiosyncratic risk will be fully pooled within the village. Alternatively, if model A is true and the default cost is prohibitive, then again there will be no defaults and risk due to the *observable* shocks will be pooled between the two households. However, idiosyncratic unobservable risk remains uninsured, and their realization will affect net lending in the following year.

Model B: Alternatively, in accordance with the observation that the loans are made with very little negotiation, there are exogenous community standards which dictate appropriate payments contingent upon the realization of particular states. The households negotiate over B and a base amount to be repaid R, so that the amount owned to the sample household in state s is $R_s = R + C_s$, where C_s is determined by community standards.[22] 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.

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. The unobservable shocks ε and η, on which no contingent payments are based, provide the variation in income that leads some households to default on their obligations.

The time-sequence of events is as follows: knowing Y^1 and $\tilde{Y}^1$, the household and the partner negotiate over B and R_s (model A) or R (model B). A deal is made and the loan is transacted. Period-one consumption by the household ($c^1 = Y^1 + B$) and partner ($\tilde{c}^1 = \tilde{Y}^1 - B$) occurs. Next the two households discover their second-period incomes $Y_s + \varepsilon$ and $\tilde{Y}_s + \eta$. 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 now decides whether to default. Let $D_{s,\varepsilon}$ ($\tilde{D}_{s,\eta}$) equal one if the household (partner) defaults and zero otherwise. Period-two consumption by the household $[c_{s,\varepsilon,\eta} = Y_s + \varepsilon + (1 - D_{s,\varepsilon} - \tilde{D}_{s,\eta})R_s]$ and partner $[\tilde{c}_{s,\varepsilon,\eta} = \tilde{Y}_s + \eta - (1 - D_{s,\varepsilon} - \tilde{D}_{s,\eta})R_s]$ occurs, and simultaneously community authorities impose direct utility costs $C_i(|R_s|)$, $i = h, p$ on any defaulter.

The separable Von Neuman–Morgenstern utility of the household is

$$U_h = u_h(c^1) + \beta \sum_s \pi_s \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} [u_h(c_{s,\varepsilon,\eta}) - D_{s,\varepsilon} C_h(|R_s|)] h_s(\varepsilon) p_s(\eta) \delta\varepsilon\delta\eta - T_h\{B \neq 0\}, \quad (10)$$

where u_h is increasing, strictly concave, bounded from above and twice differentiable. Also assume that as $x \to 0^+$, $u_h(x) \to -\infty$. There may be transaction costs ($T_h \geqq 0$) 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). The partner's utility function (U_p) is defined analogously. Let $u_i(c) = u(c_i, X_v, X_i)$ and $C_i(|R|) = C(R, X_v, X_i)$ for $i = h, p$ where X_h, X_p, and X_v are vectors of exogenous characteristics of the household, partner and village, respectively. The dependence of $D_{s,\varepsilon}$ and $\tilde{D}_{s,\eta}$ on s, ε and η must now be described.[23]

B. *The default decision and equilibrium*

Approximately 10% of all loans are defaulted, therefore the possibility of default is an important element of the model. It will be seen that the possibility of default and the associated enforcement technology provides an incentive-compatible mechanism which

22. This model is silent on the determinants of C_s. Community norms which dictate risk sharing between households are an oft-cited element of the 'moral economy' which has been hypothesized to provide a measure of security in peasant communities in risky environments (Scott (1976); Platteau (1991)). Model B may be interpreted as an effort to place an analysis of rural credit based on household optimizing behaviour within the context of a village moral economy.

23. 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 modelled more generally as $U(c_{s,\varepsilon,\eta}, D_{s,\varepsilon}, R_s)$.

permits some adjustment in repayments in response to the realization of unobservable shocks to income. In this section I explore the decision of the partner to default. I focus on the partner's decision because the partner may choose to default when $R_s > 0$. The exposition will be clarified somewhat by working with positive quantities. Assume that $C(R_s)$ is C^2, increasing, concave, bounded from above, and that as $x \to 0^+$, $C(x) \to k > 0$ so that there is a fixed cost to even a small default. The default decision is made after the realization of the observable state of nature s and the unobservable income shocks (η and ε).

The fixed cost associated with defaulting implies that in any observable state s, given $R_s > 0$, the partner will choose to default if and only if it receives a "bad" enough unobservable shock to its income. 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. Define $\eta_s(R_s)$ as the value of the unobservable shock η such that the partner will choose not to default for all $\eta > \eta_s(R_s)$ and will default for all $\eta \leqq \eta_s(R_s)$. $\eta_s(R_s)$ is the value of η at which the partner is indifferent between defaulting and repaying. The strict concavity of $u_p(\,)$ ensures that $\eta_s(R_s)$ is unique.[24] $\eta_s(R_s)$ is a continuous and continuously differentiable increasing function of R_s. For $R_s < 0$ there is no possibility that the partner will default. In this instance, $\eta_s(R_s)$ is defined so that $\text{prob}(\eta \leqq \eta_s(R_s)) = 0$. Similarly, $\varepsilon_s(R_s)$ (a decreasing function of R_s) can be defined. $\varepsilon_s(R_s)$ is the critical value of ε, below which the household will choose some level of default and above which the household will not default. $\varepsilon_s(R_s)$ and $\eta_s(R_s)$ are abbreviated to ε_s and η_s below.[25]

The household's indirect utility over B and $\vec{R} = (R_1, \ldots, R_s, \ldots, R_S)$ is

$$V_h(B, \vec{R}) = U_h(y^1 + B) + \beta \sum_s \pi_s \Bigg[\int_{\varepsilon_s}^{\infty} u_h(Y_s + R_s + \varepsilon) \times (1 - P_s(\eta_s)) h_s(\varepsilon) d\varepsilon + \int_{\varepsilon_s}^{\infty} \int_{-\infty}^{\eta_s} u_h(Y_s + \varepsilon) h_s(\varepsilon) p_s(\eta) d\eta d\varepsilon \times \int_{-\infty}^{\varepsilon_s} [u_h(Y_s + \varepsilon) - C_h(|R_s|)] h_s(\varepsilon) d\varepsilon \Bigg] - T_h\{B \neq 0\}. \tag{11}$$

The first integration is over those values of the unobservable shock ε 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 $(1 - P_s(\eta_s))$. The second integration is over those values of ε for which the household

24. Let $z \equiv \tilde{Y}_s + \eta$ and $\Psi(z) \equiv u_p(z) - C_p(R_s) - u_p(z - R_s)$. The partner will default iff $\Psi(z) > 0$. As $z \to R_s^+$, $\Psi(z) \to \infty$. Because $u_p(\,)$ is increasing, concave and bounded from above, as $z \to \infty$, $\Psi(z) \to -C_p(R_s) < 0$. Therefore, there is some z^c such that $\Psi(z^c) = 0$. $\partial \Psi / \partial z < 0$, so z^c is unique. $z^c(R_s)$ is a continuous and continuously differentiable function implicitly defined by $\Psi(z^c(R_s)) = 0$. From the implicit function formula,

$$\frac{\delta z^c}{\delta R^s} = -\frac{U_p'(z^c - R_s) - C_p'(R_s)}{U_p'(z^c) - U_p'(z^c - R_s)} > 0$$

because the denominator is negative and the numerator is positive when $\Psi(z) = 0$. Define $\eta_s(R_s) = z^c(R_s) - Y_s$. Note that as $R_s \to 0^+$, $z^c(R_s) \to 0$ and $\eta_s(R_s) \to -Y$.

25. Default is inefficient. Moreover, by defaulting, the borrower reveals he has received a severely bad shock. Both parties could be made better off by renegotiating the owed repayment taking into account this information, so the equilibrium is *not* renegotiation-proof. There must be a commitment technology, provided by the community authorities, which prohibits renegotiation.

does not choose to default and those values of η for which the partner does choose to default. The integrand is the utility in the case of the partner defaulting. The final integration is over the values of ε for which the household wants to default. Therefore, the utility cost of a default is included in this integrand. V_p is defined analogously.

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. Alternatively, the lender and borrower might engage in Nash bargaining, with threat points being no transaction. I require only that the equilibrium be in the core. The choice between alternative mechanisms which lead to an equilibrium in this set has no effect on the structure of the econometric model to follow. The choice does have implications, however, for certain coefficients, and in Section 9 this will serve as the basis of an informal test between the alternative mechanisms.

I require that the equilibrium net loan B^e and vector of state-contingent repayments $\vec{R}^e$ satisfy for some positive λ:

$$\begin{aligned} \text{Max} \quad & V_h(B, \vec{R}) + \lambda V_p(B, \vec{R}) \\ \text{s.t.} \quad & V_h(B, \vec{R}) \geqq V_h(0, 0) \\ & V_p(B, \vec{R}) \geqq V_p(0, 0). \end{aligned} \tag{12}$$

The optimization is over $\{B, R_1, \ldots, R_s, \ldots, R_S\}$ for model A and over $\{B, R\}$ for model B. Equilibrium borrowing is a function, therefore, of the characteristics of the household and its partner and of the village environment (X_v): $B^e = B(X_h, X_p, X_v)$. In model A, the repayment owed in any observable state s is $R_s^e = R_s(X_h, X_p, X_v)$.[26,27] In model B, the base repayment is a function of the characteristics of the two households, while the state-contingent adjustment in owed repayments depends on community norms (which may be sensitive to household characteristics) and the realization of observable shocks: $R_s^e = R(X_h, X_p, X_v) + C_s$.

7. DATA

Most of the data used in this section is identical to that described in Section 4. Some additional data, however, is required. 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 assume that the loan partners of each of the sample households act as a consortium, the members of which are fixed exogenously. The partners negotiate as one against the sample household.

Defaults—This model 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_s may equal zero 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

26. The equilibrium $\vec{R}$ will pool risk between the household and the partner. If all information is public (the variances of ε and η are zero) then efficiency requires standard complete risk pooling as in the competitive model: $u_h'(c_q)/u_h'(c_r) = u_p'(\tilde{c}_q)/u_p'(\tilde{c}_r)$ for any two states q and r. With private information, repayments still act to pool risk: $Y_q \leqq Y_r$ and $\tilde{Y}_q \geqq \tilde{Y}_r$ (and $h_q(\varepsilon) = h_r(\varepsilon)$ and $p_q(\eta) = p_r(\eta)$) implies $R_q^e \geqq R_r^e$.

27. An alternative model in which the households negotiate the repayment terms after s, ε and η are revealed would permit some sharing of the borrower's risk.However, *ex post* negotiations would not in general allow pooling of risk faced by the lender. Suppose that the repayment R is determined by *ex post* Nash bargaining, with disagreement resulting in no repayment and the imposition of the default penalty on the borrower. With CARA utilities, R is invariant to the lender's income.

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 I assume that the loan was defaulted. If the respondent was the borrower, the respondent was asked about the lender's willingness to make a loan to the respondent in the future. If the response was negative and the respondent expected to make no further payments on the loan, the loan is judged in default (there is no evidence that loans are rolled over—see note 14). This is not an entirely satisfactory indicator that a default has occurred. This measure permits only complete default of all repayments owed by a household. A model of partial default is identified in principle and is implemented in Udry (1991). However, it is difficult in practice to differentiate variations in the amount owed from the amount defaulted (both of which are unobserved) in cases of partial default. I restrict attention, therefore, to instances of complete default. More importantly, this measure of default 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.[28]

This measure indicates that overall, 10·3% of loans are defaulted. Respondents who were lenders reported that 8·0% of the loans that they extended were defaulted. Respondents who were borrowers admitted that they defaulted on 14·4% 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% 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 (Z_h) and its transaction partner (Z_p). These are the same measures used in the estimation of the competitive model.

Unobservable shocks to income—The household's decision to default is affected by the realization of ε, 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 ε is the variation in yields. Therefore, I measure the unobservable shocks by the vector Q_h, which is composed of the value of per hectare yield on the household's upland and lowlands farms. I assume that Q_h is not public information. This assumption is supported by the facts that (1) yields are not directly observable by other households (because harvesting is a continuous process), and (2) the sample households could not provide information concerning the yields of their partners (in contrast, they could (and did) provide accounts of the events that enter Z_p, the measure of observable shocks). The use of Q_h 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 return to it during the discussion of the results.

Q_h 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 the "difference of differences" variable YDIFF which was used in Section 5. However, this contains last year's "unobservable" shock as well as 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. It could not provide an instrument to identify the default

28. 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 mis-classification in binary choice models.

decision. Unfortunately, by definition, no measure of the unobservable income shock received by nonsample households can be constructed.

8. MODEL SPECIFICATION

The model of Section 6 established that: (1) borrowing and owed repayments are functions of the characteristics of 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 were willing to discuss their partners' farming practices and, in particular, the realization of adverse shocks on their partners' fields. However, they in general refused to reveal the identity of their partners, so I have no information on the partners' wealth or demographic characteristics. The estimation that follows therefore is affected by omitted variables bias; (2) owed repayments may vary according to the realization of observable shocks to both the household and the partner; (3) default occurs if and only if the household (or partner) receives a "bad" enough unobservable shock. This unobservable shock does not affect owed repayments, so it identifies the default decision; (4) transaction costs imply that the lending equation must be augmented by a Rosett friction model.

Equations (13a) and (13b) define net borrowing, and (14) defines owed repayments.[29]

$$B^* = X_v\alpha_0 + X_h\alpha_1 + \nu_1, \tag{13a}$$

$$B = \begin{cases} 0 & \text{if } 0 > B^* > -k, \\ B^* & \text{if } B^* > 0, \\ B^* + k & \text{if } B^* + k < 0 \ (k > 0), \end{cases} \tag{13b}$$

$$\text{REP}^* = \begin{cases} X_v\beta_0 + X_h\beta_1 + Z_h\beta_2 + Z_p\beta_3 + (X_h \otimes Z_h)\beta_4 + (X_h \otimes Z_p)\beta_5 + \nu_2 & \text{if } B \neq 0, \\ 0 & \text{if } B = 0. \end{cases} \tag{14}$$

Z_h and Z_p define the observable state of nature s. 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 so that $\beta_2 > 0$ and $\beta_3 < 0$. β_4 and β_5 capture possible interactions between household characteristics and state-contingent repayments which might be either negotiated (model A) or set by community standards (model B).

Equations (15a) and (15b) describe a sample household's default decision.

$$D_h^* = X_v\gamma_0 + X_h\gamma_1 + Z_h\gamma_2 + Q_h\gamma_3 + \text{REP}^*\gamma_4 + v_3, \tag{15a}$$

$$\begin{cases} \text{REP} = 0 \text{ and } D = 1 & \text{if } D_h^* > 0, \\ \text{REP} = \text{REP}^* \text{ and } D = 0 & \text{if } D_h^* \leqq 0. \end{cases} \tag{15b}$$

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.

29. I continue the convention that payments to a sample household are positive. An asterisk indicates a latent variable. Individual household subscripts are omitted.

Household specific variables X_h are included as predictors of income. For the same reason the indices of observable (Z_h) and unobservable (Q_h) shocks to the household's income are included. Equations (16a) and (16b) describe a partner's default decision.

$$D_p^* = X_v\lambda_0 + Z_p\lambda_1 + \text{REP}^*\lambda_2 + v_4, \tag{16a}$$

$$\begin{cases} \text{REP}=0 \text{ and } D=1 & \text{if } D_p^* > 0 \\ \text{REP}=\text{REP}^* \text{ and } D=0 & \text{if } D_p^* \leqq 0. \end{cases} \tag{16b}$$

Equations (15) and (16) should be identical, but no household characteristics of the partner are available. The only available household level indicator of the partner's income is Z_p, the index of observable adverse shocks affecting the partner household.

The random variables v_1, v_2, v_3 and v_4 are assumed to be jointly normally distributed with zero mean and covariance matrix Σ. The parameters of the default decisions 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.

The covariance between v_3 and v_4 cannot be identified. The Rosett-type friction of equation (13) is identified through its non-linearity; no variables are available to identify the friction independently of the determinants of loan size. Equation (15) is identified by the vector Q_h, which affects the amount defaulted but not the repayment owed. Equation (16) is identified only through its non-linear structure and the normality assumption, as I have no measure of the yields achieved on the partners' plots.

The assumption that the idiosyncratic shocks (both Z and Q) are serially uncorrelated is critical. Net borrowing is affected by last year's idiosyncratic shocks (Z_{t-1} and Q_{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 Z_h, Z_p and Q 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.

9. ESTIMATION RESULTS[30,31]

State-contingent payments—The results presented in Section B of Table V 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). 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 support the hypothesis that owed

30. The tables are based on specifications which gain efficiency by imposing the restriction that the covariances σ_{13}, σ_{14}, σ_{23} and σ_{24} are zero. The likelihood-ratio test of the joint restriction that these covariances are zero yields a $\chi^2(4)$ test statistic of 0·6, 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.

31. LM tests for heteroskedasticity based on the generalized error products (of order (2, 0)) of the models yield χ^2 statistics of 24·48 (5 d.f.), 21·03 (5 d.f), 7·14 (3 d.f) and 5·63 (3 d.f) for v_1, v_2, v_3, and v_4, respectively. As was the case in Section 5, the tests reject the null that the marginal distributions are homoscedastic normal. However, there is evidence that the inner product gradient method used to compute these tests leads to over-rejection in small samples.

repayments are state-contingent, and that this flexibility allows for direct risk pooling between borrowers and lenders. The estimates of the effect of the realization of adverse shocks on repayments are larger in this model (which accounts for default behaviour) than in the competitive model (which does not). This provides strong evidence that the cross-tabulations of Table I are *not* driven by default behaviour. In fact, the current estimates indicate that households are less likely to default when they realize an adverse shock (panel C of Table V).

The finding that state-contingent payments are made in response to the realization of observable shocks on lowland 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 historically have been treated differently in a number of respects, from land tenure to farming practices.[32] 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. Estimates of the competitive model also found a stronger responsiveness of repayments to the receipt of adverse shocks on lowland plots than on upland plots, although in that case the estimate of the effect on upland plots was significantly different from zero.

In order to explore 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 $\chi^2(2)$ test statistic of 3·4, which is not significantly different from zero at the 5% level. When an interaction is permitted only between lowland area and lowland adverse shocks (and the effect of upland shocks is restricted to zero) the coefficient is 1·00 with a t-statistic of 1·3, which is significantly different from zero at the 20% level. There is weak evidence, therefore, that the payment which is contingent upon receipt of a particular adverse observable shock increases with 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 LR 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. When the interactions are limited to lowland shocks, the $\chi^2(3)$ test statistic is 6·8, which is significant at the 10% level. The size of the state-contingent payments seems (weakly) to vary across the four villages. Finally, I permitted interactions between all the household characteristics and the indicators of observable shocks. The $\chi^2(10)$ LR test statistic of the restriction that these interactions are zero is 10·4, which is not significantly different from zero. When the interactions are limited to lowland shocks, the $\chi^2(4)$ LR statistic is 6·2, which again is not 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 indicates that state-contingent repayments weakly vary across villages and holdings of lowland plots, but that they are not responsive to more general household characteristics. This pattern of results does not contradict the hypothesis that households negotiate over the state-contingent payments, but it conforms more closely with the notion that these payments are prescribed by community standards.

32. See Norman (1972), Hill (1972) and Ega (1984).

TABLE V

Bilateral model estimates

A. Net borrowing equation (positive-lending from the partner to the household)			B. Net repayment equation (positive-repayments from partner to the household)			C. Default equation		
Variable	Parameter	*T*-Ratio	Variable	Parameter	*T*-Ratio	Variable	Parameter	*T*-Ratio
CONSTANT	−5·885	−26·32	CONSTANT	1·982	8·91	CONSTANT		
VILLAGE1	2·304	10·44	VILLAGE1	0·790	3·62	sample households	0·745	3·33
VILLAGE2	3·029	13·77	VILLAGE2	−1·808	−8·33	transaction partner	−4·488	2·03
VILLAGE3	1·373	6·22	VILLAGE3	−1·150	−5·26	VILLAGE1	−1·123	−5·13
WEALTH	−0·138	−2·10	WEALTH	0·083	1·24	VILLAGE2	−0·025	−0·11
AGE	0·070	3·76	AGE	−0·026	−1·57	VILLAGE3	−1·014	−4·50
SKILLS	0·629	3·14	SKILLS	−1·095	−5·77	WEALTH	0·018	0·24
UPLAND	−0·405	−3·67	UPLAND	0·257	2·81	GONA	0·776	8·20
LOWLAND	0·372	1·86	LOWLAND	−0·248	−1·33	FADAMA	0·770	3·41
FRICTION CUTOFF	4·499	21·39	Index of self-reported shocks:			Index of self-reported shocks:		
σ	7·944	41·75						
			ON UPLANDS	0·220	1·00	ON UPLANDS	−4·787	−2·14
			ON LOWLANDS	2·263	10·17	ON LOWLANDS	−8·011	−3·59
			LOAN PARTNER	−1·427	−6·45	LOAN PARTNER	2·124	0·94
			σ	6·217	35·21	Farm yield:		
			rho12	−0·759	−19·13			
						ON UPLANDS	−3·153	−1·40
						ON LOWLANDS	−8·778	−3·95
						AMOUNT OWED	5·782	28·12

−LN(Likelihood) = 1209·0

Table VI 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 seem 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, we 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.

Even more striking, however, are the results in Section B of Table VI which indicate that when adverse shocks are received by lenders, they are paid back more. There is true risk pooling between the two agents. These results conform with those of Table IV, which reports a similar exercise in the context of the competitive model. 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. An LR test of the restriction that the coefficients of the indices of adverse shocks are the same for net lenders and net borrowers yields a $\chi^2(3)$ statistic of 0·4, which is not significantly different from zero. This provides no evidence, therefore, against the hypothesis of symmetric 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 Table V supports the hypothesis of transaction costs in lending. The friction coefficient is significantly different from zero. As expected, households with higher levels of non-land wealth holdings at the start of the sample year have higher net lending. The effect of non-land wealth on repayments, however, is insignificant. These results are similar to those of the competitive model.

Ownership of upland and lowland land affect lending in opposite directions. Households with larger holdings of upland plots tend to lend more, while households with larger holdings of lowland borrow more (though this latter coefficient is only marginally significant). This may reflect the higher working capital requirements of lowlands plots. The competitive model finds weaker land effects because it neglects the effects of land ownership on default decisions.

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. These variables operate in the same direction in the competitive model, but in that context neither is significant. 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 behaviour 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.[33]

33. 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.

TABLE VI

Testing the responsiveness of contract terms to shocks: net borrowers vs. net lenders

A. Net borrowing equation (positive-lending from the partner to the household)			B. Net repayment equation (positive-repayments from partner to the household)				C. Default equation		
Variable	Parameter	*T*-Ratio	Variable	Parameter		*T*-Ratio	Variable	Parameter	*T*-Ratio
CONSTANT	−5·884	26·31	CONSTANT	2·005		9·01	CONSTANT		
VILLAGE1	2·304	−10·44	VILLAGE1	0·765		3·51	sample households	−2·209	−9·86
VILLAGE2	3·030	−13·77	VILLAGE2	−1·831		−8·43	transaction partner	−8·030	−3·69
VILLAGE3	1·375	−6·23	VILLAGE3	−1·173		−5·36	VILLAGE1	−0·083	−0·37
WEALTH	−0·138	2·10	WEALTH	0·083		1·24	VILLAGE2	−0·025	−0·11
AGE	0·070	−3·76	AGE	−0·026		−1·59	VILLAGE3	−1·451	−6·43
SKILLS	0·630	−3·14	SKILLS	−1·097		−5·78	WEALTH	0·388	4·39
UPLAND	−0·405	3·67	UPLAND	0·259		2·83	GONA	1·291	12·12
LOWLAND	0·373	−1·86	LOWLAND	·0·251		−1·34	FADAMA	0·873	3·86
FRICTION CUTOFF	4·492	21·36	Index of self-reported shocks:				Index of self-reported shocks:		
σ	7·942	41·74		Borrowing households		Lending households			
			ON UPLANDS	0·221	1·00	0·071	0·31	ON UPLANDS	−5·900	−2·63
			ON LOWLANDS	2·273	10·21	2·000	8·83	ON LOWLANDS	−13·060	−5·83
			LOAN PARTNER	−1·408	−6·37	−1·112	−4·91	LOAN PARTNER	8·335	3·69
			σ	7·947		41·75				−4·66
			rho12	−0·760		−19·14		Farm yield:		
								ON UPLANDS	−10·536	
								ON LOWLANDS	−14·358	−6·42
								AMOUNT OWED	8·611	40·67

−LN(Likelihood) = 1208·9

The estimates of the default equation for the household and its partner are presented in panel C of Table V.[34] As expected, after controlling for observable adverse events, households with 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, I estimated 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, nor is there any statistically significant change in any other coefficient.

A household's non-land wealth has no significant effect on the default decision. Households with larger land holdings are significantly more likely to default, contrary to theoretical expectation. They may be more able to withstand the punishments inflicted on defaulters. An observable adverse shock on its land reduces the probability of default by the household. This is the result which underlies the stronger responsiveness of repayments to adverse shocks in this model than in the competitive model. This is a puzzling result because the theoretical model implies that the reduction in income contingent upon the receipt of an observable adverse shock (given a fixed level of owed repayments) 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, as they do in the competitive model. They capture a variety of different collinear effects including village level shocks, infrastructure, and the socially-determined costs of default. The correlation coefficient between ν_1 and ν_2 is negative and highly significant, although not near -1. As is the case in the competitive model, this may reflect the omission of variables positively correlated with net borrowing and thus negatively correlated with net repayments to the household.

10. 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 favoured 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 paper opens with a model of a competitive market for loans in which households are price-takers. This Walrasian approach enables me to outline the general equilibrium consequences of state-contingent contracting, and to derive the efficiency properties of such equilibria. The dynamic paths of the terms at which loans are made and of individual

34. These estimates impose the restriction, derived in section 6, that the household's characteristics play no role (except through R) in the partner's default decision. An LR test of this restriction yields a $\chi^2(7)$ test statistic of 7·8, which is not significant at the five per cent level.

households' participation in the credit market are derived. Moreover, the estimation results accord well with the predictions of the general equilibrium model. The results indicate that quantitatively important insurance payments are embedded in loan repayments.

This approach treats these highly personalized transactions as abstract events in a perfectly competitive market. However, it is possible to reject the hypothesis that a fully Pareto-efficient risk-pooling allocation of village resources is achieved through these loans. The mutual insurance network available through these loans to households in rural northern Nigeria is important, but it is incomplete. Therefore, an investigation of the institutional arrangements which support these loan transactions is required before the economic role of the credit market can be fully understood.

As a step in this direction, the paper presents 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. Once again, the results indicate that borrowers and lenders are engaged in risk pooling through state-contingent loan repayments. The central finding of this paper, therefore, seems robust. It emerges in the simple cross-tabulations of Table I and is repeated in both the abstract model of a competitive equilibrium in loan transactions and the institutional model of a bilateral credit relationship.

Nevertheless, the weaknesses of the bilateral approach must be acknowledged. Some are technical, and have been detailed in the body of the paper. These include the lack 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 behaviour and providing neutral monitoring and enforcing authority. This has enabled me to analyse the behaviour 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. An obvious next step would be to examine the search process through which (multiple) transaction partners are selected. More generally, these results underscore the importance of research which examines the processes through which the social norms and community monitoring and enforcement mechanisms which set the context for informal economic interaction arise and evolve through time.

An issue immediately arises from the analysis of this paper which can not be directly addressed by these data. The credit market described above is an important mechanism for pooling risks within a local community. It is known, however, that production shocks tend to be highly correlated over small areas within the semi-arid tropics.[35] What mechanisms (if any) exist to provide for flows of resources into or out of these local communities when they are subject to important community-level shocks? There is evidence from other

35. See Ruthenberg (1971). Udry (1990) and Carter (1991) find that between 50 and 60% of yield risk is driven by village-level shocks.

studies[36] and from the non-survey portions of my fieldwork, that village-based long-distance traders may play an important role by providing "pipelines" for the flow of resources across community boundaries. This process can be modelled, but its quantitative importance cannot be evaluated until data is available from a much wider cross-section, or from a time series in a particular village.

Facilitated by the relatively free flow of information within small communities, and supported by a set of social norms and community enforcement mechanisms, credit markets play multiple roles in the economy of rural northern Nigeria. Before it can be known if this flexibility is *sui generis* to this particular economic environment, or whether informal financial markets routinely assume diverse functions, further research on these markets in other parts of the world is required.

APPENDIX A: COMPETITIVE MODEL LIKELIHOOD FUNCTION

Consider the contributions to the sample likelihood of three observationally distinguishable groups of households: (1) those who did not participate in the credit market; (2) those who were net borrowers; (3) those who were net lenders.

(1) For household i which did not participate in the market, the model of equations (7)–(9) implies

$$X_i\alpha + \alpha_B P_i + v_{1i} < 0 \quad \text{and} \quad X_i\alpha + \alpha_L P_i + v_{1i} + F > 0.$$

The contribution of this household to the sample likelihood is

$$\Pr\left(-\alpha_B P_i > v_{1i} + X_i\alpha > -\alpha_L P_i - F\right).$$

(2) For household j which was a net borrower, the model implies

$$v_{1j} = B_j - X_j\alpha - \alpha_B P_j = \bar{v}_{1j} \text{ and}$$

$$v_{2j} = R_j - X_j\beta - \beta_B P_j - Z_j\gamma = \bar{v}_{2j}.$$

The contribution of this household to the sample likelihood is then

$$f(\bar{v}_{1j}, \bar{v}_{2j}),$$

where $f(\,)$ is the bivariate normal density.

(3) For household k which was a net lender, the model implies

$$v_{1k} = B_k - X_k\alpha - \alpha_L P_k - F = \bar{v}_{1k} \quad \text{and} \quad v_{2k} = R_k - X_k\beta - \beta_L P_k - Z_k\gamma = \bar{v}_{2k}.$$

The contribution of this household to the sample likelihood is then

$$f(\bar{v}_{1k}, \bar{v}_{2k}),$$

The sample likelihood is the product of the individual contributions of the 196 observations.

APPENDIX B: BILATERAL MODEL 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. $B > 0$, the household is a net borrower:

A1. $v_1 = B - X\alpha$

Sub-case (a): $D = 0$:

A2. and $v_2 = \text{REP} - X_v\beta_0 - X_h\beta_1 - Z_h\beta_2 - Z_p\beta_3$

A3. and $\varepsilon_1 \equiv v_3 + \gamma_4 v_2 < -[X_v\gamma_0 + X_h\gamma_1 + Z_h\gamma_2 + Q\gamma_3 + \gamma_4(X_v\beta_0 + X_h\beta_1 + Z_h\beta_2 + Z_p\beta_3)]$.

36. See especially Clough (1986).

Sub-case (b): $D=1$, REP$=0$:
A4. and $\varepsilon_1 \geqq -[X\gamma_0 + X\gamma_1 + Z_h\gamma_2 + Q\gamma_3 + \gamma_4(X_v\beta_0 + X_h\beta_1 + Z_h\beta_2 + Z_p\beta_3)]$.

If v_2 and v_3 have mean zero, variances σ_2^2 and σ_3^2 and covariance σ_{23}, then

$$\sigma_\varepsilon^2 = \sigma_3^2 + (\gamma_4)^2 \cdot \sigma_2^2 + 2\sigma_{23} \cdot \gamma_4,\ \sigma_{1\varepsilon} = \gamma_4\sigma_{12} + \sigma_{13}, \text{ and } \sigma_{2\varepsilon} = \gamma_4\sigma_2^2 + \sigma_{23}.$$

Case 2. $B<0$, the household is a net lender:

A5. $v_1 = B - k - X\alpha$
Sub-case (a): $D=0$:
A6. and $v_2 = \text{REP} - X_v\beta_0 - X_h\beta_1 - Z_h\beta_2 - Z_p\beta_3$
A7. and $\varepsilon_2 \equiv v_4 + \lambda v_2 < -[X_v\lambda_0 + Z_p\lambda_1 + \lambda_2(X\beta_0 + Z\beta_1)]$.
Sub-case (b): $D=1$, REP$=0$:
A8. and $\varepsilon_2 \geqq -[X_v\lambda_0 + Z_p\lambda_1 + \lambda_2(X_v\beta_0 + X_h\beta_1 + Z_h\beta_2 + Z_p\beta_3)]$.

The covariance matrix of ε_2 and η_2 is defined similarly to that of ε_1 and η_1.

Case 3. $B=0$, the household neither borrows nor lends:

A9. $-k - X\alpha < v_1 < -X\alpha$.

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